International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

Vol.3, Special Issue 1 Aug - 2017

Experimental Investigation on the Properties of Cement Concrete Pavement using Waste Plastic

M Sreenivasulu Reddy [1], Dr.Y Ramalinga Reddy [2], Gyanen Takhelmayum[3]

[1,3]Assistance professor, [2]Dean and Director

School of Civil Engineering, REVA University

ABSTRACT

In this study sand is replaced by waste plastic in two methods, one is by direct replacement in which shredded waste plastic is added directly to concrete and another is by melting plastic with fine aggregates. Density of conventional concrete is high; hence use of plastic in concrete reduces its self-weight. As plastic is not a biodegradable material, it affects the ecological system very badly. Waste plastic is not able to manage, so people started using waste plastic in bituminous pavement construction by replacing bitumen by waste plastic or by addition of waste plastic. There are different types of plastic is available depending on chemical composition and density. Plastic can also be used in form of fibers. In this study concrete with 5% and 10% replacement of plastic with sand which is direct replaced and replacement by melting process. For this study different physical and mechanical properties of concrete were conducted.

Keywords

Waste Plastic, Composition, Density, Physical properties, Mechanical Properties.

INTRODUCTION

As plastic is not a biodegradable material, it affects the ecological system very badly. In present day research on concrete technology by using waste materials is growing at a faster rate. The sand mining in rivers had gone up to such an extent that in many countries, there is a legal prohibition on sand mining. Even In places where there is no debar, satisfactory sand is not promptly available which is required to transport sand over a long distance. The search for an alternate source is of high priority. Artificially manufactured sands are used as a substitute to the natural sands and are economical. If an appropriate industrial or agricultural by-product, which is a waste material, is used to replace sand partially it will diminish the problems and complications due to the inadequacy of sand. On the other hand, it will also be an eco-friendly technique of disposal of huge quantities of materials that would otherwise contaminate land, air and water. If this waste can be used as a partial sand replacement material in concrete, it will be an extremely valuable resource. In order to counteract this problem sand is partially replaced by waste plastic.

OBJECTIVES

The main objective of present study is to evaluate the fresh properties and physical properties of cement concrete containing waste plastic.

- To evaluate the fresh properties of cement concrete containing waste plastic by tests like slump test, compaction factor test and vee-bee consist meter test.

- To find optimum plastic content by varying percentage of waste plastic.
- To cast plain and modified (plastic) cement concrete cubes, beams and cylinders are casted and tested.
- Physical properties of cement concrete like compressive strength test, split tensile strength test and flexural strength test and young are modulus.
-

MATERIALS AND METHODOLOGY:

Cement: Locally available cement of ACC-OPC grade 43 is used

Table 1:Physical properties of cement

Sl.No	Characteristics	Test results	Recommended values (as per IS code)	IS codes
1 1	Normal consistency	32	Not less than 30	IS:4031-Part 4-1988
2	Initial setting time (min) Final setting time (min)	55 300	Not less than 30 min Not more than 600 min	IS:4031-Part 5-1988
3	Specific gravity	3.069	3.0 – 3.15	IS:4031-Part 11-1988
4	Fineness of cement	3	Not more than 10%	IS:4031-Part 1-1996
5	Soundness test (Le-chateliers Exp.) (mm)	3	Not more than 10mm	IS:4031-Part 3-1988
6	Compressive strength of cement (Mpa) 3 days 7days 28days	 23 34 48	 Not less than 23 Not less than 33 Not less than 43	IS:4031-Part 6-1988

Coarse aggregates: The aggregates retained on 4.75 mm sieve are termed as coarse aggregates. Coarse aggregates are obtained by crushing various types which are granites, hard lime stones and good quality sand stones. The coarse aggregates used in this project are of size 20mm down and 12 mm.

Table 2:Physical properties of coarse aggregates

Sl. no.	Characteristics	Test results	Recommended values	IS Code
1	Specific gravity	2.68	2.5-3	IS : 2386 (Part III) – 1963
2	Aggregate impact test (%)	17.79	30	IS 2386-(part IV)-1963
3	Aggregate crushing test (%)	21.88	30	IS 2386-(part IV)—1963
4	Water Absorption Test (%)	0.152%	Max 2	IS : 2386 (Part III) – 1963
5	Los Angeles Abrasion Value (%)	29	Max 30	IS 2386-(part IV)—1963

Fine Aggregates: Locally available natural river sand free from organic and inorganic material is used for this project

Table 3:Physical properties of fine aggregate

SL.NO.	Characteristics	Test results	Recommended values	IS Codes
1	Specific gravity	2.66	2.5-2.9	IS 383-1970
2	Fineness modulus	2.55	1.71 – 2.78	IS 383-1970
3	Water absorption (%)	0.55	0.6	IS : 2386 (Part III) – 1963
4	Free moisture content (%)	0.2	0.1 - 0.2	2386(PART III): 1963
5	Bulking of sand (%)	30.5	20-30	IS 2386(PART III): 1963

Water: Water used in this project is potable water with no impurities and salts.

Plastic: Plastic which is used for this project is Low Density Polyethylene bags of thickness 40 microns. Shattering process of this plastic is done manually and the size of the plastic is 4.75 mm down to 75 µ.

Table 4: Physical properties of plastic

SL.NO.	Characteristics	Test results	Recommended values
1	Density (g/m³)	0.92	0.91-0.93
2	Water Absorption, 24 hrs (%)	0.01	≤0.01
3	Approx. Melting Temperature (°C)	60-110	<110

Table 5:Proportions for concrete mix

Proportion	Percentage of plastic	Cement (kg/m³)	W/C ratio	Coarse aggregates (kg/m³)	Fine aggregates (kg/m³)	Plastic (kg/m ³)	Water content (kg/m³)
1:1.705:2.687	0%	413.33	0.45	1110.68	704.81	0	186
	5%	413.33	0.45	1110.68	669.5695	35.2405	
	10%	413.33	0.45	1110.68	634.329	70.481	

RESULT AND DISCUSSION:

Compressive strength

The compressive strength is calculated from the failure load divided by the cross-sectional area (150mm×150mm) resisting the load and reported in units (N/mm²) in SI units. Concrete compressive strength requirements can vary from 17 (N/mm²) for residential concrete to 28 (N/mm²) and higher in commercial structures.

Table 6: Results of compressive strength (direct replacement)

Percentage of plastic	Compressive strength (N/mm^2)		Density (kg/m^3)	
	7 days	28 days	7 days	28 days
0%	26.37	35.933	2412.44	2477.333333
	27.488	34.155	2426.07	2448.592593
	32.6	44.822	2501.63	2381.62963
5%	10.95	11.933	2023.70	2109.62963
	12.73	14.155	2077.04	2238.518519
	11.64	13.488	2051.85	2215.111111
10%	8.17	8.822	1835.56	1876.444444
	7.89	9.045	1785.19	1889.185185
	7.71	9.489	1780.15	2040

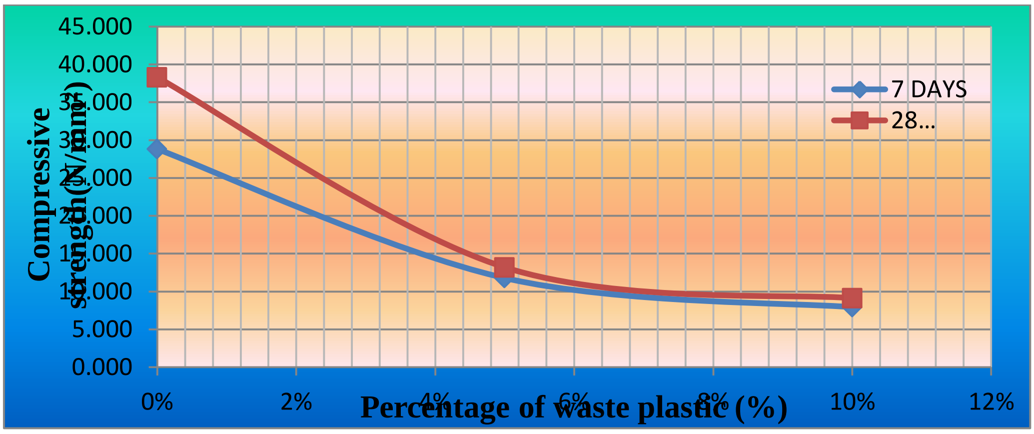


Fig 1:Graph between percentage of plastic and compressive strength

Graph 5.1 explains the 7 days and 28 days compressive strength of concrete with varying percentages of plastic. Compressive strength of concrete of 28 days with 0% replacement of waste plastic is 38.3 N/mm^2. When the percentage of replacement of fine aggregates by waste plastic increases, the compressive strength decreases upto 9.11 N/mm^2. By this the optimum waste plastic content that can be replaced with fine aggregates is 4% which gives compressive strength around 17 N/mm^2.

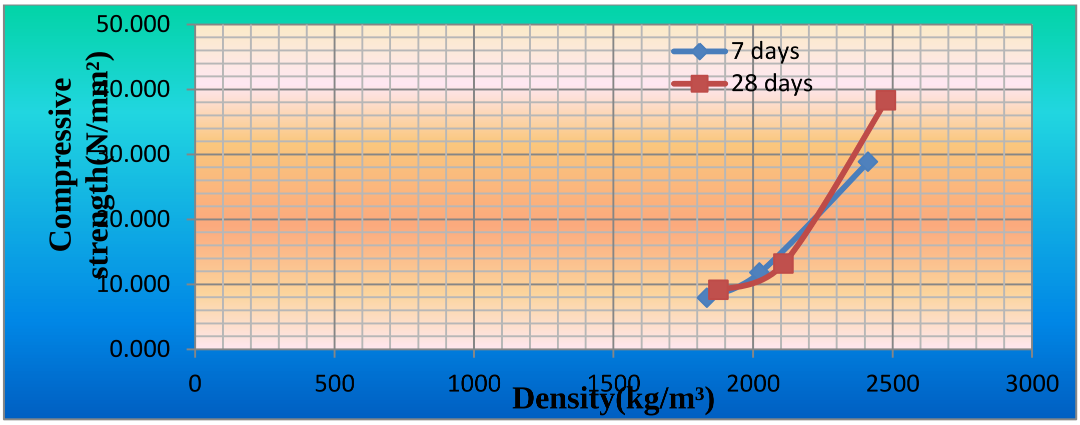
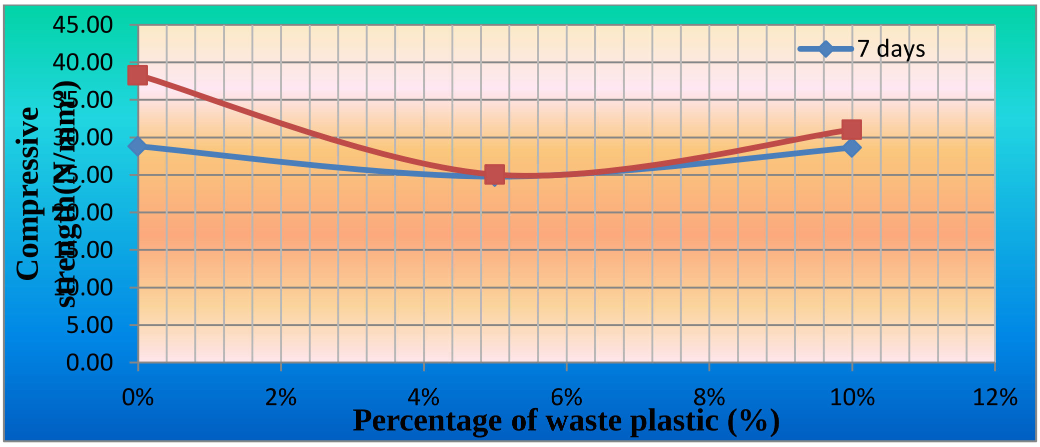


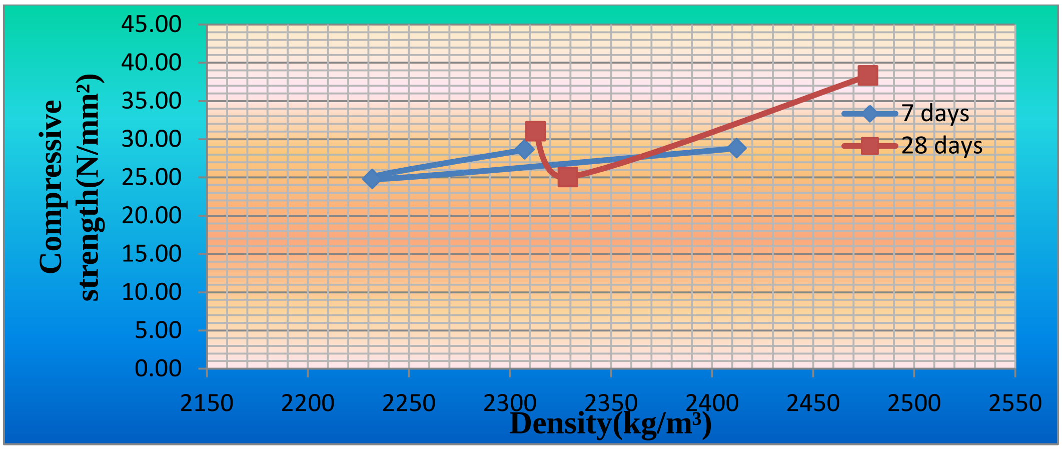
Fig 2:Results of compressive strength (melting)

From the above graph, when density is 1890 (kg/m^3) compressive strength is 9.11 N/mm^2. By the increase of density compressive strength is also increasing.

Table 6:Results of compressive strength (melting)

Percentage of plastic	Compressive strength (N/mm^2)		Density (kg/m^3)	
	7 days	28 days	7 days	28 days
0%	26.37	35.933	2412.444	2477.333
	27.48	34.155	2426.074	2448.593
	32.6	44.822	2501.63	2381.63
5%	24.62	23.266	2232	2328.889
	23.36	27.93	2220.741	2391.704
	26.35	23.93	2296	2360
10%	31.08	32.6	2307.556	2312.889
	26.2	29.04	2174.519	2389.63
	28.64	31.49	2262.222	2467.259





From the above graph, when density is 1890 (kg/m^3) compressive strength is 9.11 N/mm^2. By the increase of density compressive strength is also increasing.

Table 7:Results of split tensile strength (direct replacement)

Percentage of plastic	Split tensile strength (N/mm^2)	
	7 days	28 days
0%	6.71	12.88
	6.71	13.06
	6.69	12.851
5%	9.99	12.233
	12.25	12.237
	11.3	12.078
10%	9.43	9.692
	9.43	10.272
	9.71	9.997

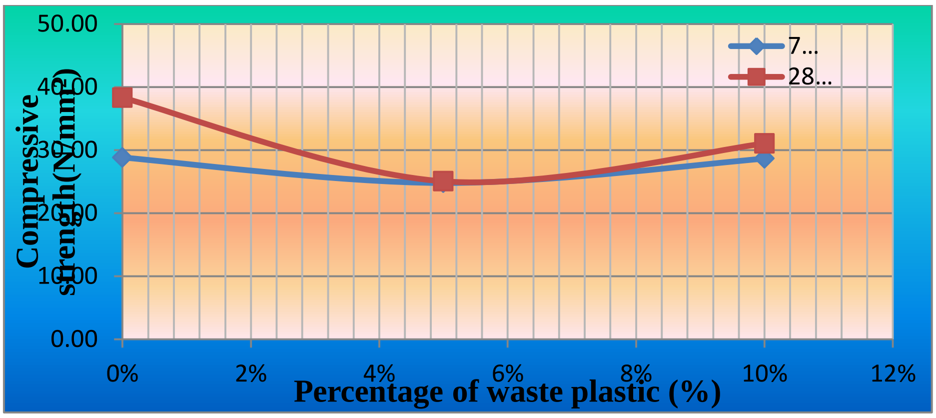


Fig 3:Graph between percentage of waste plastic and compressive strength

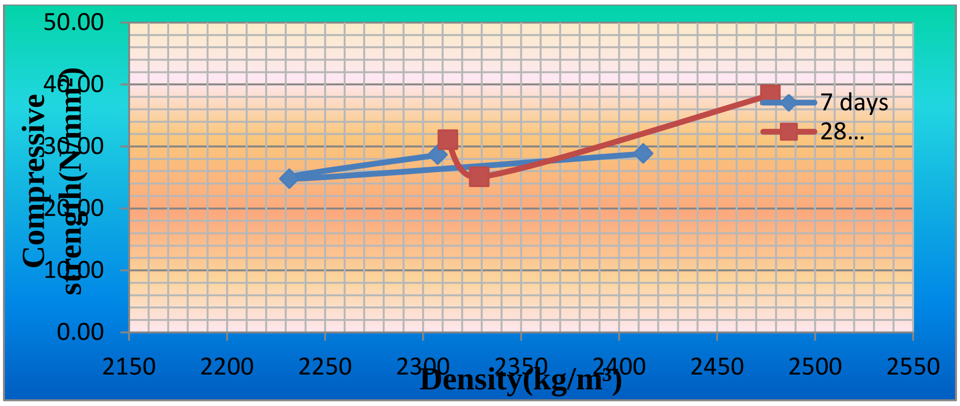


Fig 4: Graph between density and compressive strength

Percentage of plastic	Compressive strength (N/mm²)		Density (kg/m³)	
	7 days	28 days	7 days	28 days
0%	26.37	35.933	2412.444	2477.333
	27.48	34.155	2426.074	2448.593
	32.6	44.822	2501.63	2381.63
5%	24.62	23.266	2232	2328.889
	23.36	27.93	2220.741	2391.704
	26.35	23.93	2296	2360
10%	31.08	32.6	2307.556	2312.889
	26.2	29.04	2174.519	2389.63
	28.64	31.49	2262.222	2467.259

Table 8: Results of split tensile strength (direct replacement)

Percentage of plastic	Split tensile strength (N/mm²)	
	7 days	28 days
0%	6.71	12.88
	6.71	13.06
	6.69	12.851
5%	9.99	12.233
	12.25	12.237
	11.3	12.078
10%	9.43	9.692
	9.43	10.272
	9.71	9.997

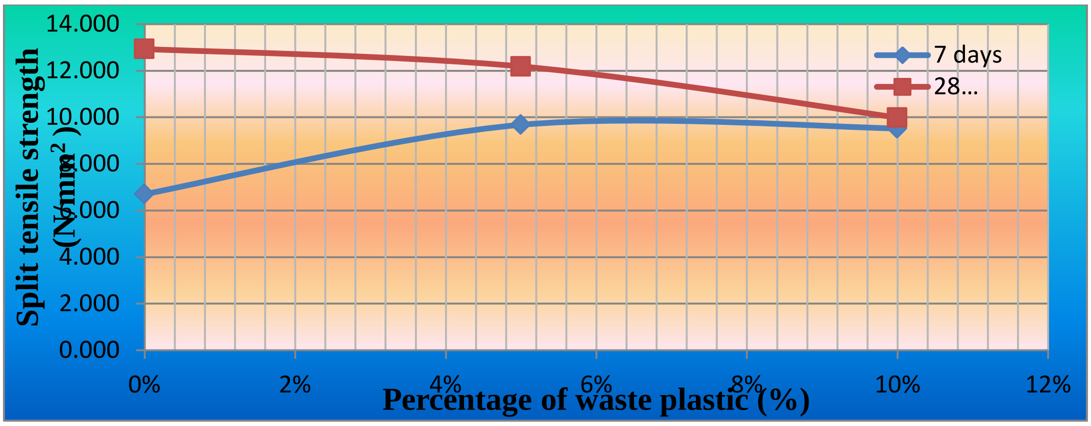
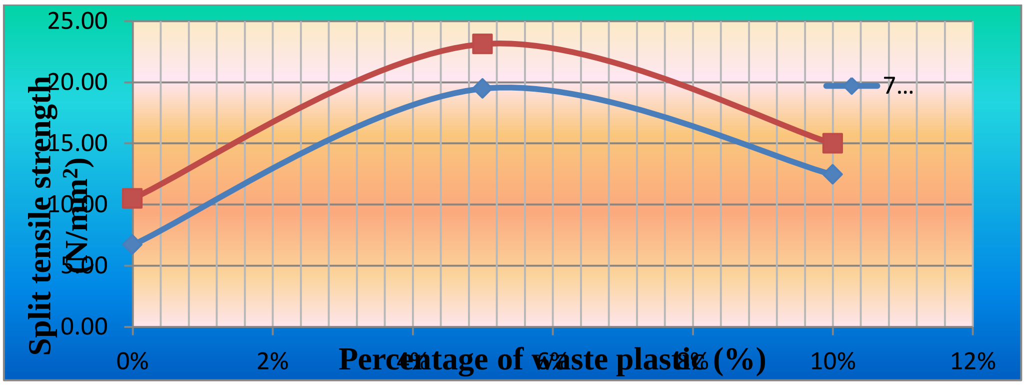


Table 9:Results of split tensile strength (melting)

Percentage of plastic	Split tensile strength (N/mm²)	
	7 days	28 days
0%	6.71	12.88
	6.71	13.06
	6.69	12.851
5%	9.99	12.233
	12.25	12.237
	11.3	12.078
10%	9.43	9.692
	9.43	10.272
	9.71	9.997



From the above a graph the split tensile strength at 0% of fine aggregates replaced with waste plastic by melting process is 10.5 N/mm^2. The split tensile strength is increasing for 5% of replacement of fine aggregates with waste plastic is increasing till 23.12 N/mm^2. At 10% of waste plastic replacement with fine aggregates the split tensile strength is decreasing till 15 N/mm^2. And the optimum waste plastic content that can be replaced with fine aggregates by melting process is 5% which gives compressive strength around 23.12 N/mm^2

Table 10: 7 day Results of split tensile strength (melting)

Percentage of waste plastic	Weight of cubes before testing (kg)	7 day split tensile strength	
		Split tensile strength (N/mm^2)	Average split tensile strength (N/mm^2)
0%	12.82	6.71	6.70
	12.925	6.71	
	13.06	6.69	
5%	12.325	19.04	19.48
	11.948	18.94	
	12.568	20.46	
10%	11.64	12.258	12.45
	11.61	12.54	
	11.781	12.54	

Table 11: 28 day Results of split tensile strength (melting)

Percentage of waste plastic	Weight of cubes before testing (kg)	28 day split tensile strength	
		Split tensile strength (N/mm^2)	Average split tensile strength (N/mm^2)
0%	12.88	10.05	10.50
	13.06	10.56	
	12.851	10.88	
5%	12.92	22.49	23.12
	12.814	23.7	
	12.635	23.18	
10%	12.143	14.24	14.99
	11.714	15.65	
	11.652	15.088	

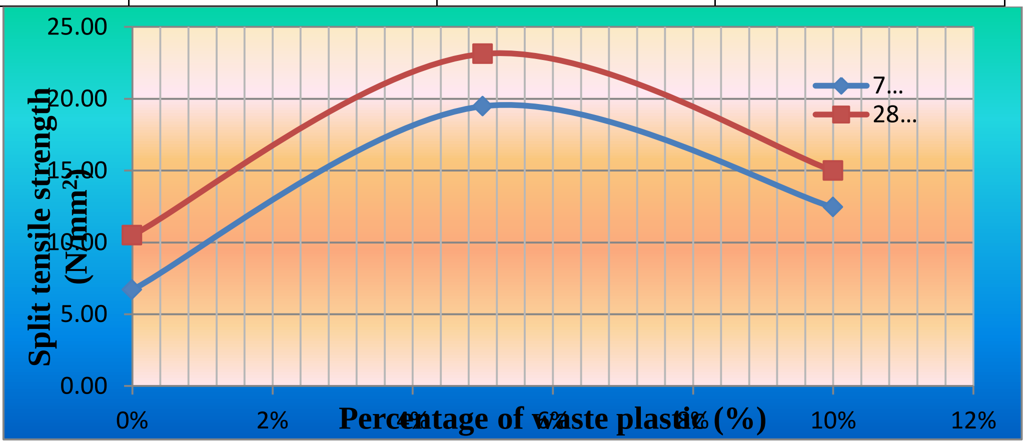


Fig 5: Graph between percentage of waste plastic and split tensile strength

Table 12:Results of flexural strength (control mix)

Control mix	max. load(KN)	max. load(KN)	Avg. (KN)	Flexural strength(N/mm²)
7 days	12.5	12.85	12.675	6.3375
28 days	19.35	18.65	19	9.5

Table 13:Results of flexural strength (5% melting)

5% melting	max. load(KN)	max. load(KN)	Avg. (KN)	Flexural strength(N/mm²)
7 days	14.8	15.65	15.225	7.6125
28 days	16.5	16.15	16.325	8.1625

Table 14:Results of flexural strength (5% direct replacement)

5% replacement	max. load(KN)	max. load(KN)	Avg. (KN)	Flexural strength(N/mm²)
7 days	12.4	15.25	13.825	6.9125
28 days	14.65	15.45	15.05	7.525

Table 15:Results of flexural strength (10% melting)

10% melting	max. load(KN)	max. load(KN)	Avg. (KN)	Flexural strength(N/mm²)
7 days	14.35	15	14.725	7.3625
28 days	16.85	18.1	17.475	8.7375

Table 16:Results of flexural strength (10% direct replacement)

10% replacement	max. load(KN)	max. load(KN)	Avg. (KN)	Flexural strength(N/mm²)
7 days	12.2	11.65	11.925	5.9625
28 days	12.25	11.9	12.075	6.0375

Table 17:Results of young's modulus (control mix)

Displacement (mm)	load 1 (KN)	load 2 (KN)	load 3 (KN)	avg. load (KN)	Average stress	Average strain

0	0	0	0	0.00	0.00	0
0.1	11.75	22.95	14.25	16.32	0.92	0.00033
0.2	14.35	38.65	18.2	23.73	1.34	0.00067
0.3	16.75	45.65	26.65	29.68	1.68	0.001
0.4	16.9	58.95	29.9	35.25	2.00	0.00133
0.5	17.15	64.5	35.6	39.08	2.21	0.00167
0.6	17.65	76.25	39.1	44.33	2.51	0.002
0.7	19.95	80.65	42.15	47.58	2.69	0.00233
0.8	21.9	96.25	46.85	55.00	3.11	0.00267
0.9	24.6	99.45	51.95	58.67	3.32	0.003
1	25.85	110.45	54.95	63.75	3.61	0.00333
1.1	29.05	117.05	62.35	69.48	3.93	0.00367
1.2	34.95	129.7	67.15	77.27	4.37	0.004
1.3	39.15	138.85	98.25	92.08	5.21	0.00433
1.4	43.25	149.65	68.95	87.28	4.94	0.00467
1.5	48.75	151.2	72.35	90.77	5.14	0.005
1.6	56.95	177.8	74.65	103.13	5.84	0.00533
1.7	67.35	181.15	80.35	109.62	6.20	0.00567
1.8	75.65	187.25	85.95	116.28	6.58	0.006
1.9	106.55	196.25	93.2	132.00	7.47	0.00633
2	108.3	215.3	99.5	141.03	7.98	0.00667
2.2	119.5	233.5	15.25	122.75	6.95	0.00733
2.4	130.95	246.1	180.25	185.77	10.51	0.008
2.6	167.45	248.55	187.25	201.08	11.38	0.00867
2.8	191.8	238.7	201.35	210.62	11.92	0.00933
3	211	230.5	228.65	223.38	12.64	0.01
3.2	229.6	224.8	218.25	224.22	12.69	0.01067
3.4	245.3	215.6	206.35	222.42	12.59	0.01133

Table 18:Results of all tests (direct replacement)

Percentage of plastic	**Compressive strength (N/mm^2)**	**Split tensile strength (N/mm^2)**	**Flexural strength(N/mm^2)**	**Modulus of elasticity**
0%	38.303	12.93	9.5	0.934
5%	13.192	12.18	7.525	0.934
10%	9.118	9.99	6.0375	0.965

Table 19:Results of all tests (melting)

Percentage of plastic	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)	Flexural strength(N/mm^2)	Modulus of elasticity
0%	38.03	10.5	9.5	0.934
5%	25.042	23.12	8.1625	0.879
10%	31.043	14.99	8.7375	0.979

CONCLUSION

From the above experimental it is concluded the following results

1) From the above results and comparison it can be seen clearly that the compressive strength of concrete with 5% and 10% replacement of plastic with sand which is direct replaced is reducing to some extent. So from this comparison we can conclude that the compressive strength of the concrete decreasing by direct replacement of plastic in concrete.
2) From graph 4.2 it can be observed that the compressive strength of concrete with 5% plastic which is added by melting process is decreasing till some point which is not too much when compared to 0% and compressive strength of concrete with 10% plastic which is added by melting process is again increasing when compared to 5%, by this it can be concluded that 10% of replacement of plastic by melting process holds good for compressive strength.
3) From the above graph for split tensile strength by direct replacement of plastic to concrete, it can be seen that the split tensile strength of concrete is decreasing by addition of plastic. From split tensile strength of concrete by replacing plastic by melting process, the strength is increased for 5% of plastic replacement and decreasing for 10% replacement.
4) Modulus of elasticity is increasing with the increase of plastic when compared with normal concrete. And also the results show that the melting process is effective compared to direct replacement process.
5) From above results of flexural strength, the strength concrete with plastic is slightly less compared to normal concrete and also the flexural strength of concrete with plastic replaced by melting process is more compared to direct replacement process. The flexural strength is increasing with increase of plastic from 5%.
6) Taking all parameters in consideration it can be concluded that the concrete with 10% of fine aggregates replacement with plastic by melting process gives satisfactory results which holds good for cement concrete pavements.

REFERENCE

[1] Ganesh Tapkire,Satish parihar,Pramod Patil,Hemraj R Kumavat," Recycled plastic used in concrete paver block," International Journal of Research in Engineering and Technology Volume: 03 Special Issue:09 June 2014.

[2] Nitish Puri, Brijesh Kumar, Himanshu Tyagi," Utilization of Recycled Wastes as Ingredients in Concrete Mix," International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278- 3075, Volume-2, Issue-2, January 2013

[3] R.Lakshmi, S. Nagan, "Utilization of waste E plastic particles in cementitious mixtures" Journal of Structural Engineering,Vol.38, No. 1, April – May 2011, pp. 26-35

[4] FV Khilesh sarwe "Study of strength property of concrete using waste plastics",The International Journal Of Engineering And Science (IJES)-Volume-3-Issue-5-Pages-(09/11/2014)

[5] Adnan Flayih Hassan Al-Sibahy, "Thermo-mechanical behaviour of a novel lightweight concrete and its application in masonry walls," 2012 Doctor of Philosophy, The University of Manchester.

[6] Gurpreet singh, A thesis on "strength and durability studies of concrete containing waste foundry sand," Thapar university.

[7] Ali J. Hamad, "Materials, Production, Properties and Application of Aerated Lightweight Concrete" International Journal of Materials Science and Engineering Vol. 2, No. 2, December 2014.