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EXPERIMENTAL STUDY OF LIGHT WEIGHT CONCRETE MANUFACTURE USING RECYCLE WASTE PLASTIC AGGREGATE, FLY ASH & SILICA FUMES - PART-1

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Abstract
In the manufacture of lightweight concrete it is necessarily very important to know the optimum dosage of substitute of natural resources and cementitious material and mineral admixture. Every material has their unique property so in this research paper review plastic aggregate (coarse and fine) being used as substitute of natural aggregate partially and also fly ash, silica fuels, GGBS being used as SCM (Substitute of Cementitious Material), their dosage and effect on fresh and hardened properties of fiber reinforced cement concrete. The result of this study showed that great and considerable findings are quality strength and workability when use of optimum dosage. This study will help to figure out the optimum dosage of material to be used to get satisfactory and quality results. Major findings of this research paper are satisfactory. Based on the results of the various trials, it can be concluded that 10% SF, 25% FA, and 0–20% plastic waste have the highest strength and structural stability. When 0%–20% of plastic waste is replaced with coarse aggregate, the split tensile strength of concrete improves by up to 12%–15% when compared to conventional concrete. Concrete's compressive and flexural strengths degrade. The weight of design mix concrete with compared to nominal concrete is 20-30% lighter. M25 nominal concrete cube weight was between 9 - 9.3 kg and DM M25 was 8.3 - 8.5 kg with 10% of replacement, 8-8.3 kg with 20% replacement, 7.4-7.7 kg with 30% replacement. It shows decrement in weight as we wanted. Observed while adding the plastics above 20% the concrete lose the compressive strength suddenly. Reducing use of natural resources, waste disposal, pollution prevention, and energy conservation. For mass concreting purpose, the cost of construction will reduce gradually or M25, M45 and M70 respectively

Keywords: Plastic Aggregate (coarse), fly ash, silica fumes, Optimum dosage, mineral admixture.

1. Introduction

We began using cement concrete after Sir Joseph Aspdin invented cement. Since 1824, many concrete mixtures have been created, each with its own set of properties. Concrete consumption is increasing rapidly as infrastructure development accelerates. Certain problems have been observed in conventional concrete, such as heavy weight, lower durability, lower resistance to chemical attack, and a shorter design life. FRCC entered the picture to improve these concrete properties or to improve concrete performance.

Every year, the concrete industries require thousands of tonnes of aggregates., including gravel and sand found naturally. In recent years, the trend of using recycled aggregates in order to manufacture lightweight concrete and conserve natural resources has been increasing. Admixtures are added for improvement properties and quality of concrete such as strength and durability etc. There are various materials available as a substitute for cement like GGBS, fly ash, silica fume, rice husk, etc. However materials like silica fume, GGBS, fly ash are the most common cement spare material that is used for improvement strength parameters of concrete. Each material has unique characteristics and properties they will affect or make a big effect both on concrete in different ways. Many researchers have done experimental study or investigation to find out the optimum dosage of artificial aggregate and mineral admixture to get best results. Because of the use of artificial aggregate or mineral admixture excessively or less than optimum dosage shown bad results as

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reduction of strength, concrete workability and other factors also affected. In this paper we compare and summarize the optimum dosage according to independent findings.

2. Literature

Ashraf M. Ghaly et al. (2003) has done experimental study on basic mechanical properties such as the compression and deformation behavior of utilized plastics in concrete. In the study they have made a total 198 concrete cube by replacing coarse aggregate with plastic aggregate by its mass from 5%, 10% and 15%. After performing various tests on the cube while curing it from 1, 7, 17, 21 and 28 days they found in measurement a high degree of deformability compared to normal concrete. Also, adding plastic aggregate leads lower the compressive strength, while also demonstrating the ability to deform before failure and lowering the unit weight of concrete.

Yun Wand Choi et al. (2004) investigated the effects of plastic bottle waste on concrete characteristics. In the study of effect they have replaced the fine aggregate by WPLA by 0, 25, 50 and 75% by its volume. WPLA was made from pet bottles and GBFS. Compressive strength, splitting tensile strength, elastic modulus, slump, and density tests were performed on specimens using lightweight aggregate concrete (WPLAC). The final results demonstrate that as the exchange ratio rises, WPLAC's structural efficiency declines. Additionally, it was discovered that workability improved with increased replacement rates and water-cement ratios and that the surface of the aggregate can be strengthened by adhering GBFS to the surface of WPLA.

Zainab Z. Ismail et al. (2007) conducted experimental study of use Plastic waste in concrete mixes as an aggregate substitute in the study they partly replaced sand (fine aggregate) by 0, 10, 15 and 20% in 800 kg concrete mixture during study they has 86 experiments and 254 tests on specimens which includes 70 cubes and 54 prisms to determine the efficiency of concrete. various test they they perform includes slump, compressive strength, flexural strength toughness index, fresh density and dry density, at cure times of 3, 7, 14 and 28 days at the end of study they conclude that the compressive strength, flexural strength, fresh density decreases and dry density value also decreases where the minimum dry density is greater than the dry density range of lightweight structural concrete at 28 days of curing age.

S.C. Kou et al. (2008) Carried out the investigation of the property of PVC-granule-prepared concrete made from discarded PVC pipes. In the investigation they prepared specimen made of recycle plastic used from scrap PVC pipe as a fine aggregate by partial replace of river sand to it volume of 0% 15% 30% and 45%. Various laboratory tests on specimens performed and find out when they are replaced partially it shows more ductile, shrinkage and increased resistance to chloride ion penetration, but the compressive strength and splitting strength of concrete were lowered when sand was replaced.

Kinda Hannawi et al. (2010) Have done experiment to study the property physically and mechanically of motor contain waste PET and PC aggregate in this experiment they have replaced natural aggregate and sand as per volume by 3%, 10%, 20% and 50% they perform various test on specimen after curing it for 7 to 28 days they found results that the viability of utilizing PC and PET waste aggregate as a partial alternative for natural aggregates, notwithstanding some disadvantages such as compressive strength, specific weight decreases also flexural toughness increases significantly with volume up PC and PET aggregate also gives good energy absorbing materials which can be used some structures more effectively and dynamically.

Feng Lui et al. (2014) have done experimental investigation on concrete made with recycled plastic under static and impact load. In the experiment they have replaced the fine aggregate with sand value in volume by 5, 10, 15, 20% respectively. The results of the tests revealed that the value of several strength criteria grew and declined when the plastic component was replaced. The results of the experiment show that as the volume of plastic content increases, the density, cube strength, cylindrical compressive strength, and elastic modulus all decrease, and proportionally, the ultimate strain of RPC under static load increases, energy absorption rises, and dynamic compressive strength falls.

Awham Mohammed Hameeda et al. (2019) Researcher carried out experimental study on employment of Plastic waste in order to create lightweight concrete. The researchers used RPA, or recycled plastic aggregate, is a different kind of aggregate. The qualities of concrete built with recycled polyethylene terephthalate (PET) aggregate are the subject of the first experimental investigation presented in this publication. Five different batches were produced with different PET 1 wt%, 3 wt%, 5 wt%, 7 wt%, and 10 wt% of the contents. Researchers perform various tests to find out after splitting and hardening the density of each batch, the impact of RPA content on tensile strength, flexural strength, and compressive strength. Results showed that the use of PT at 1% resulted in a 58% increase in compressive strength compared to other batches. Flexural strength increases 1% and 3% (value 23.11% and 25.59%). The density decreases when PET content increases.

M. Tamil Selvi et al. (2021) Researcher explore the mechanical property on lightweight aggregate concrete using high density polyethylene granules. Researchers partially replace the coraes aggregate by high density polyethylene in granular form (HDPE). They prepared 5 different mixes by replacing 1-5% of coares aggregate made using m30 grade of concrete. Several tests are performed to know the characteristics of m30 class concrete, such as bulk strength, tensile strength, splitting strength, and compressive strength. They found that the value of the above-mentioned properties increased, then partially replaced coarse aggregate from 1-3% and decreased from 4-5%.

3. Objective of Study

•To investigate the properties of fiber reinforcement cement concrete, including its advantages and limitations, as well as the mix design of FRCC.
•The effects of partial cement replacement with industrial waste on strength parameters.
•Inclusion of recycled plastic waste and investigation of its effects on strength parameters.
•Determine the best mineral admixture dosage and recycle plastic waste dosage as aggregate.
•To investigate FRCC behavior under cyclic loading.
•To define a common point curve under cyclic loading.
•Determine the stability point curve under cyclic loading.

4. Experimental Programme

4.1 Material Used

4.1.1 Cement

In this program, ordinary Portland cement of Ultratech grade 53 complying with IS 12269: 1987 was used, and physical properties were tested in accordance with Indian standard specifications.

Table 4.1 Properties of Cement

Physical Properties		Test values
Standard consistency (%)		30
Setting Time(minutes)	**Initial**	145
	Final	205
Compressive strength (Mpa)	**3 Day**	25.60
	7 Day	41.57
	28 Day	53.33
Specific Gravity		3.1

4.1.2 Fine Aggregate

As fine aggregate, locally accessible natural river sand and manufactured sand are used. Their physical characteristics are tested in accordance with Indian standard specifications, and gradation is carried out in accordance with IS 383: 2016.

Table 4.2 Physical Properties of Fine Aggregate

Physical Properties		Test Results
Fineness modulus		**3.37**
Specific gravity	River Sand	2.59
	M- Sand	2.60
Water absorption (%)	River Sand	1.49
	M- Sand	1.89

4.1.3 Coarse Aggregate

A coarse aggregate mixture consisting of 40% size 20 mm and 60% size 10 mm is used. The loose and rodded densities of aggregate are used to determine the size ratio. Several trials with 20 mm and 10 mm aggregate at various fractions were conducted to achieve the maximum packing density of coarse aggregate.

Table 4.3 Properties of Coarse Aggregate

Physical Properties	Observed Values
Specific Gravity	2.74
Bulk Density (Loose), kg/m^3	1539
Bulk Density (compacted), kg/m^3	1780
Water absorption	0.5 %
Fineness modulus	3.09

4.1.4 Recycle Waste Plastic Aggregate

A recycle waste plastic aggregate mixture consisting of 40% size 12-20 mm and 60% size 6-10 mm is used. The loose and rodded densities of RWPA are used to determine the size ratio. Several trials with 15-20 mm and 8-10 mm aggregate at various fractions were conducted to achieve the maximum packing density of coarse aggregate.

Table 4.4 Properties of Recycle Waste Plastic Aggregate (HDPE)

Physical Properties	Observed Values
Specific Gravity	**2.62**
Bulk Density kg/m^3	**930 - 970**
Water absorption	**0.01 %**
Fineness modulus	**0.32**

Table 4.5 Properties of Recycle Waste Plastic Aggregate (PET)

Physical Properties	Observed Values
Specific Gravity	**1.297**
Bulk Density kg/m^3	**280 - 320**
Water absorption	**0.2 %**
Fineness modulus	**0.32**

Industrial Engineering Journal
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4.2 Mix Proporion

In the table below various mix proportion has been shown. The first mix represent the control mix (CM), while the Mix represent design mix that contain Silica Fumes, Fly Ash, & Recycle Plastic Aggregate. The percentage of DA is varied from 0-100%.

Table 4.6 Proportion of Materials in Mix Design M25 Grade

Nomenclature	Cement (Kg/m^3)	Fine Aggre-gate (Kg/m^3)	Coarse Aggre-gate (Kg/m^3)	Water (Kg/m^3)	Fly Ash (Kg/m^3)	Silica Fume (Kg/m^3)	PWA (Kg/m^3)
Mix 1 Controlled Nominal Mix	448.25	713.44	1127.78	197.3	0	0	0
Mix 2 FA 20%	358.94	713.44	1127.78	197.3	89.73	0	0
Mix 3 FA 25%	336.50	713.44	1127.78	197.3	112.17	0	0
Mix 4 FA 30%	314.069	713.44	1127.78	197.3	134.60	0	0
Mix 5 FA 35%	291.64	713.44	1127.78	197.3	157	0	0
Mix 6 FA25 + SF05	319.67	713.44	1127.78	197.3	112.17	16.8	0
Mix 7 FA25 + SF10	302.85	713.44	1127.78	197.3	112.17	33.65	0
Mix 8 FA25 + SF15	285.6	713.44	1127.78	197.3	112.17	50.4	0
Mix 9 FA25 + SF10 + RPA10%	302.85	713.44	1015	197.3	112.17	33.65	112.78
Mix 10 FA25 + SF10 + RPA20%	302.85	713.44	902.224	197.3	112.17	33.65	225.56
Mix 11 FA25 + SF10 + RPA30%	302.85	713.44	789.45	197.3	112.17	33.65	338.334
Mix 12 FA25 + SF10 + RPA40%	302.85	713.44	676.67	197.3	112.17	33.65	451.11
Mix 13 FA25 + SF10 + RPA50%	302.85	713.44	563.89	197.3	112.17	33.65	563.89
Mix 14 FA25 + SF10 + RPA60%	302.85	713.44	451.11	197.3	112.17	33.65	676.67
Mix 15 FA25 + SF10 + RPA75%	302.85	713.44	281.95	197.3	112.17	33.65	845.84
Mix 16 FA25 + SF10 + RPA100%	302.85	713.44	0	197.3	112.17	33.65	1127.78

5. Result and Discussion

5.1 Compressive Strength test

For the compressive strength test and determine the dosage of fly ash, silica fumes and recycle waste plastic aggregate the specimen of size 150mm x150mm x 150mm is casted and tested using compressive testing machine. We get best results on 25% replacement of fly ash, 10% replacement of SF and 20% replacement of RWPA.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, No. 1, July : 2023

Table 5.1 Compressive Strength of Cubes for optimum dosage of FA

Fly Ash	7 Days Strength (Mpa)	28 Days Strength (Mpa)
20%	16.1	21.7
25%	16.75	23.6
30%	12.5	22.3
35%	10	19.2

Table 5.2 Compressive Strength of Cubes for optimum dosage of SF

Fly Ash 25% + SF	7 Days Strength (Mpa)	28 Days Strength (Mpa)
5%	13.7	20.9
10%	16.9	22.4
15%	15.1	21.1

Table 5.3 Compressive Strength of Cubes for optimum dosage of RWPA

RWPA (%)	Cube compressive strength (Mpa) M25		Cube compressive strength (Mpa) M45		Cube compressive strength (Mpa) M70	
Days	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
Nominal	26.53	31.69	34.43	47.65	48.95	73.72
10	23.41	28.73	32.06	45.72	46.80	70.93
20	24.57	29.01	32.53	46.78	47.16	72.78
30	20.65	24.58	31.40	44.30	42.25	65.23
40	15.34	21.48	28.92	43.68	38.67	60.55
50	13.55	20.63	26.38	39.11	35.99	50.66
60	10.48	15.72	15.55	27.82	20.09	21.44
75	9.63	11.69	11.10	15.47	12.93	13.59
100	5.71	7.26	7.30	9.84	10.63	10.05

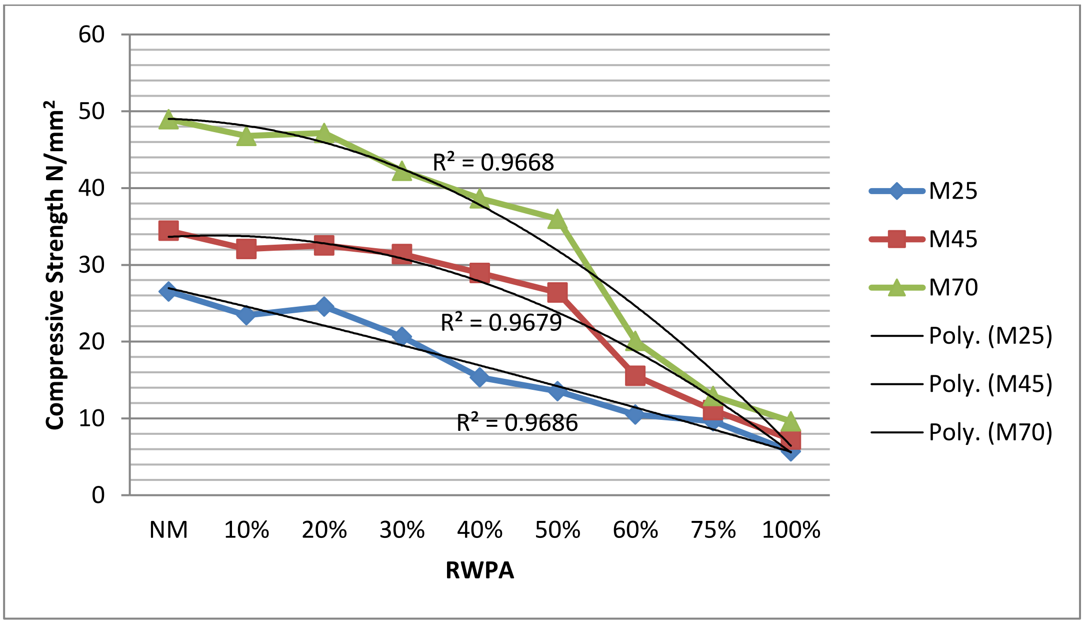

Figure 5.1: Optimum dosage curve for RWPA 7 Days

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Volume : 52, Issue 7, No. 1, July : 2023

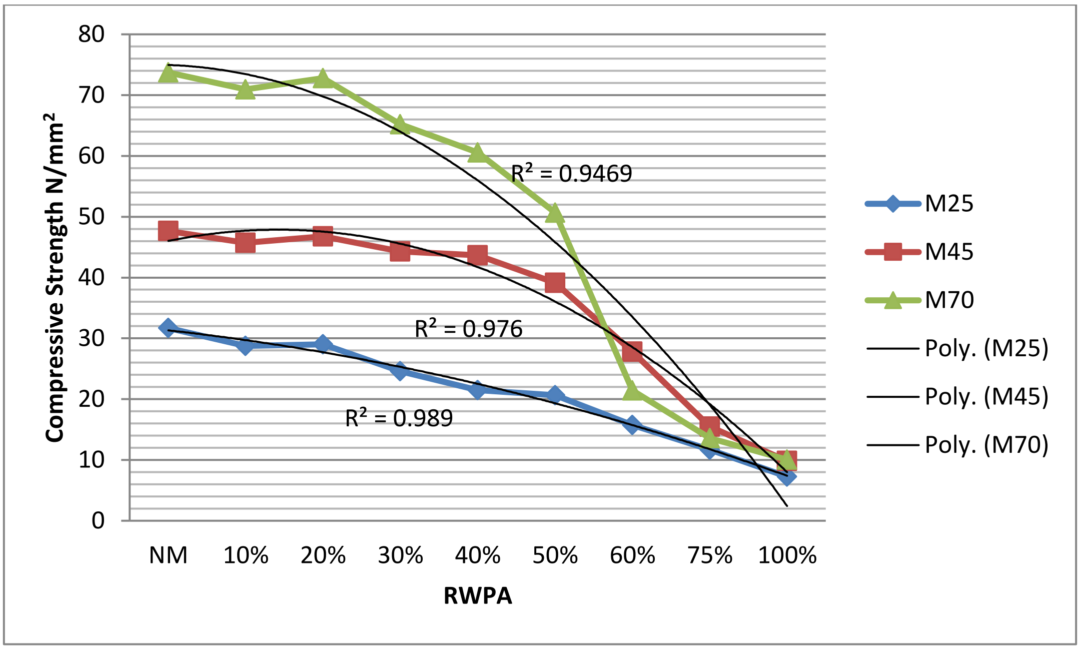

Figure 5.2: Optimum dosage curve for RWPA 28 Days

5.2 Split Tensile test

For the compressive strength test of pervious concrete, the specimen of size 150mm x150mm x 150mm is casted and tested using compressive testing machine.

Table 5.4 Split tensile strength test results

Grade	7 days tensile strength (Mpa)	28 days tensile strength (Mpa)
N-M25	2.89	3.89
DM-M25	3.04	3.98
N-M45	3.63	4.91
DM-M45	3.94	4.94
N-M70	6.21	7.01
DM-M70	6.31	7.05

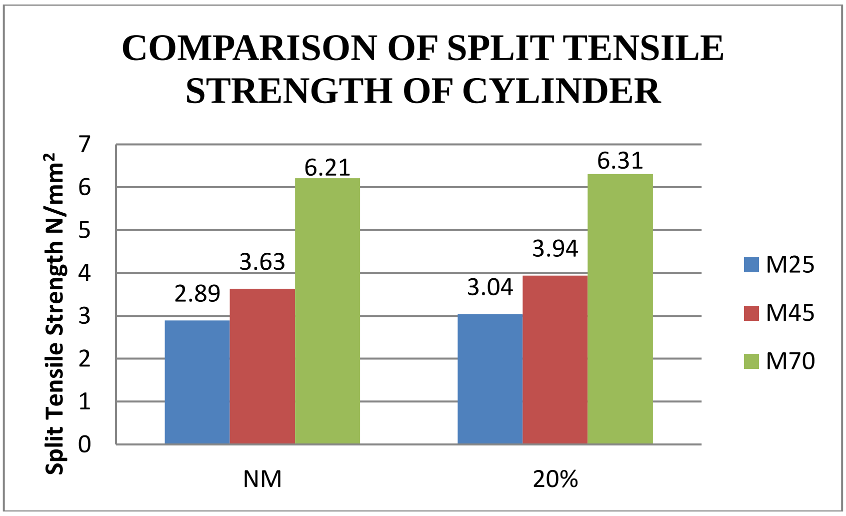

Figure 5.3: Split Tensile Strength of Cylinder After 7days

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Volume : 52, Issue 7, No. 1, July : 2023

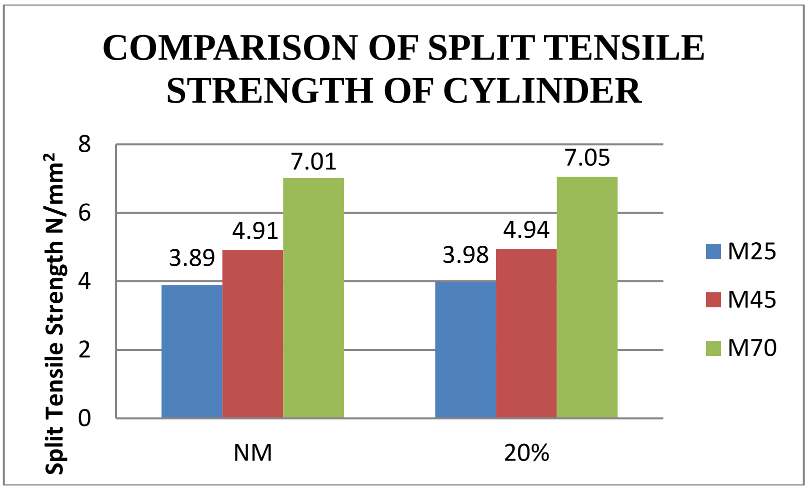

Figure 5.4: Split Tensile Strength of Cylinder After 28days

5.3 Weight Analysis

The self weight of the concrete is too low compare to conventional concrete. below table shows weight of cube according to replacement percentage.

Table 5.5 List of weight of cubes

NOMENCLATURE	M25 KG	M45 KG	M70 KG
Controlled Nominal Mix	9.03	9.33	9.357
FA25 + SF10 + RPA10%	8.52	8.71	8.30
FA25 + SF10 + RPA20%	8.29	8.446	8.24
FA25 + SF10 + RPA30%	7.60	7.56	7.62
FA25 + SF10 + RPA40%	7.46	7.38	7.58
FA25 + SF10 + RPA50%	7.36	7.27	7.45
FA25 + SF10 + RPA60%	7.16	7.03	7.23
FA25 + SF10 + RPA75%	5.49	5.74	5.84
FA25 + SF10 + RPA100%	3.82	3.94	4.2

6. Conclusion

Within the limitation of the present work following conclusions

a. Based on the results of the various trials, it can be concluded that 10% SF, 25% FA, and 20% plastic waste have the highest strength and structural stability.
b. When 0%–20% of plastic waste is replaced with coarse aggregate, the split tensile strength of concrete improves by up to 12%–15% when compared to conventional concrete.
c. The weight of DM concrete compared to nominal concrete is 20-30% lighter. M25 nominal concrete cube weight was between 9.0 - 9.3 kg and DM M25 was 8.3 - 8.5 kg with 10% of replacement, 8-8.3 kg with 20% replacement, 7.4-7.7 kg with 30% replacement. It shows decrease in weight as we wanted.
d. The strength of the concrete such as compressive and tensile is increased up to 12%-15%.
e. Study shows that increase in percentage of mineral admixtures adversely affects the workability hence, superplasticizer demand increases.
f. While adding the plastics above 20% the concrete loses the compressive strength suddenly.
g. Above results show that, if we go for mass concreting, the cost of construction reduces gradually to M25, M45 and M70 respectively.

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