An Experimental Investigation on Concrete Using Recycled Plastic as a Partial Replacement for Fine Aggregate and Nanosilica as a Partial Replacement for Cement

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ABSTRACT

Concrete, as a constructive material, has been used in construction industry for about two centuries. Approximately, the whole bulk of the concrete is used in one year is more than one ton apiece. Therefore, doing research about using modern technologies in production concrete is of great importance. Furthermore, one of the most critical problems of the world has been related to remove the wastage and reusing of it. Reducing the necessary amount of Portland cement without reducing the performance of concrete is significant for big projects that require a large amount of cement. Furthermore, Portland cement clinker production consumes large amounts of energy and has a notable environmental impact, which involves massive quarrying for raw materials. Waste material recycling through using in concrete manufacturing not only provides a promising resource to produce a high-quality concrete, but also helps to properly encounter the problem of waste disposal. A large bulk of ceramic tiles change into wastage, these waste materials are not reusable and recyclable due to their physical and chemical structure. Given the high amount of concrete production and the possibility of wastage materials in them, using ceramic wastage could be an effective measure in maintaining the environment and improving the properties of concrete. The present experimental study deal with the investigation of possibility of using plastic in concrete as fine aggregate replacement upto 25% with 5% fixed proportion along with nano silica as cement replacement of 0, 4 and 8% respectively of M20 & M30 grade of concrete Besides, all other parameters are constant. Finally, the slump value, compressive strength of the concrete for the samples were calculated.

I. INTRODUCTION

Portland cement clinker production consumes large amounts of energy and has a notable environmental impact, which involves massive quarrying for raw materials because it 1.7 tons are required to produce 1 ton of clinker and the emission of greenhouse and other gases into the atmosphere. Approximately 850 kg of CO2 is emitted per ton of clinker produced. Hence, pozzolan and cementitious materials play an important role in concrete production. In recent years, the disposal of waste materials has presented a complex problem for many agencies worldwide, and industries must find ways to reuse their wastes. The replacement of cement in concrete by wastes represents a tremendous saving of energy and has important environmental benefits. In addition, it will also have a major effect on decreasing concrete costs because the cost of cement represents more than 45% of the cost of concrete. According to some authors, the best way for the construction industry to become more sustainable is by using wastes from other industries as building materials. Ceramic wastes, which are durable, hard and highly resistant to biological, chemical and physical degradation forces, cannot be recycled by any existing process. The use of inorganic industrial residual products in the production of concrete will lead to sustainable concrete design and a greener environment. The amount of waste in the different production stages of the ceramic industry ranges from 3% to 7% of daily production.

A number of previous studies have examined the use of waste ceramic in concrete as an aggregate replacement or partial cement replacement, such as pozzolan. Lavat et al. observed a decline in strength at early ages. Ay and -nal confirmed the pozzolanic reactivity of waste ceramic powder, and Toledo Filho et al. measured a slight increase in compressive strength for cement replacement by brick powder of up to 10–20%. Torgal and Jalali reported a slight decrease in compressive strength and a decline in water permeability and chloride ion diffusion in concrete with 20% of ground ceramics used as Portland cement replacement. On the other hand, Nanotechnology is one of the most important sciences where many researchers studied its effect. Nanotechnology plays an important role in clean up the environment. Ferdinand Brandl and Nicolas Bertrand demonstrated a method for using nanoparticles and ultraviolet (UV) light to quickly isolate and extract a variety of contaminants from soil and water.

In recent years, nanoscale zero valent iron (nZVI), carbon nanotubes and nano fibers were applied for the remediation of a variety of contaminants including chlorinated compounds, hydrocarbons, organic compounds and heavy metals. Nanowaste materials consumed in concrete production is a valuable issue in clean-up the environment.

OBJECTIVES

The most important objectives of this study are

Fine aggregate with plastic waste 25% with 5% fixed proportion along with nano silica as cement replacement of 0, 2, 4 6, 8% respectively of M20 & M30 grade of concrete

1) To study the relative strength development with age of Nano silica concrete with control concrete.

2) To study the comparative strength development with age of (Nano silica) concrete, with control concrete along with coarse aggregate replacement with ceramic tiles.

4) Use of industrialized waste in a positive way.

5) To conduct compression test on (Nano silica) and ceramic waste with ordinary concrete on standard IS specimen size

6) To protect the environment by utilizing waste properly

8) Increment in strength with very less cost of materials

EXPERIMENTAL PROGRAM

This investigation focuses on the following pattern of work

- Nano-Silica are used as partial replacement of cement and fine aggregate as coarse aggregate replacement.
- In the present experimental investigation, the cement in volume by nano silica and fine aggregate by plastic waste of M20 & M30 grade of concrete
- Curing was done at the ages of 7,28 and 56 days were tested i.e., compression and split tensile strength

II. LITERATURE REVIEW

- Sreenath & Harishankar, (2017) stated that replacing sand by LDPP with 10% increasing of compressive strength from 34.96N/mm2 to 38.957N/mm2. Ramadevi & Manju, (2012) reported that replacing 2% of sand by PET fibres has increase the compressive strength but more than 2% the strength start decrease.
- Aravind & John, (2015) determined that with replace any percentage fine aggregates by plastic fines decrease the compressive strength at 28days.
- Arivalagan.S, (2016) found that replacing 10% of PET waste plastic as sand in concrete, the compressive strength is increased by 26% compare to control sample but replace more than 15% the compressive strength less than control sample.Guendouz et al., (2016) determined that at replacement 20% of sand by using LDPE powder increase 30% of compressive strength as concrete have more ductile tolerant.
- Ghernouti et al., (2009) has determinedthe bulk density of the concrete cube at 28days. It shown that if containing higher plastic waste the density will be lower so, with containing 40% of the plastic waste is lighter than the others as the plastic waste lighter 70% than the sand. Suganthy etal., (2013) carried out that replacing percentage of sand by plastic, the cube weight decrease and seen like the linear with replacement of sand by plastic. Guendouz et al., (2016) reported that replace 40% of the sand by using LDPE powder decrease 10% of bulk density of the concrete at 28days.
- Sreenath & Harishankar, (2017) stated that replacing 10% sand by LDPP has increasing to the control sample. (Ramadevi & Manju, 2012) reported that with replacing 2% of sand by PET fibres increasing the split tensile strength but when replacing more than 2% started decrease. Jaffe et al., (2015) determined that replacement 20% of fine aggregates by plastic increased splitting tensile strength compare to control sample but after replace more than 30% startdecrease. Aravind & John, (2015) shown that replace 5% of fine aggregates by plastic fines more higher than control sample but more than 10% much lower than control sample.
- Amalu et al.,(2016) shown that with increasing ratio of waste plastic, the flexural strength will decrease. By replacing 25% of sand by plastic has lowest value flexural strength at 28days. Sreenath & Harishankar, (2017) reported that replacing 10% sand by LDPP, the flexural strength has increasing but replacing from 10% to 20% has decreasing.

III. MATERIALS AND METHODOLOGY

Materials:

- Cement
- Fine aggregate (sand)
- Coarse aggregate
- Water
- Nano silica
- Recycled plastic waste

CEMENT

The most widely recognized bond utilized is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 review (OPC) fitting in with IS: 8112-1989 is utilized. A bond is a fastener, a substance utilized as a part of development that sets, solidifies and clings to different materials, restricting them together. Bond is only sometimes utilized exclusively, however is utilized to tie sand and rock (total) together.

FINE AGGREGATE

Fine aggregate are fundamentally sands won from the land or the marine condition. Fine aggregates by and large comprise of regular sand or pulverized stone with most particles going through a sifter. Likewise with coarse aggregates these can be from Primary, Secondary or Recycled sources. The choice of fine aggregate is likewise on imperative factor as it straightforwardly influences the quality of cement with the shifting usage of water. Fine aggregate with unforgiving surface requires high measure of water, so fine aggregate with smooth surface and adjusted shape is being utilized as it requires low measure of water and consequently delivers high quality cement

COARSE AGGREGATE

Coarse aggregates are particles more noteworthy than 4.75mm, however for the most part extend between 9.5mm to 37.5mm in width. They can either be from Primary, Secondary or Recycled sources. Essential, or 'virgin', aggregates are either Land-or Marine-Won. Rock is a coarse marine-won aggregate; arrive won coarse aggregates incorporate rock and squashed shake.

RICE HUSK

Rice husk is a potential material, which is amenable for value addition. The usage of rice husk either in its raw form or in ash form is many. Most of the husk from the milling is either burnt or dumped as waste

Recycled Plastic waste:

Polyethylene terephthalate (PET) bottles were used. The waste PET bottles have a thickness of 1–1.5 mm. The bottles were washed to remove the impurities, and then blade mill was used to grind the plastic to the size of 4–0.075 mm, the PET waste after crushing and shredding. Uncrushed natural sand was used in this study. Properties of sand as long as coarse aggregate and PET.

Nano SiO2

The average size of nano silica was found to be 236 nm from Particle Size Analyzer, the report of which has been presented in the Appendix. The properties of the material, the nano silica used in the experiment. Nanotechnology is widely regarded as one of the twenty-first century's key technologies, and its economic importance is sharply on the rise. In the construction industry, nanomaterials has potentials that are already usable today, especially the functional characteristics such as increased tensile strength, self-cleaning capacity, fire resistance, and additives based on nano materials make common materials lighter, more permeable, and more resistant to wear

Quantity of materials in kg / m^3 of concrete @ M20

Mix	Nano Silica % of cement	Replacement of Recycled plastic Waste Replacement		Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (lit/m^3)
CC	0%	0%	0	360	584	1223.8	180.42
		5%	29.2	360	554.6	1223.8	180.42
		10%	58.4	360	525.6	1223.8	180.42
		15%	87.6	360	496.4	1223.8	180.42
		20%	116.8	360	467.2	1223.8	180.42
		25%	146	360	438	1223.8	180.42
Mix-1	4%	0%	0	360	584	1223.8	180.42
		5%	29.2	360	554.6	1223.8	180.42
		10%	58.4	360	525.6	1223.8	180.42
		15%	87.6	360	496.4	1223.8	180.42
		20%	116.8	360	467.2	1223.8	180.42
		25%	146	360	438	1223.8	180.42
Mix-2	8%	0%	0	360	584	1223.8	180.42
		5%	29.2	360	554.6	1223.8	180.42
		10%	58.4	360	525.6	1223.8	180.42
		15%	87.6	360	496.4	1223.8	180.42
		20%	116.8	360	467.2	1223.8	180.42
		25%	146	360	438	1223.8	180.42

Quantity of materials in kg / m^3 of concrete @ M30

Mix	Nano Silica % of cement	Replacement of Recycled plastic Waste Replacement		Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (lit/m^3)
CC	0%	0%	0	394	732	1139	197
		5%	36.6	394	695.4	1139	197
		10%	73.2	394	658.8	1139	197
		15%	109.8	394	622.2	1139	197
		20%	146.4	394	585.6	1139	197
		25%	183	394	549	1139	197
Mix-1	4%	0%	0	394	732	1139	197
		5%	36.6	394	695.4	1139	197
		10%	73.2	394	658.8	1139	197
		15%	109.8	394	622.2	1139	197
		20%	146.4	394	585.6	1139	197
		25%	183	394	549	1139	197
Mix-2	8%	0%	0	394	732	1139	197
		5%	36.6	394	695.4	1139	197
		10%	73.2	394	658.8	1139	197
		15%	109.8	394	622.2	1139	197
		20%	146.4	394	585.6	1139	197
		25%	183	394	549	1139	197

VI EXPERIMENTAL INVESTIGATION

The following are the strength tests which was conducted in the project:

- Compressive strength test
- Split tensile strength test

V RESULTS

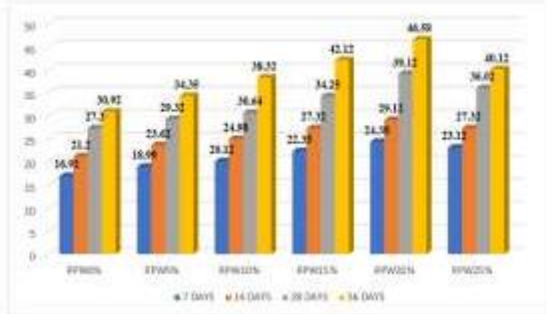
The results completed in the present investigation are reported in the form of Tables and Graphs for various percentage of Recycled plastic waste as fine aggregate and nano silica with cement

Slump test for Concrete

S.No.	RPW (Recycled Plastic Waste)	M20	M30
1	0%	65	50
2	5%	93	80
3	10%	108	86
4	15%	116	95
5	20%	135	150
6	25%	112	125

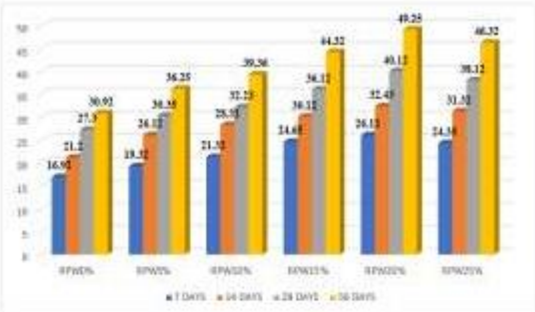
Compressive strength of concrete with mix design of M20 @ 0% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	16.92	21.2	27.3	30.92
RPW5%	18.99	23.62	29.32	34.35
RPW10%	20.12	24.98	30.64	38.32
RPW15%	22.35	27.32	34.25	42.12
RPW20%	24.38	29.12	39.12	46.58
RPW25%	23.12	27.32	36.02	40.12



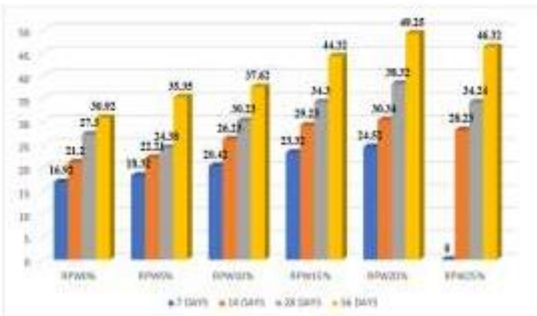
Compressive strength of concrete with mix design of M20 @ 4% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	16.92	21.2	27.3	30.92
RPW5%	19.32	26.12	30.35	36.25
RPW10%	21.32	28.32	32.23	39.36
RPW15%	24.65	30.12	36.12	44.32
RPW20%	26.12	32.43	40.12	49.25
RPW25%	24.35	31.32	38.12	46.32



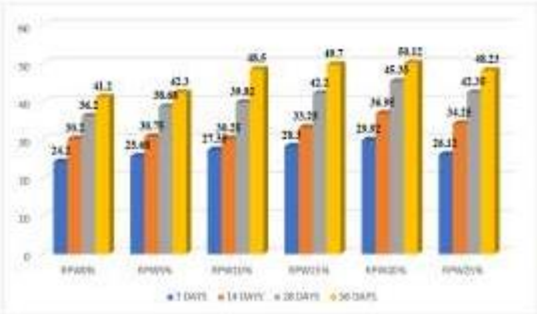
Compressive strength of concrete with mix design of M20 @ 8% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	16.92	21.2	27.3	30.92
RPW5%	18.32	22.21	24.38	35.35
RPW10%	20.42	26.23	30.23	37.62
RPW15%	23.32	29.23	34.3	44.32
RPW20%	24.52	30.34	38.32	49.25
RPW25%	21.33	28.23	34.24	46.32



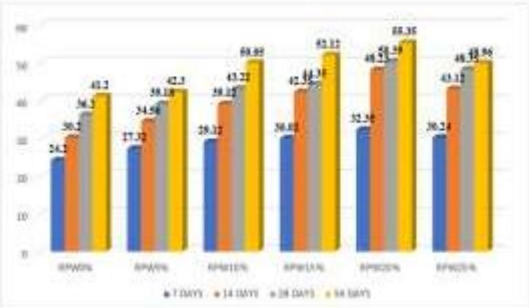
Compressive strength of concrete with mix design of M30 @ 0% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	24.2	30.2	36.2	41.2
RPW5%	25.68	30.75	38.68	42.3
RPW10%	27.35	30.25	39.82	48.5
RPW15%	28.3	33.25	42.2	49.7
RPW20%	29.92	36.95	45.35	50.12
RPW25%	26.12	34.25	42.35	48.23



Compressive strength of concrete with mix design of M30 @ 4% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	24.2	30.2	36.2	41.2
RPW5%	27.32	34.56	39.18	42.3
RPW10%	29.12	39.12	43.22	50.05
RPW15%	30.02	42.35	44.35	52.12
RPW20%	32.35	48.23	50.39	55.35
RPW25%	30.24	43.12	48.35	49.96

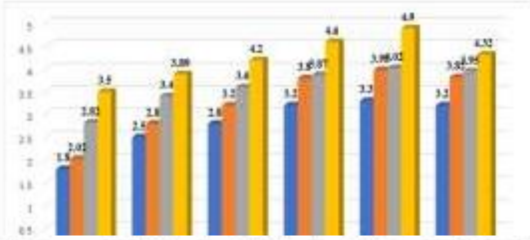


Compressive strength of concrete with mix design of M30 @ 8% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	24.2	30.2	36.2	41.2
RPW5%	26.23	32.56	36.23	40.12
RPW10%	28.32	38.01	40.23	49.12
RPW15%	29.21	40.12	42.3	50.12
RPW20%	30.12	42.32	49.23	52.12
RPW25%	29.12	39.12	46.12	48.23

Split tensile strength of concrete with mix design of M20 @ 0% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.8	2.02	2.82	3.5
RPW5%	2.5	2.8	3.4	3.89
RPW10%	2.8	3.2	3.6	4.2
RPW15%	3.2	3.8	3.87	4.6
RPW20%	3.3	3.98	4.02	4.9
RPW25%	3.2	3.82	3.95	4.32

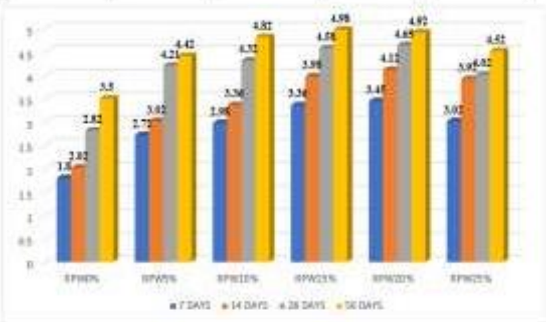


Sp

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.8	2.02	2.82	3.5
RPW5%	2.68	2.98	3.98	4.02
RPW10%	2.98	3.36	3.92	4.42
RPW15%	3.36	3.98	4.02	4.85
RPW20%	3.45	4.12	4.32	4.92
RPW25%	3.02	3.82	3.92	5.02

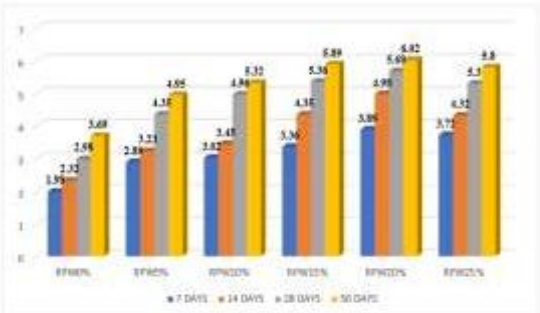
Split tensile strength of concrete with mix design of M20 @ 8% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.8	2.02	2.82	3.5
RPW5%	2.72	3.02	4.21	4.42
RPW10%	2.98	3.36	4.32	4.82
RPW15%	3.36	3.98	4.58	4.98
RPW20%	3.45	4.12	4.65	4.92
RPW25%	3.02	3.92	4.02	4.52



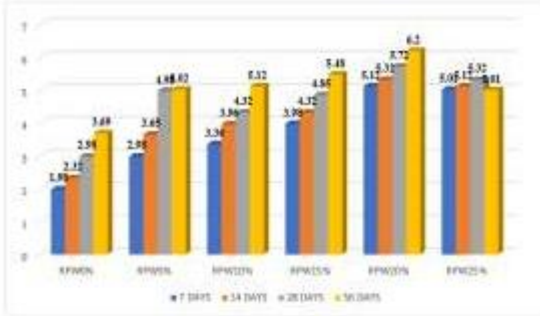
Split tensile strength of concrete with mix design of M30 @ 0% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.98	2.32	2.98	3.69
RPW5%	2.89	3.23	4.35	4.95
RPW10%	3.02	3.45	4.96	5.32
RPW15%	3.36	4.35	5.36	5.89
RPW20%	3.89	4.98	5.68	6.02
RPW25%	3.72	4.32	5.3	5.8



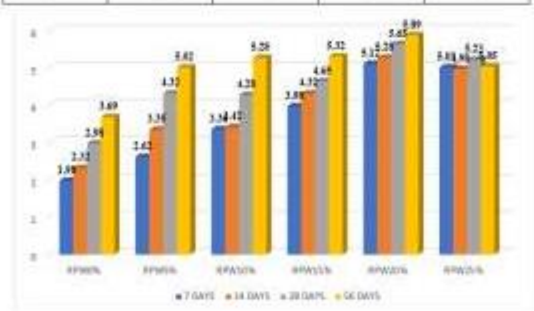
Split tensile strength of concrete with mix design of M30 @ 4% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.98	2.32	2.98	3.69
RPW5%	2.98	3.65	4.98	5.02
RPW10%	3.360	3.96	4.32	5.12
RPW15%	3.98	4.32	4.85	5.48
RPW20%	5.12	5.32	5.72	6.2
RPW25%	5.02	5.12	5.32	5.01



Split tensile strength of concrete with mix design of M30 @ 8% Nano Silica

RPW (Recycled Plastic Waste)	7 DAYS	14 DAYS	28 DAYS	56 DAYS
RPW0%	1.98	2.32	2.98	3.69
RPW5%	2.62	3.35	4.32	5.02
RPW10%	3.360	3.42	4.28	5.28
RPW15%	3.98	4.32	4.65	5.32
RPW20%	5.12	5.28	5.65	5.89
RPW25%	5.02	4.98	5.23	5.05



VI. CONCLUSIONS

Following results drawn from the study on effect of nano materials as cement replacement in concrete incorporating ceramic tiles as coarse aggregate replacement

1. Replacement of fine aggregate with recycled plastic waste has much effect on the workability of concrete.
2. Compressive strength of concrete mixes up to 20% replacement of recycled plastic waste is greater than conventional concrete mix.
3. For 7, 14, 28 and 56 days of curing, compressive strength of 20% replacement of recycled plastic waste is greater than conventional concrete.

4. Adding 4% Nano Silica of weight of the cement by various percentage recycled plastic waste as replacement of fine aggregate increases the compressive strength of it up to 20% compared to the normal concrete.
5. For 7, 14, 28 and 56 days of curing, split tensile strength of 20% replacement of recycled plastic waste is greater than conventional concrete.

Values observed from test results are
Compressive strength
M20
20% REPLACEMENT
- 0% Nano Silica for 7days, 14 days, 28 days and 56 days are 24.38, 29.12, 39.12, 46.58 N/mm^2 respectively
- 4% Nano Silica for 7days, 14 days, 28 days and 56 days are 26.12, 32.43, 40.12, 49.25 N/mm^2 respectively
- 8% Nano Silica for 7days, 14 days, 28 days and 56 days are 24.52, 30.34, 38.32, 49.25N/mm^2 respectively

M30
20% REPLACEMENT
- 0% Nano Silica for 7days, 14 days, 28 days and 56 days are 29.92, 36.95, 45.35, 50.12 N/mm^2 respectively
- 4% Nano Silica for 7days, 14 days, 28 days and 56 days are 32.35, 48.23, 50.39, 55.35 N/mm^2 respectively
- 8% Nano Silica for 7days, 14 days, 28 days and 56 days are 30.12, 42.32, 49.23, 52.12 N/mm^2 respectively

Split Tensile Strength
M20
20% REPLACEMENT
- 0% Nano Silica for 7days, 14 days, 28 days and 56 days are 3.3, 3.98, 4.02, 4.9 N/mm^2 respectively
- 4% Nano Silica for 7days, 14 days, 28 days and 56 days are 3.45, 4.12, 4.32, 4.92 N/mm^2 respectively
- 8% Nano Silica for 7days, 14 days, 28 days and 56 days are 3.28,4.02,4.15,4.62 N/mm^2 respectively

M30
20% REPLACEMENT
- 0% Nano Silica for 7days, 14 days, 28days and 56 days are 3.89, 4.98, 5.68, 6.02N/mm^2 respectively
- 4% Nano Silica for 7days, 14 days, 28days and 56 days are 5.12, 5.32, 5.72, 6.2 N/mm^2 respectively
- 8% Nano Silica for 7days, 14 days, 28days and 56 days are 5.12, 5.28, 5.65, 5.89N/mm^2 respectively

6. Adding 4% Nano Silica of weight of the cement by various percentage recycled plastic waste as replacement of fine aggregate increases the split tensile strength of it up to 20% compared to the normal concrete.
7. According to Grade M20 and M30 grade replacement of coarse aggregate with recycled plastic waste
8. Optimum results upto recycled plastic waste 20% replacement of fine aggregate along with 4% nano silica recommendable.

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