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Experimental investigation on strength properties of concrete using polypropylene pellets

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ABSTRACT

The revolution of using new materials as reinforcement in concrete has become all the rage. It is due to the fact that he habitual construction materials we generally use, decreases in quantity on regular basis. Thus there arises a vacuum to replace those habitual materials with the resources of identical property. The good quality river sand has now become a demand because of its scarcity. Thus replacing the conventional river sand with M-Sand (manufactured sand) will reduce this demand. In turn the M sand is readily available at the time of need. M-Sand is of the disposal of plastic waste materials such as polythene bags, water bottle etc., may cause environmental damage. Polypropylene is the second most widely produced synthetic plastic after polyethylene. The usage of polypropylene in concrete will improve its mechanical properties. In this project, M-Sand has been partially replaced by POLYPROPYLENE in the form of plastic pellets in range of (0-30% at the interval of 10%) in M-20 grade of concrete. The concrete has been tested for compressive strength, split-tensile strength and flexural strength for 28 days.

Keywords: polypropylene, M-Sand, plastic pellets, strength of concrete.

INTRODUCTION

With increase in population and urbanization, demand of raw materials such as cement and aggregate has increased in the construction industries. Further, it has been recognized that use of plastics and polypropylene are of large volume and this volume is increasing every year. Utilization of plastics and polypropylene not only the solution of disposal problems but also helps to conserve natural resources for meeting increased demand of aggregates and save energy. This study deals with the mixing of plastics and used as a binding material to prepare concrete as a replacement M-Sand. M-Sand, plastics wastes, cement are tested to determine the physical properties. The polypropylene was incrementally added as a binding material. Also we experiment the application of plastics waste replacing cement and helps in cost of castings. The main objective of this study is to use the polypropylene in manufacturing of concrete and making the concrete economic without compromising the strength parameter. The conventional concrete has been compared to the concrete made with polypropylene. In this investigation, various properties like compressive strength, split tensile strength and flexural strength were conducted. This project aims to study the possibility of using polypropylene as a binding material instead of M-Sand in the manufacturing of concrete.

The study Deals with polypropylene terepthalate basis. This experimental study shows the physical and mechanical properties of polypropylene concrete. Cement has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. A good concrete must possess high strength and low permeability. Hence, alternative composite materials are gaining popularity because of ductility and strain hardening. To improve the post cracking behavior, short discontinuous and discrete fibers are added to the plain concrete. Addition of fiber improves the post peak ductility performance, pre-crack tensile strength, fracture strength, toughness, impact resistance, flexural strength resistance, fatigue performance etc. The ductility of fiber added concrete depends on the ability of fibers to bridge cracks at high levels of strain. Addition of polypropylene fibers decreases the unit weight of concrete and increases its strength.

2. EXPERIMENTAL METHOD

This section showed the detailed material information and methods to determine the strength properties of the concrete specimen.

2.1 Cement

Cement is the most important constituent, because it is used to bind sand and aggregate. The most common cement used in an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53grade conforming to IS 12269:1987 is used. Many tests were conducted on cement; some of them are specific gravity, consistency tests, setting time tests. The chemical properties of cement are shown in Table 2.1 and physical properties of cement are shown in table 2.2.

Table 2.1 *chemical properties of cement*

Sl. No.	Properties	% Present
1	Silicon Dioxide (SiO_2)	21.77%
2	Calcium Oxide (CaO)	57.02%
3	Magnesium Oxide (MgO)	2.71%
4	Aluminium Oxide (Al_2O_3)	2.59%

Table 2.2 *physical properties of cement*

Sl. No.	Physical properties of cement	Results	Requirementsas per IS 12269:1987
1	Specific Gravity	3.15	3.10-3.15
2	Standard Consistency	32%	30-35
3	Initial setting time (hours, min)	35 minimum	30 maximum
4	Final setting time (hours, min)	567 minimum	600 maximum

Setting Time of Cement

Take 400g of cement and prepare a neat paste with 0.85% of water by weight of cement. Gauge time is kept between 3 to 5 minutes. Start the stopwatch at the instant when the water is added to the cement. Record this time. In the beginning, the needle completely pierces the test block. Quickly releasing the needle after every 2 minutes till the needle fails to pierce the block for about 5mm measured from the bottom of the mould. Note this time. For final setting time needle with an annular attachment. The cement is considered finally set when upon applying the final setting needle gently to the surface of the test block. The needle makes a About 1000 grams of naturally dried sand samples are collected. Arrange the sieves in order such that coarse sieve is kept at the top and the fine sieve is at the bottom. Place the closed pan below the finest sieve. Arrange the sieve set in orders of 4.75mm, 2.36mm, 1.18mm, 1mm, 600μ, 300 μ, 150 μ sizes and a pan at the bottom. Position the sieves set in the sieve shaker and sieve the sample for a period of 10minutes. The permissible values of fineness modulus 2.9 to 3.2 Refer (IS: 2386-1963 part- 1). The good concrete the values of fineness modulus for the M sand should between 2 and 3.5. The weight of sample should not be less than 1.5kg. Table 4.5 shows the grain size analysis of M-sand. Record this time. Initial setting time = 35minutes and Final setting time = 9hrs 27minutes

2.2 M-Sand

Manufactured sand is a substitute of river sand for concrete construction. Manufactured sand is produced from hard granite stone by crushing. The M sand is of cubical shape with grounded edges,

Fig 2.1

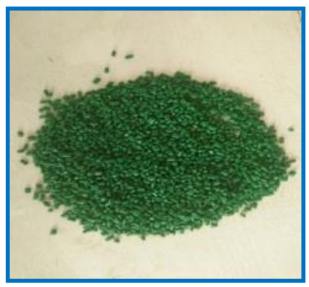

Fig 2.2

Washed and graded to as a construction material. The size of manufactured sand is less than 4.75 mm.The material smaller than 4.75mm size is called fine aggregate. Natural sands are generally used as fine aggregate.

Table 2.3 *Specific gravity of M-Sand*

S.No.	Weight of empty pycnometer W1 (gm)	Weight of pycnometer + dry sand W2 (gm)	Weight of pycnometer +sand+water W3 (gm)	Weight of pycnometer +waterW4 (gm)	Specific gravity (G)
1	450	855	1480	1230	2.61
2	450	855	1480	1230	2.61

Table 2.4 *Grain size analysis of M-Sand*

S. No	Sieve size in mm	Weight of C.A.retained (Kg)	percentage weight retained (%)	%Weight passing	Cumulative % wt. retained
1	80	0	0	100	0
2	40	0.865	28.63	71.17	28.38
3	20	1.105	36.83	63.17	65.66
4	16	-	-	-	-
5	12.5	-	-_	-_	-_
6	10	0.670	22.33	77.67	87.99
7	4.75	0.195	6.5	93.5	94.49
8	2.36	-	-	-	-
					Σc = 276.97

The particle size distribution from sieve analysis and the experimental results carried out to find other properties of fine aggregate are given. IS sieve ranging from 4.75mm to 150 microns were used to conduct the sieve analysis and fineness modulus was found out. From the sieve analysis results, it is found that the fine aggregate confirms to zone II and is designated as fine sand. The picture of M-sand is shown in figure 2.1

Specific Gravity of M Sand

Take a clean dry pycnometer with its cap and find the weigh it (W1). Take about 1/3rd of dry sand in the pycnometer and find the weight of pycnometer with sand (W2). Fill the pycnometer with distilled water up to the hole in the conical cap and shake it to remove the air. Then take the weight of pycnometer with M sand and water (W3). Empty the pycnometer and clean it thoroughly. Then fill it with water up to the hold of the conical cap and weigh it (W4). From the above weights, the specific gravity of fine aggregate is calculated. Table 2.3 shows the specific gravity of M sand.

Sieve Analysis

About 1000 grams of naturally dried sand samples are collected. Arrange the sieves in order such that coarse sieve is kept at the top and the fine sieve is at the bottom. Place the closed pan below the finest sieve. Arrange the sieve set in orders of 4.75mm, 2.36mm, 1.18mm, 1mm, 600μ, 300 μ, 150 μ sizes and a pan at the bottom. Position the sieves set in the sieve shaker and sieve the sample for a period of 10minutes. The permissible values of fineness modulus 2.9 to 3.2 Refer (IS: 2386-1963 part- 1). The good concrete the values of fineness modulus for the M sand should between 2 and 3.5. The weight of sample should not be less than 1.5kg. Grain size distribution is listed in table 2.4.

The fineness modulus of sand can be calculated using the formula,

Fineness modulus = Total cumulative % retained /100 = 240.4 / 100

Fineness modulus = 2.40

2.3 PLASTIC PELLETS

Plastic pellets are an industrial raw material for the plastic industry and are unintentionally released to the environment during both manufacturing and transport. These plastic pellets made from polyethylene and polypropylene. Pellets or hurdles as they are often called as pre-production plastic resin .Essentially raw plastic before it has been made into an end use item such as a plastic bag, bottle or toy. The picture of plastic pellets shown in figure 2.2.

2.4 COARSE AGGREGATE

Coarse aggregate to be used for production of concrete must be strong, impermeable, durable and capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. The various properties of coarse aggregate are given in table 2.4

Table 2.5 *Coarse aggregate properties*

Sl. No.	Properties	Observed values (20mm)
1	Specific Gravity	2.88
2	Fineness modulus	2.77
3	Bulk Density(kg/m^3)	2.014

2.5 MIX PROPORTION

Table 2.6 *Mix propotion of concrete*

Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	W/C ratio
437	758.47	1085	0.45

2.6 COMPRESSION TEST ON CUBE

The average results of compressive strength of the concrete cubes at the end of the 28 days are calculated. The compressive strength of cube is listed in the table 2.7 and Compressive strength of concrete cubes at 28 days using plastic pellets shown in the fig 2.2

2.7 TENSILE TEST ON CYLINDER

The average results of tensile strength of the concrete cylinders at the end of the 28 days casted using plastic pellets are calculated. The length of the specimens shall not be less than the diameter and not more than twice the diameter. For routine testing and comparison of results, unless otherwise specified the specimens shall be cylinder 150 mm in diameter and 300 mm long. The tensile strength of individual cylinders is listed in the table 2.8 are as follows

2.8 FLEXURAL TEST ON PRISM

Specifications and investigation of apparent low strengths should take into account the higher variability of flexural strength results. Standard deviation for concrete flexural strengths up to 5.5 MPa for projects with good control range from about 0.3 to 0.6 MPa. Standard deviation values over 0.7 Moa may indicate testing problems, or moisture differences within a beam caused from premature drying will cause low strength. The flexural strength of individual prism is listed in the table 2.9 are as follows

Table 2.7 *Compressive strength of concrete*

% of Replacement	Average Value of compressive strength (N/mm^2)
0	24.4
10	26.14
20	31.62
30	28

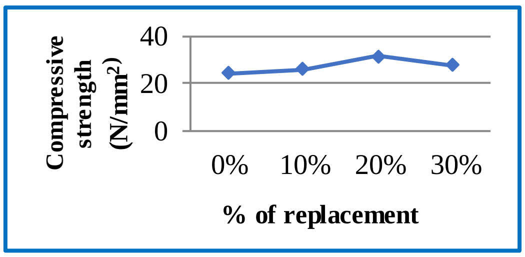

Fig 2.3 *Compressive strength of concrete*

Table 2.8 *tensile strength of concrete*

% of Replacement	Average Value of tensile strength (N/mm^2)
0	3.08
10	3.46
20	3.48
30	3.36

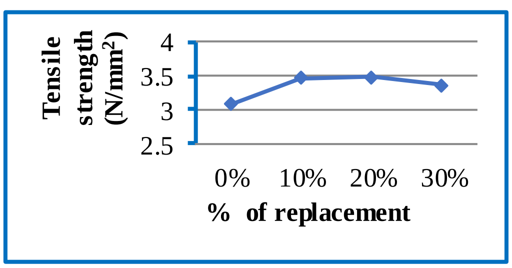

Fig 2.4 Tensile strength of concrete

Table 2.9 *Flexural strength of concrete*

% of Replacement	Average Value of flexural strength (N/mm^2)
0	2.01
10	2.49
20	2.66
30	2.71

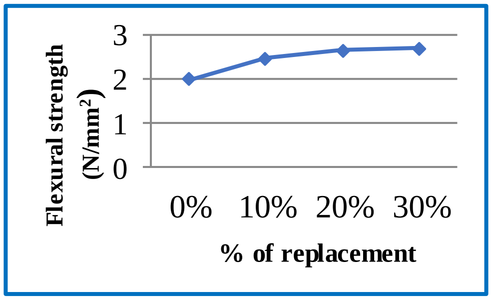

Fig 2.5 *Flexural strength of concrete*

CONCLUSION

Experimental results show that the addition of polypropylene pellets promotes a marginal increase in the mechanical strength. The compressive strength, split tensile strength and flexural strength were conducted to investigate the harden properties of concrete. This work relates to the usage of polypropylene pellets, a waste cheap material used in the concrete mixtures. The following conclusions were drawn based on the experimental investigations carried out and the results obtained from those tests, which are as follows:

1) This study concluded that compressive strength of the concrete improved upto 31.75% for the replacement level of polypropylene pellets with M Sand by 20% compared to conventional concrete.
2) It could be said that replacement of polypropylene pellets with M Sand improved the split tensile strength upto 12.98% by the replacement level of polypropylene pellets with M Sand by 20% compared to conventional concrete.
3) It could be said that replacement of polypropylene pellets with M Sand improved the flexural strengthup to34.8% of the replacement level of polypropylene pellets with M Sand by 30% compared to conventional concrete.
4) The compressive strength results of cubes and split tensile strengths of cylinder shows that the optimum percentage of replacement of polypropylene pellets with that the M Sand was 20% and the flexural strength of prisms shows the optimum percentage at 30% of replacement of polypropylene pellets.
5) For higher replacement of polypropylene pellets with M Sand (grater than 20%) the compressive and split tensile strength decreases due to an increase of free water content in the mix.
6) Hence the mix proportion containing 20% and 30% polypropylene pellets with M Sand is the optimum mix that can be used for costruction purposes.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.