PERFORMANCE EVALUATION OF PLASTIC GRANULES AND QUARRY DUST AS FINE AGGREGATE IN M_{40} GRADE CONCRETE

Mrs.I.Rahmath Nisha* and Mrs.T.Ganga*

**Assistant Professor of Civil Engineering, New Prince Shri Bahvani College of Engineering and Technology, Chennai, Tamilnadu, India*

Abstract- In this context an experimental study is done based on Quarry Dust Wastes (QDW) and polypropylene plastic granules (PPG) for replacement of fine aggregate in concrete. The strength properties of M_{40} grade concrete is studied with different proportions of plastic granules and quarry dust along with addition of 1% super plasticizer. The various proportions of plastic and quarry dust used are 25% and 30% replacement by volume of river sand in the concrete. Strength tests are carried out with different proportions of replacements of river sand with QDW and PPG. Cube specimens, cylinder specimens and prism specimens of 9 numbers each were cast for different proportions of M_{40} concrete , cured and tested for 7 ,14 and 28 days. Compression, split tensile and flexural strength tests were done and the results are compared with 100% river sand concrete specimens.

Keyword - river sand, polypropylene plastic granules, quarry dust, industrial wastes, super plasticizer.

I.INTRODUCTION

Concrete is suitable as a medium of recycling wastes or industrial by products. In the era of increased attention to the environmental impact of construction and sustainable development, waste materials usage in concrete plays a major role. Using waste materials as replacement of conventional natural materials minimizes the depletion of natural resources. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. The mining of aggregates in rivers has led to deterioration of river basins, also increase in pollution and changes in pH level. This process has in turn led questions to mankind to solve the problems generated by this growth. Hence in order to overcome the above said problems waste products should be employed as construction material.

Plastic waste is now a serious environmental threat to the modern way of living. “As per the survey conducted by central pollution control board (CPCB, 2015) in 60 cities of India, it is estimated 15,342.6 tons of plastic wastes are collected of which 9205 tons/day are collected and recycled while 6137 tones remains uncollected and littered.” As one of the greatest inventions in 20th century, plastic has brought huge benefit in human life. Numerous plastic products are being consumed with the development of society. However, large amounts of plastic waste give much pressure on the environment due to the very low biodegradability of plastic. It is necessary to develop a rational approach for the waste disposal indicating both the economy and environmental protection .The productive use of waste material represents a means of alleviating

some of the problems of solid waste management.

Quarry dust which is obtained by crushing the rock is emerging as a viable alternative to river sand. The use of this artificial sand is picking up in major cities of India. Quarry dust has a better quality consistency and high strength with significant saving. Disposal of Quarry dust is also causing a significant problem. QDW has the same physical characteristics to sand. Quarry dust is fine rock particles. The disposal of this is a serious environmental problem. If it is possible to use this crushed stone dust in making concrete by partial replacement of natural river sand, then this will not only save the cost of construction but at the same time it will solve the problem of disposal of this dust. This project is an investigation on the attempt to evaluate the characteristics of concrete using Polypropylene Plastic granules and Quarry dust as fine aggregate, for the purpose of exploring the characteristics comparison of these materials with natural sand.

II.MATERIALS USED

Materials Used

The materials used in this project includes Cement OPC 53 grade, River sand, Polypropylene plastic granules, Quarry dust, Super plasticizer and Coarse aggregate

Cement

Cement is the bonding material used in between coarse aggregates and fine aggregates. It is the mostly widely used important ingredient in construction works. Ordinary Portland cement (Dalmia OPC 53 grade) confirming to requirements of IS 12269-1987 is used. Fineness of cement is 1.3% with a consistency of 31%. The initial setting time is 35 mins. The final setting time is 10 hours.

Natural River Sand

Due to increase in the utilization of concrete in construction sector, the need for river sand has been increased enormously. Limitations have been laid on the large scale mining of river sand from river beds. The fine aggregate used in this study was clean river sand purchased from traders at Chennai. Gradation of Fine Aggregate Conforms to Zone II of IS 383 with a specific gravity of 2.65 and bulking of 33%

Polypropylene Plastic Granules

Polypropylene (PPG), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer bank notes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. The plastics used in this study in polypropylene plastic granules collected from CIPET, Chennai.

Quarry Dust

Quarry dust is a waste product produced during the crushing process which is used to extract stone, and there is a great deal of it around, making it plentiful and cheap. The dust produced by quarrying has already been used in the construction industry for projects such as road building, and making materials such as bricks and tiles. Experiments suggest

that river sand has a naturally stronger and harder quality which makes the quarry dust less likely to be usable as a replacement.

Coarse Aggregate

The fineness modulus of coarse aggregate is 4.36 and Grading of Coarse Aggregate conforms to Table 2 of IS 383. The specific gravity of coarse aggregate is 2.65.

Table 1 Property of aggregates

Property	R. sand	PPG	QD	Coarse agg
Fineness modulus	2.1	3.3	3.0	4.76
Specific gravity	2.65	0.81	3.7	2.65
Bulk density	33%	-	21.6	-
% of Voids	37.4	-	-	-
Density	-	0.89G/cm3	-	-
Young's modulus	-	1300 N/mm^2	-	-
Thermal properties	-	Melting point 130° C	-	-
Organic impurities	Nil	Nil	Nil	Nil

Super Plasticizer

Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. Conplast SP430 complies with IS: 9103:1999 and BS: 5075 Part 3. Conplast SP430 is based on Sulphonated Napthalene Polymers and supplied as a brown liquid instantly dispersible in water. Conplast SP430 has been specially formulated to give high water reductions upto 25% without loss of workability or to produce high quality concrete of reduced permeability. During the present investigation, dosage of 1% by

Experimental Investigation

The experimental investigation consisted of making M40 concrete with various proportions of quarry dust and plastic granules as a replacement to fine aggregate and determining the mechanical properties of concrete. M30 mix was designed as per IS 10262:2009 and its mix ratio was found to be 1: 2.2: 3.07 :0.4. The required materials were weighed and mixing of concrete was carried out manually. Cube specimens of size 150 mm x 150 mm x 150 mm, cylinder specimens of diameter 150 mm and length 300 mm and prism specimens of size 500 mm x 100 mm x 100 mm were cast. The specimens were de molded after 24 hours of casting and the specimens were cured in tank for 28 days. Testing was carried out using a Universal Testing machine.

III.METHODOLOGY

Methodology During the present study natural river sand was replaced with 100% quarry dust, 70% quarry dust 30% plastic granules, 75% quarry dust 25% plastic granules, 75% river sand 25% plastic granules and 70% river sand 25% plastic granules. For each of the mixes 1% dosages of super plasticizer by weight of cement were added. Fifty four cube specimens, fifty four cylinder specimens and fifty four prism specimens were cast.

Compression Test of Concrete

The specimen is removed from water after specified curing time and wipe out excess water from the surface. The dimension of the

specimen is taken to the nearest 0.2m. Clean the bearing surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140kg/cm^2/minute till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

Table 2 Compressive strength of concrete

Comp. Strength (N/mm^2)	Age(days)		
	7	14	28
S1	37.36	43.20	50.80
S2	33.37	36.06	40.80
S3	37.15	41.48	48.80
S4	35.31	36.50	41.64
S5	32.91	35.29	40.16
S6	30.91	32.45	36.77

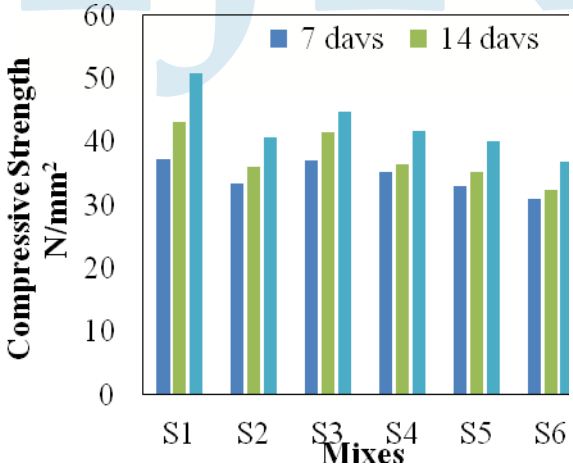
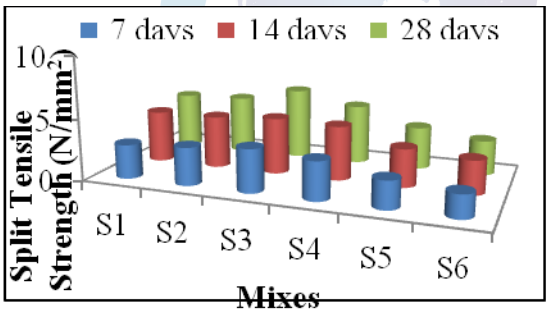


Fig Variations in compressive strength of concrete by replacing the fine aggregate with varying percentages of plastic granules and quarry dust

SPLITTING TENSILE TEST OF CONCRETE

The wet specimen from water is taken after the required days of curing and wiped out of water from the surface of specimen. Diametrical lines are drawn on the two ends of the specimen to ensure that they are on the same axial place. The weight and dimension of the specimen are noted and compression testing machine is set for the required range. Keep are plywood strip on the lower plate and place the specimen. Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate. Place the other plywood strip above the specimen. Bring down the upper plate to touch the plywood strip. Apply the load continuously without shock at a rate of approximately 14-21kg/cm2/minute. Note down the breaking load (P)



Flexure Test of Concrete

The thickness and width of the beam are measured. The loading block is gripped and test jig in the upper and lower gripping head respectively. The specimen is located so that the upper surface is to the side and centered in loading assembly. The machine is operated until the loading block was bought into contact with the upper surfaces of the specimen. Full contact between the load (and supporting) surfaces and the specimen is ensured to secure. The required parameters

are set on the control panel. The load recorder is adjusted on the front panel controller to zero, to read load applied. The specimen is observed, as the load was gradually applied. The maximum load is recorded and loading is continued until complete failure.

Samples	Age of curing (days)	Flexure strengths(N/mm^2)			Avg flexure strength (N/mm^2)
S1 (100% RS concrete)	7	3.54	3.52	3.49	3.51
	14	5.04	5.12	5.02	5.06
	28	5.38	5.43	5.45	5.42
S2 (100% QD concrete)	7	3.31	3.36	3.42	3.36
	14	4.59	4.61	4.58	4.59
	28	5.27	5.29	5.31	5.29
S3 (75% RS and 25% PG)	7	3.28	3.26	3.31	3.28
	14	4.77	4.81	4.79	4.46
	28	5.05	5.07	5.09	5.07
S4 (70% RS and 30% PG)	7	3.44	3.43	3.44	3.43
	14	4.48	4.45	4.46	4.79
	28	4.78	4.82	4.81	4.80
S5 (75% QD and 25% PG)	7	3.41	3.45	3.43	3.43
	14	4.72	4.74	4.73	4.73
	28	5.36	5.42	5.34	5.37
S6 (70% QD and 25% PG)	7	3.32	3.36	3.38	3.35
	14	4.59	4.60	4.54	4.57
	28	4.86	4.81	4.84	4.83

$$Ff = \frac{Pl}{bd}2$$

F_f = flexure strength

P= maximum load sustained by the specimen
d= diameter of the specimen
l= length of the specimen
b= breadth of the specimen

Table 5 Flexure Strength of Concrete

Samples	Age of curing (days)	Flexure strengths(N/mm^2)			Avg flexure strength (N/mm^2)
S1 (100% RS concrete)	7	3.54	3.52	3.49	3.51
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	28	5.38	5.43	5.45	5.42
S2 (100% QD concrete)	7	3.31	3.36	3.42	3.36
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	14	4.77	4.81	4.79	4.46
	28	5.05	5.07	5.09	5.07
S4 (70% RS and 30% PG)	7	3.44	3.43	3.44	3.43
	14	4.48	4.45	4.46	4.79
	28	4.78	4.82	4.81	4.80
S5 (75% QD and 25% PG)	7	3.41	3.45	3.43	3.43
	14	4.72	4.74	4.73	4.73
	28	5.36	5.42	5.34	5.37
S6 (70% QD and 25% PG)	7	3.32	3.36	3.38	3.35
	14	4.59	4.60	4.54	4.57
	28	4.86	4.81	4.84	4.83

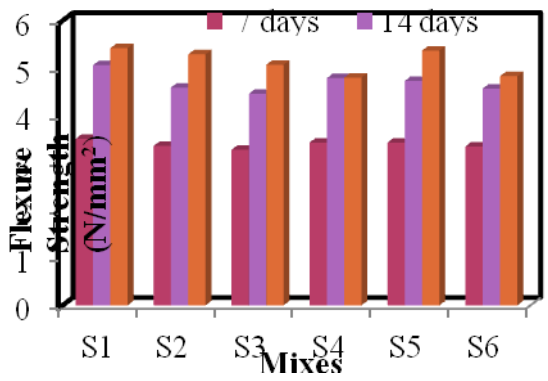

Fig. 4Variation in Flexure Strength of Concrete by Replacing the Fine Aggregate with Varying Percentages of Plastic Granules and Quarry Dust

IV.CONCLUSION

The usage of quarry dust and polypropylene plastic granules in concrete acts as a medium of converting waste to wealth. This besides being a solution for reducing environmental pollution also helps in developing characteristics properties of concrete, performance increase and also cost reduction. It also reduces the consumption of natural river sand. The test result shows that samples S3 (75% RS and 25% PG) S4 (70% RS and 30% PG) has a compressive strength of 44.80 N/mm^{2}and 41.64 N/mm^2 respectively which is less than compressive strength of concrete with 100% river sand 50.80 N/mm^{2}but has attained a greater strength than the proposed mix design .The test result shows that samples S5(75% QD and 25% PG) has a compressive strength of 40.16 N/mm^2 which is less than compressive strength of concrete with 100% quarry dust 40.80 N/mm^{2}but has attained a greater strength than the proposed mix design .The sample S6(70% QD and 30% PG) has a compressive strength of 36.77 N/mm^{2}which is less than the proposed mix design ,thus can be used for non-structural purposes. Thus usage of 30% of river sand can be reduced by using Plastic granules whereas 100% of river sand can be reduced and managed by using 100% quarry dust. The tensile strength of concrete with 100% quarry dust 4.70 N/mm^2 which is greater than the 100% river sand concrete which infers 100% of river sand can be reduced and managed by using 100% quarry dust. Thus usage of 30% of river sand can be reduced by using Plastic granules. The test result shows that samples S2(100 % QD) has a flexure strength of 5.27 N/mm^2 which is less than tensile strength of 100% river sand but has attained the target strength. Thus usage of 100% of river sand can be reduced by using Plastic granules.

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