International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

Effect of Waste Polypropylene and Metakaolin on Strength of Concrete

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***Abstract*- The disposal of solid waste is a major problem in populated countries. Plastic is one of the common waste materials which produce many environmental issues on the basis of physical property plastics are classified into different categories. Plastic waste must be recycled or reused because there are non- biodegradable. Polypropylene is the thermoplastic polymer which is a major category of plastic. It is also known as polypropene and is used in a wide variety applications. The main objective is to study the behavior and certain properties of the concrete which is made of the polypropylene materials.**

In this study M30 cement concrete is considered in which the polypropylene is used as the partially replacement of fine and coarse aggregate in the concrete. Concrete cube and cylinder were casted taking 1 to 7% and 2.5- 10% weight of polypropylene as partial replacement of fine aggregate and coarse aggregate respectively. This project also covers experimental study for the possibility of effective replacement of cement with metakaolin along with optimum polypropylene (0%, 5%, 10%, 15%, 20% and 25%). Metakaolin differs from other cementitious materials like slag, fly ash and silica fume, in that it is not a byproduct of an industrial process. When used as a partial replacement for Portland cement, metakaolin improves the mechanical properties of concrete.

Keywords-- solid waste, Alternative material, polypropylene, comparison, compressive strength, Tensile strength, % replacement, Metakaolin.

I. INTRODUCTION

Concrete is the most widely used material in the construction industry. It consists of binding materials such as lime or cement, well graded fine and coarse aggregate, water and admixtures. In concrete mix cement and water form a paste which is use to fill the voids of the fine aggregate and binds them together. Through a hydration process, the paste hardens and gains strength to form the rock-like mass known as concrete. Concrete is plastic and malleable when newly mixed, strong and durable when hardened. These qualities explain why one material, concrete, can build skyscrapers, bridges, sidewalks and super highways, houses and dams.

The major problem in construction industry is the unavailability of construction materials. Various attempts have been made to reduce the use of fine aggregate, course aggregate and other ingredients of concrete which are non renewable. Past investigation suggest that partial replacement of aggregate of concrete with waste plastic such as plastic bottles and bags can improve properties such as abrasion resistance, impact resistance, ductility, shock absorption and thermal conductivity. It also shows that addition of plastic bottle and bags to concrete causes some reduction in mechanical properties such as compressive strength, split tensile strength, flexural strength etc.

In this investigation, we made the comparison of yield strength for conventional concrete and concrete containing plastics at 28 days curing. Polypropylene plastic and M30 grade concrete is chosen for the investigation. An attempt is made to replace coarse and fine aggregate by pulverized polypropylene in concrete. Possibility of effective replacement of optimum fine aggregate with polypropylene and cement with metakaolin is also checked in this project.

a) About Metakaolin

Metakaolin differs from other supplementary cementitious materials (SCMs), like fly ash, silica fume, and slag, in that it is not a byproduct of an industrial process. Metakaolin is fine, natural white clay made by heating kaolin to particle structure making it a highly reactive, amorphous pozzolans. By adding metakaolin during hydration process, it forms additional CSH material by reacting with free lime, thus the concrete becomes more strong and durable.

b) About polypropylene

In this project we are use polypropylene plastic obtain from plastic chair industry. Polypropylene (PP), also known as polypropene is a thermoplastic polymer used in a wide variety of applications.. It is a white, mechanically rugged material, and is resistant to many chemical solvents, bases and acids. Polypropylene is hard material which is used for manufacturing of bottles, furniture etc.

II. OBJECTIVES OF THIS PROJECT

- To evaluate material properties of polypropylene.
- To evaluate workability of different percentages of replacements of fine aggregate and coarse aggregate with polypropylene.
- To evaluate workability and strength characteristics of different percentages of replacement of optimum fine aggregate and cement with metakaolin.
- To compare the engineering properties of replaced concrete with normal concrete.

III. METHODOLOGY

In this project work we used crushed polypropylene plastic as a partial replacement of fine and coarse aggregates collected from aluva plastic industry, kerala and metakaolin as a partial replacement of cement collected from Astra chemicals, Chennai.

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The flow chart shown in Fig. 1 illustrates the methodology of the project.

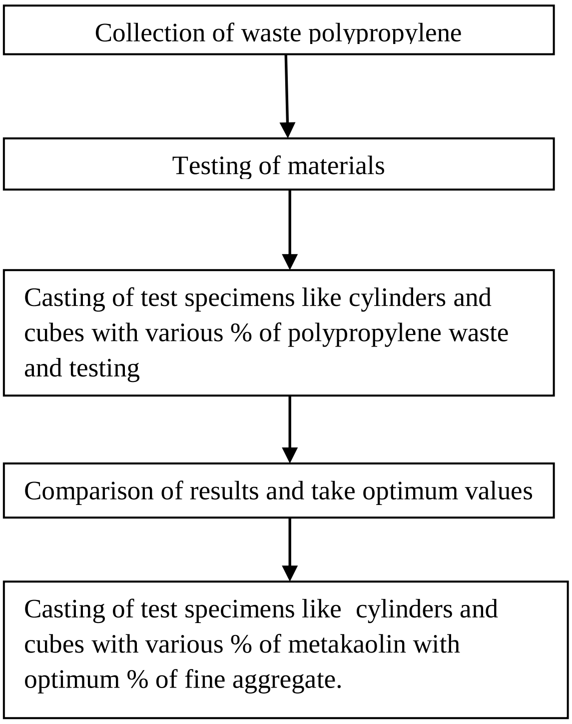

Fig.1: Methodology of the project

IV. MATERIALS USED

Cement : 43 grade OPC, chettinadu

Metakaolin : Replacing cement

Fine aggregate : M. Sand

Polypropylene : Replacing fine and coarse aggregate

Coarse aggregate : 20 mm size

Water : potable water

Fig.2: Polypropylene as coarse aggregate

Fig.3: Polypropylene as fine aggregate

Fig 4: metakaolin

V. MIX DESIGN

The required properties of the materials are:

Specific gravity of cement = 3.10

Specific gravity of fine aggregate = 2.55

Specific gravity of coarse aggregate = 2.69

Water absorption

Coarse aggregate = 1.1%

Fine aggregate = 12%

The mix design for M30 concrete is calculated by using IS Code method. The ratio of materials required as per design is = 1: 1.64: 2.70: 0.45

Table 1: Quantity of materials

	cement (kg)	fine aggregate (kg)	Coarse aggregate (kg)	Water content (kg)
for 1m^3	414	680	1119	187
for 1 cube	1.6	2.64	4.34	0.73
for 1 cylinder	1.77	2.90	4.78	0.8

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VI. TEST RESULTS AND DISCUSSIONS

a) Mix proportioning (polypropylene alone)

Table 2: Quantity of material required for preparation of concrete with replacing coarse aggregate

% polypropylene	0	2.5	5	7.5	10
cement (kg)	414	414	414	414	414
Fine aggregate (kg)	680	680	680	680	680
Coarse aggregate (kg)	1119	1091	1063	1035	1007
Water	187	187	187	187	187

Table 3: Quantity of material required for preparation of concrete with replacing fine aggregate

polypropylene	0	1	3	5	7
cement (kg)	414	414	414	414	414
Fine aggregate (kg)	680	673	659	646	632
Coarse aggregate (kg)	1119	1119	1119	1119	1119
Water	187	187	187	187	187

b) Slump test (polypropylene alone)

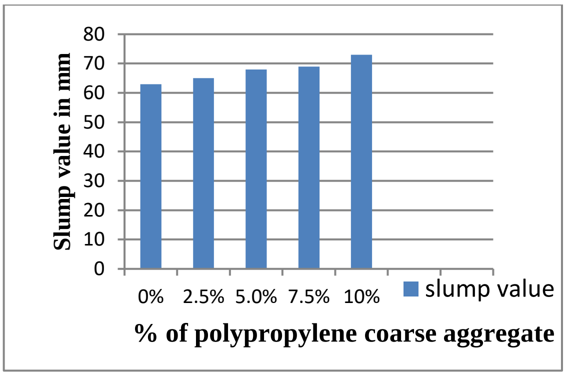

Fig 4: slump value obtained for various proportions of polypropylene as coarse aggregate.

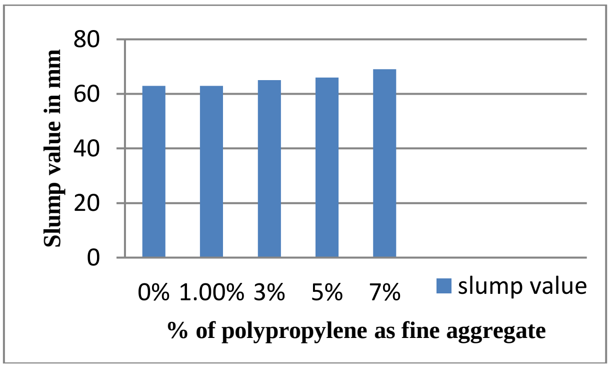

Fig 5: slump value obtained for various proportions of polypropylene as fine aggregate.

The maximum slump value obtained by the replacement of polypropylene as coarse aggregate compared to fine aggregate. From the above results medium range of degree of workability was obtained.

c) Strength test results (polypropylene alone)

Table 4: Strength test results for various % fine polypropylene at 28 days curing

% Replaced	Comp. strength (N/mm^2) at 28 days	Tensile strength (N/mm^2) at 28 days
0	30.22	3.93
1	30.44	4.02
3	29.77	3.50
5	26.66	3.14
7	24.44	2.88

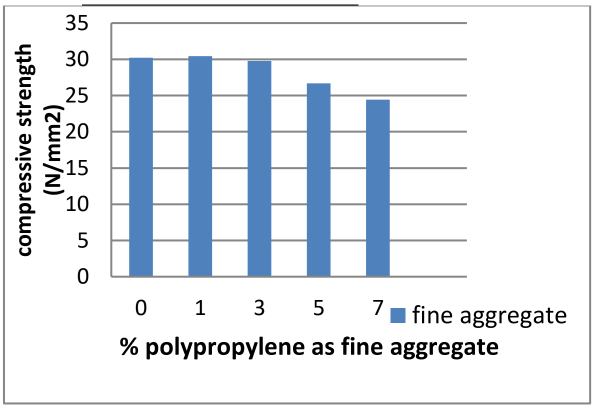

Fig. 6: Variation of compressive strength with polypropylene after 28 days

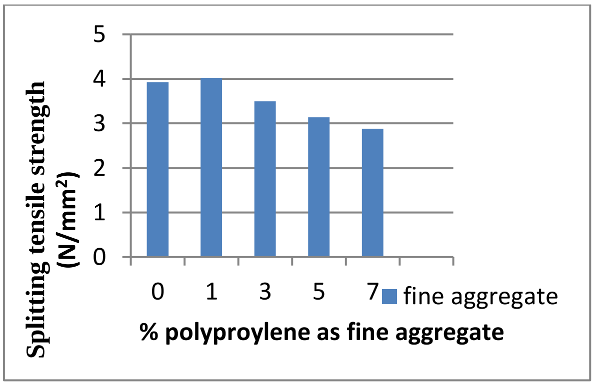

Fig 7: Variation of compressive strength with polypropylene after 28 days

The variation of compressive strength with percentage replacement of polypropylene is depicted in fig 6 - 7. In the case of replacing 1% of fine aggregate with polypropylene, the compressive strength is having higher value compared with normal specimen. As per IS 456-2000 characteristic compressive strength of M30 concrete is $30N/mm^2$. From the range calculation for 28 days the required compressive strength is 30.22 N/mm^2 and the obtained compressive strength of M30 concrete for 1% polypropylene is $30.44N/mm^2$, which is greater than the standard value. So it is of good quality.

In the case of replacing coarse aggregate (fig 6) with polypropylene, the compressive strength is having lower value compared with normal specimen.

Table 5: strength test results for coarse polypropylene at 28 days.

% replaced	Comp. strength (N/mm^2) at 28 days	Tensile strength (N/mm^2) at 28 days
0	30.22	3.93
2.5	22.80	3.36
5	23.55	4.16
7.5	20.89	4.02
10	20.40	2.27

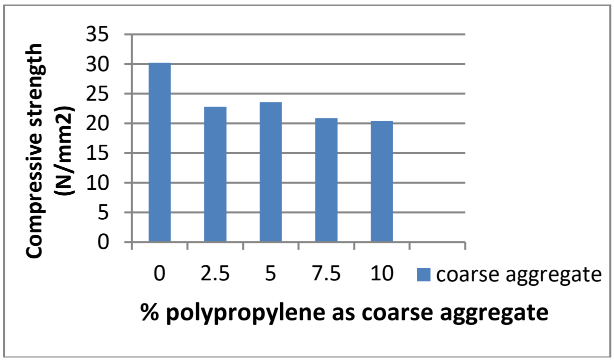

Fig 8: Variation of tensile strength with replacing polypropylene as coarse aggregate after 28days curing

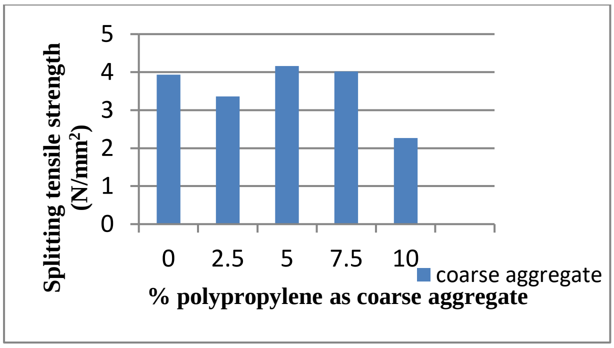

Fig 9: Variation of tensile strength with replacing polypropylene as fine aggregate after 28 days

In the case of replacing 1% of fine aggregate with polypropylene the splitting tensile strength having higher value 4.02 N/mm^2 when compared with normal. As per IS 456, clause 6.2.2 splitting tensile strength of concrete is given by $0.7\sqrt{30} = 3.83\ N/mm^2$.

d) Mix proportioning (polypropylene + metakaoline)

Table 6: Quantity of material required for preparation concrete with replacing fine aggregate with optimum % of polypropylene aggregate and cement with metakaolin

% metakaolin	0	5	10	15	20	25
cement	414	393	373	352	331	310
Fine aggregate	680	673	673	673	673	673
coarse aggregate	1119	1119	1119	1119	1119	1119

e) Slump test results (polypropylene + metakaolin)

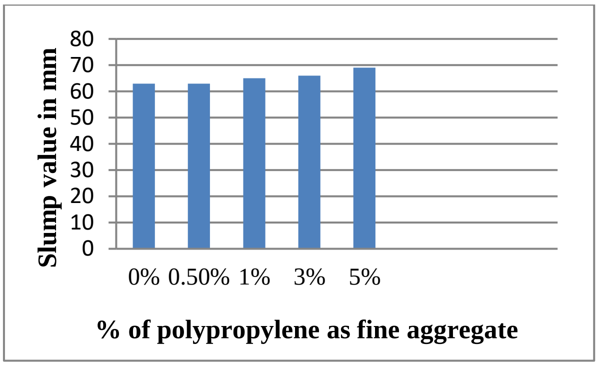

Fig. 10: Slump for different % of metakaolin replacement.

As the percentage replacement of metakaolin increases slump increases. Increase in slump may be due to water absorption rate of metakaolin.

f) Strength Test Results

Table 7: Strength test results

% replacement of metakaolin with 1% polypropylene fines	7th day strength		28th day strength	
	compressive strength (N/mm^2)	split tensile strength (N/mm^2)	compressive strength (N/mm^2)	split tensile strength (N/mm^2)
0	21.36	1.26	30.44	4.02
5	23.44	1.48	33.16	3.95
10	26.12	1.52	37.69	4.15
15	30.56	1.61	41.15	4.23
20	28.60	1.42	35.28	4.08
25	22.30	1.33	31.11	3.90

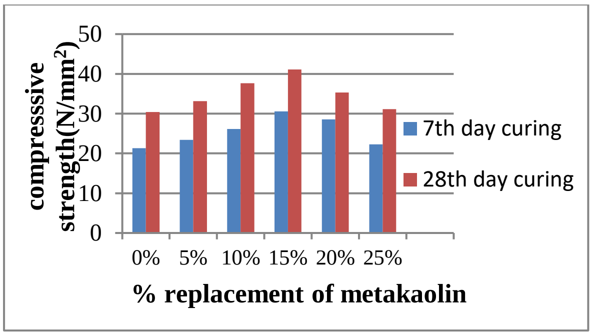

Fig.11: Variation of compressive strength with replacing metakaolin as cement with 1% polypropylene fines.

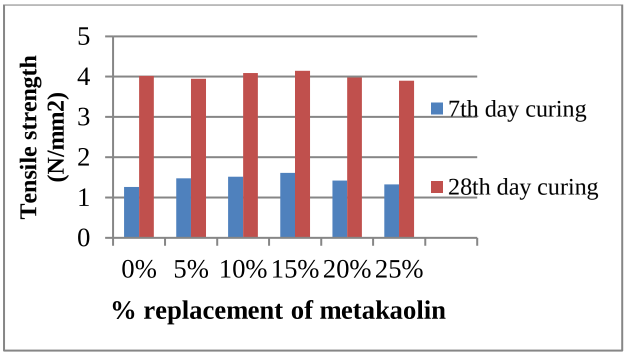

Fig.12: Variation of tensile strength with replacing metakaolin as cement with 1% polypropylene fines.

Metakaolin is fine particle structure making it a highly reactive, amorphous pozzolanos.during the cement hydration process, water reacts with Portland cement and forms calcium-silicate hydrate (CSH). The by-product of this reaction is the formation of calcium hydroxide (lime). This lime has weak link in concrete, and hence reduces the effect of the CSH. When Metakaolin is added in the hydration process, it reacts with the free lime to form additional CSH material, thereby making the concrete stronger and more durable. From the fig 11 the compressive strength of concrete mix is increases up to 15% of metakaolin added then decreases gradually because of reducing quantity of calcareous content. From the fig. 12 the splitting tensile strength of concrete is increase up to certain limit

VII) CONCLUSIONS

- Workability of concrete increased as the percentage addition of polypropylene increased .It is due to no water absorption capacity of plastic.
- The compressive and split tensile of M30 grade concrete increased with the replacement of fine aggregates with polypropylene.
- The strength results of M30 grade concrete decreased with the replacement of coarse aggregates with polypropylene. In this case compressive strength is less than that of values obtained for control mix and tensile strength is greater than that of values obtained for control mix.
- Increase in addition of metakaolin leads to the decrease in workability of concrete due to increase in water absorption capacity of metakaolin.
- By comparing engineering properties of replaced concrete with conventional concrete it can be concluded that concrete mix with 1% polypropylene replacing fine aggregate and 15% metakaolin replacing cement is a better substitute for construction purposes.

VIII) SCOPE FOR FURTHER WORK

- Study can be further extended with different grades of cement and with different grades of concrete.
- Further studies can be done on durability characteristics by conducting different tests like sulphate attack, sea water test, rapid chloride penetration test, accelerated corrosion test etc.

REFERENCES

[1]. Ankit Kumar, Vikas Srivastava and Rakesh Kumar "Effect of Waste Polythene on Compressive Strength of Concrete" Journal of Academia and Industrial Research (JAIR) Volume 3, Issue 3 , ISSN: 2278-5213 August 2014

[2]. Brajesh Mishra , Ravi Shanker Mishra, "A Study on Use of Plastic Waste Aggregate as Partial Replacement of Natural Coarse Aggregate in Cement Concrete Mix" International Journal of Innovative Research in Science, Vol. 4, Issue 11, November 2015

[3]. Sampada Chavan, Pooja Rao "utilization of Waste PET Bottle Fibers in Concrete as an Innovation in Building Materials" International Journal of Engineering Research Volume No.5,Issue Special 1 pp : 304-3 , 8 & 9 Jan 2016.

[4]. Rajendra T N and Surendra B.V "Effect of Partial Replacement of Cement by Fly Ash and Metakaolin on Concrete Strength with M. Sand as Fine Aggregate" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 06 , June -2017.

[5]. Sunny A.Jagtap, Mohan N. Shirsath, Sambhaji L. Karpe "Effect of Metakaolin on the Properties of Concrete" International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 07 , July -2017.

[6]. M Narmatha, Dr.T.Felixkala "Meta kaolin –The Best Material for Replacement of Cement in Concrete" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 13, Issue 4 Ver. I ,Jul. - Aug. 2016.

[7]. Bindu Biju and Imran H "Partial Replacement of Cement with Metakaolin in High Performance Concrete" International Journal of Innovative Research in Science, Engineering and Technology ,Vol 5, Special Issue 14, December 2016.

[8]. P. Suganthy, Dinesh Chandrasekar, Sathish Kumar. P. K " Utilization of Pulverized Plastic in Cement Concrete as Fine Aggregate" Volume:02 Issue:06 June-2013

[9]. Khilesh Sarwe " Study of Strength Property of Concrete Using Waste Plastics and Steel Fibers" Department of Civil Engineering , Jabalpur Engineering College, Jabalpur, India.vol 3,Issue 5, Pages 09-11, 2014

[10]. Pramod S. Patil, J.R.Mali, Ganesh V. Tapkire, H. R. Kumavat "Innovative Techniques of Waste Plastic Used in Concrete Mixture" International Journal of Research in Engineering and Technology.

[11]. Mohd Mustafa Al Bakri, G. Che Mohd Ruzaidi, M.N. Norazian, H. Kamarudin, S. Mohammad Tarmizi "effects of hdpe plastic waste aggregate on the properties of concrete" 06August 2017.