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Investigation on Properties of PET and HDPE Waste Plastic Concrete

Marabathina Maheswara Rao[1], Ramakrishna Gangadhar Ravula[2]
[1]*Research Scholar, Veera Surendra Sai University of Technology, Burla, Odisha, India.*
[2]*M.Tech. Scholar, Aditya College of Engineering & Technology, Surampalem, A.P., India.*

Abstract: ***Quantities of plastic wastes have increased in recent years due to increase in industrialization and the rapid improvement in the standard of living. In India, most plastic wastes are abandoned and not recycled, causing serious problems, such as the waste of natural resources and environmental pollution. Plastic products are made from petrochemical compounds, and they degrade extremely slowly in the natural environment. Plastic materials are not easily biodegradable even after a long period. In fact, a wide variety of waste materials can be utilized as inert materials in the cement matrix. The aim of this work is to study the properties of HDPE (High Density Polyethylene) concrete and PET (Polyethylene Terephthalate) concrete to characterize this plastic waste concrete as a potential replacement for coarse aggregate and fine aggregate in concrete. Four compositions of coarse aggregate with different HDPE waste 100:0, 95:5, 90:10, 85:15 coarse aggregate by volume ratios and fine aggregate with PET waste in similar replacement levels is used. Comparisons of conventional concrete with plastic waste as coarse aggregate and Fine aggregate are made. The effects of plastic wastes on the workability and strength of the concrete with fresh and hardened concrete tests were analyzed. After conducting the experiments it is observed that there is decrease in the slump values and decrease in the strength values in Compressive strength and Flexural strength and increase in Split Tensile Strength with increase in percentage replacement of PET and HDPE plastic waste. By the experimental analysis it is concluded that the plastic waste concrete is recommended for general ordinary constructions.***
Keywords: HDPE, PET, Workability, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Concrete mainly contained with cement, fine aggregate, coarse aggregate and water, in addition to this some admixtures are added to maintain workability. Aggregate are the important consideration in concrete mix because it can occupy about 60 to 80 percentage by its volume. So that we can take care of using aggregate for maintaining better strength and durability property. In this project, plastic wastes are introduced by replacing coarse aggregate and fine aggregate. As it is becoming difficult and expensive to dispose the plastic waste in dumpsites there is dire need to take measures to reduce the plastic waste that are delivered to dump sites. in general, are becoming overcrowded and expensive for waste disposal, efforts must be made to minimize the quantities of materials that are delivered to landfills. As the production of waste cannot be prevented, then it is suggestible to find a possible way that uses the waste for another purpose instead of dumping in the garbage sites. Therefore the recycling can be advantageous in economy point of view, requires less cost for removal of waste and due lower costs of removing the waste and the lowering of environmental pollution of pollution and makes hazard free. Plastics are non-eco-friendly, these are obtained mainly from petro- chemicals and can be molded into required form. So that it is better chance to find the strength variations in concrete by using plastic waste with respect to aggregates. Using plastic waste in concrete, the mechanical properties like compressive strength, split tensile strength and flexural strength and also workability of concrete is observed. So that it can utilize this waste product as a conservative product. And also minimize the waste disposals. Here HDPE (High Density Polyethylene) and PET (Polyethylene Terephthalate) are the plastic wastes used in different proportion in the place of aggregate. Coarse aggregate is replaced with HDPE and Fine aggregate is replaced with PET in different percentages. Here, Fine Aggregate is replaced with PET in different proportions like 0%, 5%, 10% and 15% by its volume. And similarly Coarse aggregate is replaced with HDPE in different ratios at 0%, 5%, 10% and 15% by its volume.

II. LITERATURE REVIEW

Abhijitpawer, Akhasy Gabgurde and K. Vikram replacedfine aggregate by 10 to 20 % with plastic waste to achieve green concrete. In addition to this, sand is replaced to 30% in members that do not carry Heavy loads. Plastic waste like Polyvinyl chloride (PVC), Polyethylene, Poly Propylene (PP) are introduced in concrete, and concluded that it can reduce the environmental problems and can minimize the issues of disposals of major plastic waste and hence can reduce global pollution, especially countries which face the

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problem regarding waste management. In order to the environmental considerations it was noted that the use of plastic waste in concrete production, it may be used to be a fight the obstacle of scarcity of Natural sand in India and some other countries. Finally, Author concluded that the use of such plastic waste can reduce the cost of construction and also pollution.

Youcef Ghernouti, Bahia Rabehi, Brahim Safi and RabahChaid has done research on replacement of plastic waste bags in place of fine aggregate in different proportions (10 – 40%). The Workability, bulk density and on mechanical properties, and Non Destructive Test (NDT) of concrete were investigated, and concluded that there is decrease in bulk density considerably for all replacement levels of fine aggregate with plastic waste bag. Concrete becomes lighter at 40% replacement level compared to conventional concrete. The plastic waste bag replaced concrete shown good workability. The obtained compressive strength with plastic waste bag as replacement with fine aggregate is nearer to the conventional concrete. They also concluded that reduction of compressive strength at 28 days is about 9% and 23% on the concrete which contain 10% and 20% of plastic waste bag replaced concrete respectively. From the Ultra Sonic pulse velocity test, the speed of the sound is higher in concrete containing lowpercentage plastic waste bag with reference to conventional concrete. Compactness is reduced due to the addition of plastic waste bag this reduction is due to the circular shape of the waste which increases the voids volume. Finally he concluded that Plastic Waste Bag (PWB) replacement as successful substitute of natural aggregate. As these shows strength development without any detrimental effects.

Raghatateatul m. has done research on “Use of plastic waste in a concrete to improve its properties”. He used the plastic waste bag as additional material in different proportions from 0 to 1 %. Concrete is prepared with these plastic waste for M20 grade with water cement ration of 0.45. Concrete specimens are tested at 3days, 7days and 28days. He conducted experiments to find out the mechanical properties such as compressive strength ad split tensile strength. From his experimental studies he concluded that there is a decrease in strength about 20%, after 28days by the addition of 1% plastic waste. With the percentage increase in plastic content he observed the decrement of the strength. The rate of reduction of strength is very low. Split tensile strength goes on increase up to a replacement level of 0.8 percent and there after shown decrease of its strength. Finally he concluded that the use of plastic bag improves the properties and also acts as a reduction measure of disposal.

alekbatayneh, Iqbalmarie, Ibrahim asi has done investigation on “use of selected waste materials in concrete mixes”. He used ground plastics, glass as replacements to fine aggregate up to 20% and recycled concrete as replacement to fine aggregate up to 20%. His investigation focused on the workability, unit weight, compressive strength, indirect tensile strength and flexural strength. By his observations we came to know that there is decrease in the slump value with increase in plastic particle content, the use of glass will show no significant effect on slump, Whereas other replaced material shows lower slump at higher percentage of replacement and reduce the compressive strength about 25% it 20% replacement level of plastic particle compared to conventional concrete. The compressive strength reduced up to 72% with the replacement of 20% and 20% reduction in strength with 5% replacement. Compressive strength is decreased in both the concrete replaced with crushed concrete and plastic particle and there is more decrease in strength in case of plastic particle replacement compared to crushed concrete replacement. And glass shows increased strength.

Manhal A Jibrael1 and Farah Peter: They had done the research onrecycledplastic waste (Polyethylene) in 1%, 3%, 5% replacement with fine aggregate. He conducted tests on 126 samples to find mechanical properties like compressive strength, split tensile strength and flexural strength 7days and 28days. From his observations we came to know that the compressive strength decreases for 12.8 percent, 10.8 percent and 4 percent at 7days for replacement levels of 1%, 3%, 5% and similarly for 7.9%, 28,5% and 23.5% at 28days for replacement levels of 1%, 3%, 5%. And 27.5%, 29.4% and 7.9% decrease in strength is observed at the age of 7days at replacement levels of 1%, 3%, 5% and at 28days age is 16.41%, 27.4% and 32.5% there is more decrease in strength of concrete containing waste plastic bags as replacement than waste plastic bottle replacement. He finally concluded that these concrete mixes are used for nonstructural concrete members.

III. EXPERIMENTAL INVESTIGATION

A. Materials used

1) Cement: Portland Slag cement is used.

B. Fine aggregate

The material which passes through BIS test sieve number 4 (4.75mm) is termed as fine aggregate usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as fine aggregates. In our region fine aggregate can be found from Godavaririver. It conforms to IS: 383- 1970 comes under zone II.

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C. Coarse Aggregate

Coarse aggregate crushed angular granite metal of 12 mm, 20mm size was used.

D. Plastic waste

In this study, HDPE and PET plastic waste particles are used.

Fig.1 HDPE plastic particles

Fig. 2 PET plastic waste particles

IV. EXPERIMENTAL PROGRAM

A. Mix Proportions

Mix proportions were adopted as per IS-10262-2009. For test specimens Portland Slag cement, natural river sand and coarse aggregate, HDPE and PET plastic waste are utilized. The experimental program was designed to the study of properties of concrete with replacement of aggregates with plastic waste for M20 grade of concrete.

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Fig. 3. Shredding plastic waste

Fig. 4. HDPE particles

Fig. 5. PET particles

Fig. 6. Mixing of ingredients

Fig. 7. Casting of Specimens

Fig. 8. Water Curing

B. Workability of Concrete

The workability of concrete can be found out by using Slump Cone test.

Fig. 9. Slump Cone Test

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TABLE 1
Slump values of M20 Mix concrete(PET replacement)

S.No	Percentage of PET replacement	Slump value
1	0	58
2	5	42
3	10	36
4	15	.17

TABLE 2
Slump values of M20 Mix concrete(HDPE replacement)

S.No	Percentage of PET replacement	Slump value
1	0	58
2	5	40
3	10	35
4	15	.0

C. Compressive Strength of Cubes

The compressive strength of concrete was determined by conducting tests on 150 mm x 150 mm x 150 mm cube specimens were casted and cured for 7 and 28 days. The test was carried out in the compression testing machine of 2000kN capacity. In this test 24 cubes were tested. The cubes were placed in the compression testing machine and the load was applied until the failure of the specimen. The average values of three samples were taken as strength.

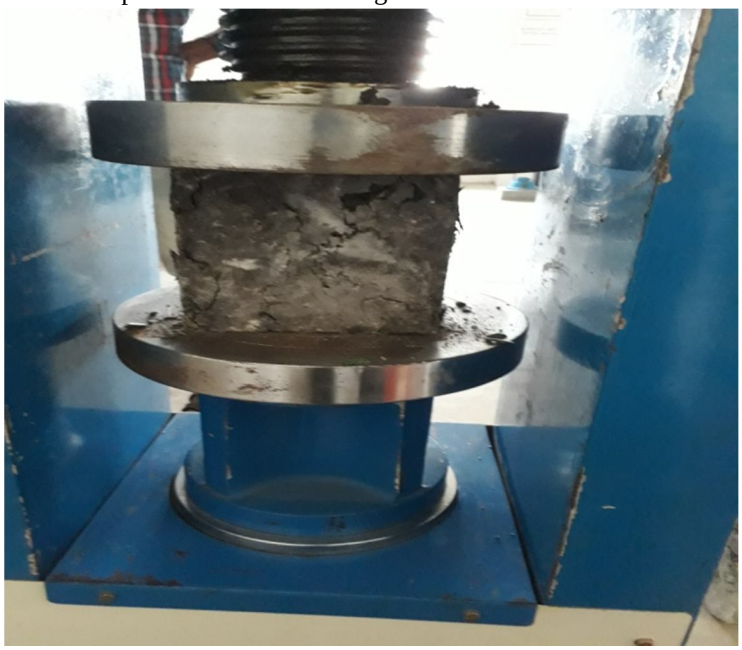

Fig 10.Compressive Strength Test

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The compressive strength of the cubes after replacement of natural aggregates with plastic waste of is studied for 28days shown in Table 3 & 4.

TABLE 3
Compressive Strength of M20 Mix concrete(PET replacement)

S.No	Percentage of PET replacement	28 Days(Mpa)
1	0	27.96
2	5	19.89
3	10	14.48
4	15	8.00

TABLE 4
Compressive Strength of M20 Mix concrete(HDPE replacement)

S.No	Percentage of HDPE replacement	28 Days(Mpa)
1	0	27.96
2	5	14.81
3	10	14.17
4	15	5.21

D. Split Tensile Strength of Cylinders

The determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. Split tensile strength is an indirect method of finding out the tensile strength of concrete. 24 numbers of 150 mm diameter and 300 mm height cylinders were prepared tested for Tensile splitting strength The test is carried out by placing the cylindrical specimens horizontally between the loading surfaces of the compression testing machine and the load is applied until the failure of the cylinder.

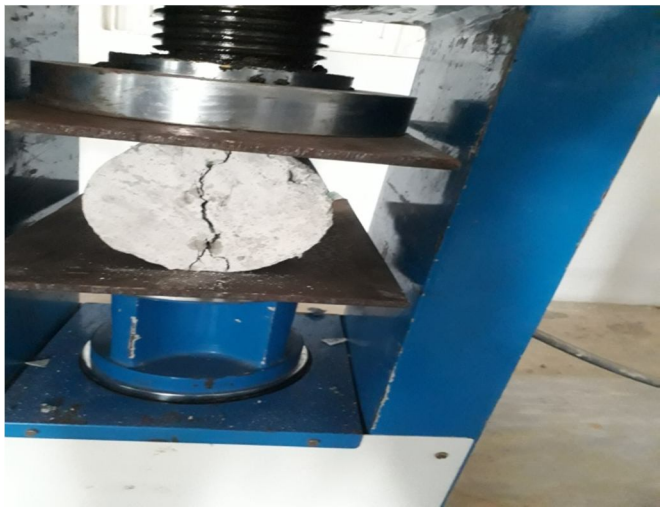

Fig. 11 Split Tensile Strength Test

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The 28 days split tensile strength of the cylinders after replacement of natural aggregates with plastic waste isshown in Table 5 & 6.

TABLE 5
Split tensile Strength of M20 Mix concrete(PET replacement)

S.No	Percentage of PET replacement	28 Days
1	0	0.82
2	5	1.36
3	10	1.51
4	15	1.61

TABLE6
Split tensile Strength of M20 Mix concrete(HDPE replacement)

S.No	Percentage of HDPE replacement	28 Days
1	0	0.82
2	5	1.50
3	10	1.503
4	15	2.42

G. Flexural Strength of Prism

Flexural strength tests were carried out on 100 mm x100 mm x 500 mm prisms on the 28th day using Universal Testing Machine (UTM) apparatus. The two point loading system was used in finding out the flexural strength as per IS 516–1959.

Fig. 12 Flexural strength Test

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The flexural strength of the prisms after replacement of natural aggregates with plastic waste of is studied for 28day is shown in Table 7 & 8.

TABLE 7
Flexural Strength of M20 Mix concrete(PET replacement)

S.No	Percentage of PET replacement	28 Days(Mpa)
1	0	4.93
2	5	3.73
3	10	1.87
4	15	.73

TABLE 8
Flexural Strength of M20 Mix concrete(HDPE replacement)

S.No	Percentage of HDPE replacement	28 Days
1	0	4.93
2	5	4.13
3	10	3.86
4	15	2.8

V. DISCUSSIONS AND RESULTS

A. Slump Values

It is a measure of workability and consistency. The workability of concrete increases with the increase in water cement ratio and decreases with decrease in water-cement ratio. As the percentage replacement of waste plastic increases, there is decrease in slumpin concrete mixes containing HDPE and PET. There is a decrement in slump value in both cases. This is because the mixture forms a stiff paste which is less workable.

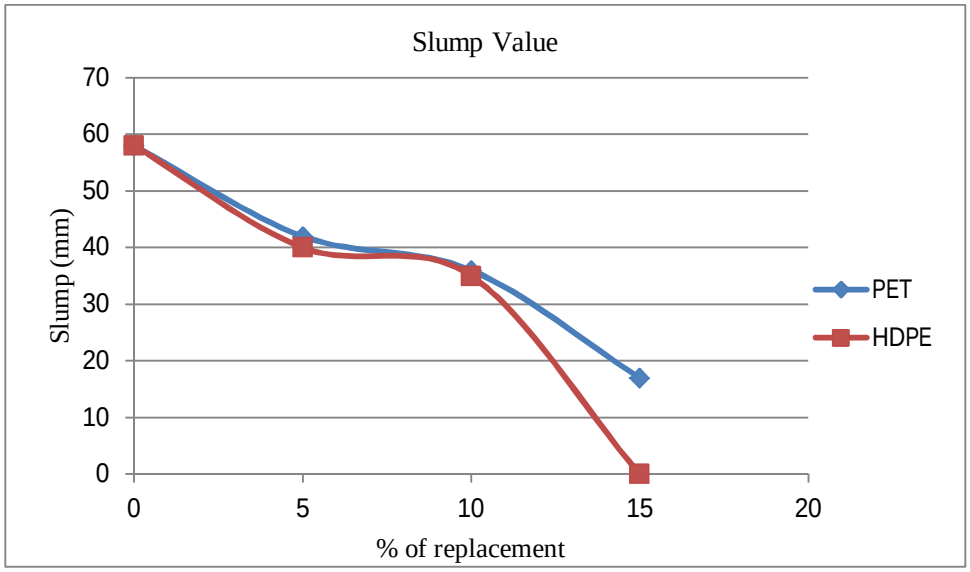

Fig. 13 Relation between Percentage of replacement and Slump

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B. Compressive Strength

As the percentage of replacement of waste plastic increases, there is decrease in Compressive strength in Concrete mixes containing HDPE and PET waste plastic compared to conventional concrete. Concrete containing PET particles shown decrement in compressive strength by 28%, 48% and 71% at 5%, 10% and 15% replacement levels respectively whereas Concrete containing HDPE particles shown decrement in compressive strength by 48%, 49% and 81% at 5%, 10% and 15% replacement levels respectively.

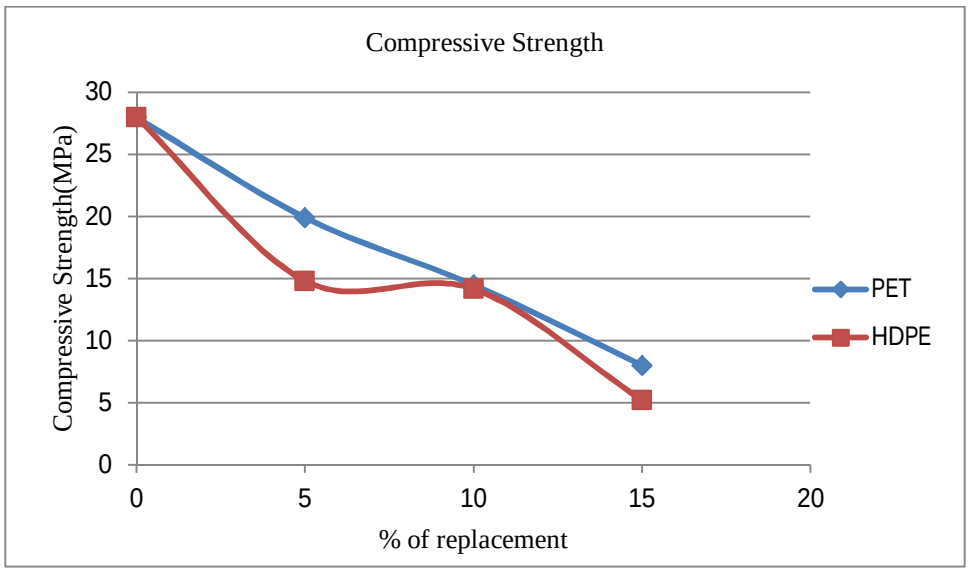

Fig. 14. Relation between Percentage of replacement and Compressive Strength

C. Split Tensile Strength

As the percentage replacement of waste plastic increases, there is increase in Split Tensile strength in Concrete mixes containing HDPE and PET waste plastic compared to conventional concrete. In case of concrete containing PET there is increase in strength by 65% at 5% replacement level,84% increase in strength at 10% level and 96% increase in strength at 15% replacement level and in case of concrete mix containing HDPE waste plastic there is increase in strength by 82% at 5% replacement level,83% increase in strength at 10% replacement level and 195% increase in strength at 15% replacement level.

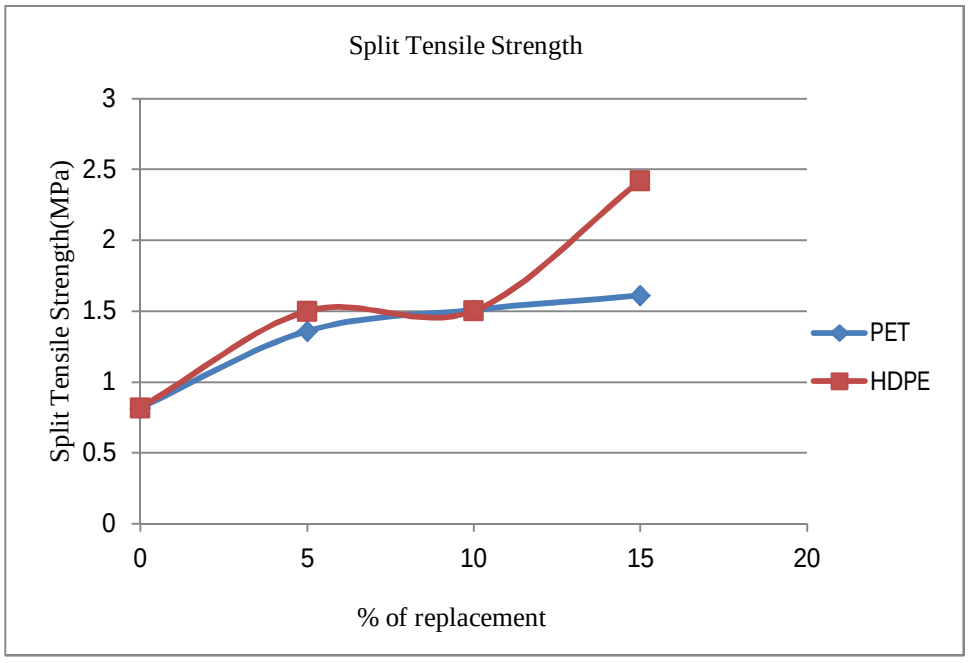

Fig. 15. Relation between Percentage of replacement and Split Tensile Strength

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D. Flexural Strength

As the percentage replacement of waste plastic increases, there is decrease in Flexural strength in Concrete mixes containing HDPE and PET waste plastic compared to conventional concrete. In case of concrete containing PET there is decrease in strength by 24% at 5% replacement level,62% decrease in strength at 10% level and 65% decrease in strength at 15% replacement level and in case of concrete mix containing HDPE waste plastic there is decrease in strength by 16% at 5% replacement level,22% decrease in strength at 10% replacement level and 43% decrease in strength at 15% replacement level.

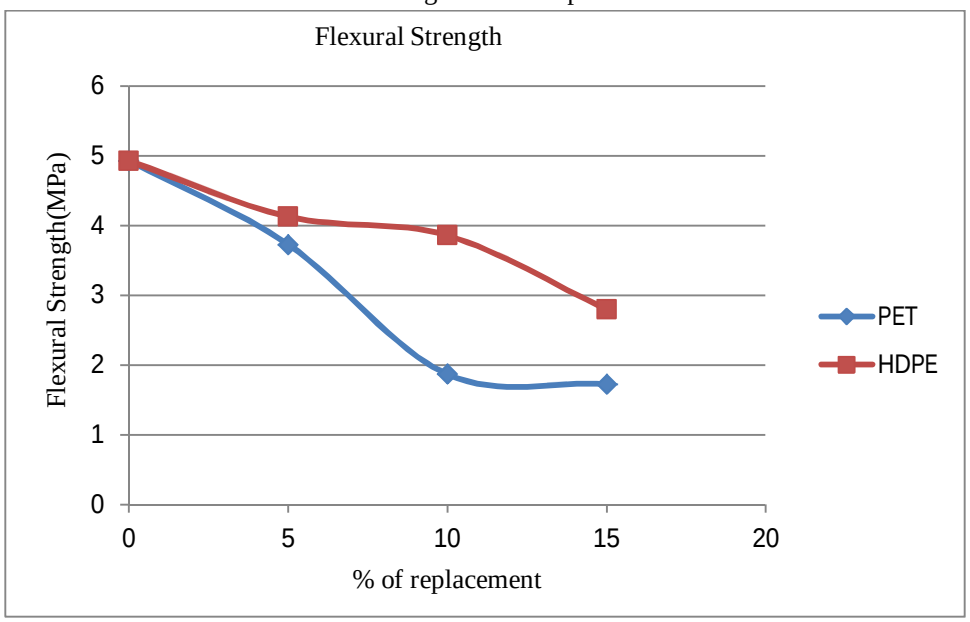

Fig. 16. Relation between Percentage of replacement and Flexural Strength

VI. CONCLUSION

A. By considering the workability from the Slump cone test, the conventional concrete is more Workable and concrete containing with HDPE plastic and PET plastic are less workable. The workability of concrete containing PET particles decreased by a maximum of 70% at 15% replacement level and the workability of concrete containing HDPE particles shown zero slump at 15% replacement level.

B. Compressive strength of concrete reduced gradually in both cases with increase in percentage of HDPE plastic and PET plastic waste in concrete, there is more reduction in strength in concrete mix containing HDPE waste plastic than in concrete mix containing PET plastic waste. The compressive strength of concrete containing PET particles decrease bya maximum of71% at 15% replacement level and the compressive strength of concrete containing HDPE particles decrease by a maximum of 81% at 15% replacement level compared to control mix.

C. Split Tensile strength values are increased in concrete mixes using HDPE and PET plastic waste with increase in percentage of replacement. There is more increase in strength in concrete mix containing HDPE waste plastic than in concrete mix containing PET waste plastic. The Split Tensile strength of concrete containing PET particles increase by a maximum of96% at 15% replacement level and the Split Tensile strength of concrete containing HDPE particles increase by a maximum of 195% at 15% replacement level compared to controlmix.

D. Flexural strength values are reduced in concrete mixes using HDPE and PET plastic waste with increase in percentage of replacement. There is more reduction in flexural strength in concrete mix containing HDPE waste plastic than in concrete mix containing PET plastic waste. The flexural strength of concrete containing PET particles decrease by a maximum of 65% at 15% replacement level and the flexural strength of concrete containing HDPE particles decrease by a maximum of 43% at 15% replacement level compared to control mix.

E. Finally from the overall analysis, it can be concludes that concrete containing plastic waste can be recommended for concrete. Therefore can reduce the pollution and wastage up to some extent.

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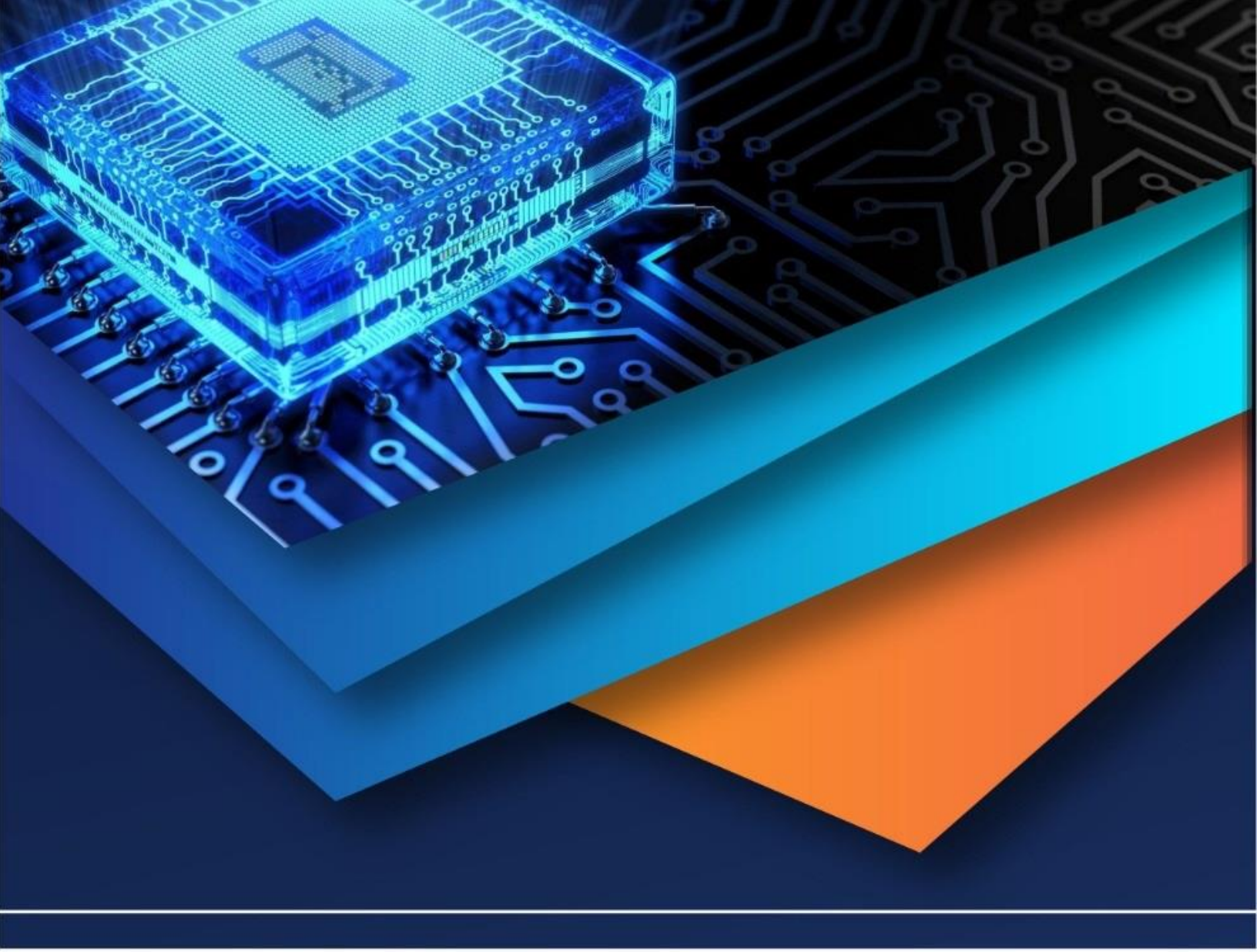

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