International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL STUDY ON CONCRETE WITH PULVERIZED PLASTIC AS REPLACEMENT FOR FINE AGGREGATE

Gopal B Bekkeri[1], Sachin K C[2], Chetan K M[3], Impa K A[4]

[1]Assistant Professor, Department of Civil Engineering, KLE Dr. MSSCET, Belagavi, Karnataka, India
[2]Research Scholar, Department of Civil Engineering, RV College of Engineering, Bengaluru, Karnataka, India
[3]Assistant Professor, Department of Civil Engineering, Rajeev College of Engineering, Hassan, Karnataka, India
[4]Assistant Professor, Department of Civil Engineering, Coorg Institute of Technology, Kodagu, Karnataka, India

---***---

Abstract: *Expansion in urban area and luxury life style is creating huge quantum of waste. Solid waste creates negative impact on the environment by polluting land, air and water. The prime eco-detrimental constituent of solid waste is plastic. As the plastic decomposition rate is too low, it is retained in the environment for long time. Concrete being a best construction material, provides a platform to restrict the movement and to gallop the waste materials in it as an ingredient. Plastic waste is pulverized and used as aggregate in concrete as it answers the problem of plastic waste disposal. In this study pulverized plastic is replaced for fine aggregates at various replacement levels in concrete. From the studies it is proved that, pulverized plastic can partially replace the fine aggregate, there by contributing to reduce the impact of sand mining. As this concrete reduces the raw material usage and ill-effects on environment, it can be considered as an eco-friendly concrete*

Keywords: Concrete, Fine aggregate, Manufactured sand, Pulverized plastic, Eco-friendly concrete

1. INTRODUCTION:

Concrete is a prime construction composite consisting of binder, fine and coarse aggregates which forms a solid mass on hydration. Aggregates forms the major constitute of concrete by having a share of about 75% in volume [1]. With the rapid growth in infrastructure activities, rate of concrete utilization has increased drastically leading to over exploitation of natural resources such as sand. Excess usage of river sand has led to extreme mining activities in river which deplete water retaining strata, deep river beds, decline of water table and negative impact on aquatic life. Excessive quarry activity for crushed rock sands might also cause risk of landslides and other adverse effect on the environment and man kind in the vicinity [2][3]. Hike in price and shortage of raw materials of concrete has made the technocrats to adopt waste or discarded materials as a replacement to the in-short materials. Aggregates shall be carefully replaced by alternatives as their characteristics will affect the fresh, mechanical and durability properties of concrete [4].

Solid waste disposal has become a challenge to the municipal authorities. Wastes of polymer are major kind of plastics found in urban solid waste. Plastic has become a vital part of human life because of its strength, durability, low cost and weight. It is used in almost all sectors right from packaging to automobile parts. As plastic waste is non-biodegradable, it can stay on the earth for decades and pollute soil, water and air [5][6][7]. Plastics have very high strength to weight ratio in comparision with other materials. It is also durable, mouldable at low cost with minimum density [8]. In 2015, around 320 million tonnes of plastic was manufactures on earth [9].

Used plastic are treated by either of these 3 process, land filling, recycling and incineration. Landfill creates soil pollution as these are non-bio degradable and incineration liberates toxic gases into atmosphere creating air pollution. Recycling reduces pollution and energy requirement and also saves natural resources and leads to sustainable environment [10]. 4.8 to 12.7 million ton wastes of plastic are dumped in water bodies such as oceans creating a havoc in marine environment[7][9]. It is better to replace these waste in landfills by light weight aggregate as a part of waste management. If the surface of plastic waste aggregates is smooth and spherical in shape, workability will increase with increase in replacement levels [6].

Plastic wastes shall be treated to form pulverized plastic to meet the requirements of fine aggregates. It will reduce the cost of the composite and land fill area requirement. This kind of concrete are economical, durable, resistant to chemical ingress, light in weight, with low thermal and electrical conductivity [11][12][10]. Workability of concrete containing plastic aggregates is influenced by the type treatment the aggregates are subjected to while preparation [6]. Workability and density of plastic aggregate incorporated concrete reduces with increase in replacement due to non-uniform and irregular shapes [5][13][12]. Use of plastic as aggregates, reduces the total weight of concrete, thereby reducing the density which provides a positive effect during earthquakes due to low self-weight [12]. Modulus of elasticity of concrete reduces with increase in replacement levels of plastic aggregates. Increased air content, hydrophobic aggregates, immiscibility of natural and fine aggregates are the drawbacks of using plastic aggregates [8]. Incorporation of pulverized plastic aggregates reduces the requirement of natural aggregates and also reduces the cost of construction. As the waste material is recycled and use of virgin material is suppressed, this concrete shall be called as eco-friendly concrete, which is very much essential for sustainable environment.

2. MATERIALS USED

Materials used for this experimental studies were examined as per the IS Codes.

Coarse Aggregates (CA)

Commercially available coarse aggregate of size ranging from 20mm to 4.75mm was procured from a quarry at Hassan district. Studies were conducted according to IS 2386-1988 part-3 [14]and represented in Table 1.

Table 1: Properties of coarse aggregate

Features	Obtained values
Fineness Modulus	5.712
Specific gravity	2.66
Water Absorption	1.6%
Bulk Density	1590Kg/m^3

Fine Aggregates (FA)

M sand procured from Chikkaballapura quarry was used as fine aggregate. Tests were conducted as per IS code 2386-1968 part-3 and IS: 383- 2016 [14], [15] are listed in table 2.

Table 2: Properties of Fine aggregates

Features	Obtained values
Fineness Modulus	4.11
Specific gravity	2.52
Water Absorption	2.1%
Bulk Density	1810kg/m^3

Cement

Chittinad OPC 53 grade Cement was used for this study. Cement sample was tested as per code IS-4031-1988 and IS 269-1976 [16][17].The various physical properties of cement are examined and listed below in table 3.

Table 3: Properties of cement

Features	Obtained values
Specific gravity	3.09
Fineness of cement	5%
Specific gravity	3.12
Standard consistency	36%
Initial setting time	50 min
Final setting time	250 mins
28 days compressive strength	56.5 MPa

Pulverized Plastic

Pulverized plastic is a recycled product, manufactured in the form of thin wires and cut down to a size of lesser than 4mm. Plastic being a polymer material, exhibit uniform properties unlike conventional aggregates. Tests were conducted as per IS code 2386-1968 part-3 and IS: 383- 2016 [14], [15] are listed in table 4.

Table 4: Properties of Pulverized plastic

Features	Obtained values
Specific gravity	0.71
Fineness modulus	1.77
Bulk density	490kg/m^3

Water

Water is an essential in concrete for lubrication of ingredients, hydration process and curing. The portable water available in laboratory is used for this research. Properties of water satisfies the requirements according to IS:456 – 2000 [18].

3. EXPERIMENTATION

Mix design was prepared according to IS: 10262- 2019 [19] for M-35 concrete with 0.45 water-cement ratio for moderate exposure condition. Ingredients of concrete was subjected to uniform dry mixing in drum mixer, followed by the addition of water mixed with 1% of super plasticizer to attain a slump of 100mm. Pulverized plastic aggregates were replaced for M-sand at 15, 30, 45 and 60% by weight of fine aggregates. The details of the mix design and fine aggregate replacement are as mentioned in the Table 5.

The material were subjected to weigh batching and mixed in drum mixer until uniform dry mix is obtained. Workability of wet concrete was determined using slump cone test as per IS: 1199 – 1959 [20]. The concrete was filled in 3 layers into the cube, cylinder and beam moulds according to IS: 516 -1959 & IS: 10086 -1982 [21], [22].

Demoulding was done after 24 hours and then the specimens were cured till the date of testing. Compressive strength, split tensile strength and flexural strength of the specimens were determined according to IS: 516-1959 [21]. To check porosity of the specimens, sorptivity test was conducted.
Concrete specimen of 7.5cm diameter and 7,5cm height was used to determine the sorptivity. After 28 days of curing, samples were subjected to drying under sunlight and dry weight was noted. Specimens were placed in water immersion of only 5cm height from bottom portion of sample. Specimens rested on the 3cm height metal piece for the free movement of water. After 24 hours, specimens were

taken out of water and weight was noted. Sorptivity of the specimen was determined using following formula.

$$\text{Sorptivity} = (q / a) \times (1 / \sqrt{T})$$

q = (Saturated weight) – (dry weight)
a = area of exposed surface
T = Time

Table 5: Mix Proportion of Trial Mixes

Mix Name	Plastic aggregate Replacement (%)	Cement (kg/m³)	C.A (kg/m³)	F.A (kg/m³)	P.P (kg/m³)	SP [1%]	Water (ltrs)	Workability (mm)
Mix 1	0			668.99	0			100
Mix 2	15			568.65	100.34			106
Mix 3	30			468.3	200.69			115
Mix 4	45	361.87	1202.38	367.94	301.05	3.61	162.84	Shear (128)
Mix 5	60			267.59	401.4			Collapse

4. RESULTS AND DISCUSSIONS

A. Compression strength test

Compression strength of concrete increased with age and the mix containing 30% pulverized plastic aggregates exhibited maximum strength at 28 days. Replacing m-sand by pulverized plastic aggregates increased the workability as plastic aggregates will absorb minimum water. By increased availability of water, make the matrix to occupy the voids due to vibratory compaction making it more sturdy. Compression strength of various trial mixes are represented in figure 1.

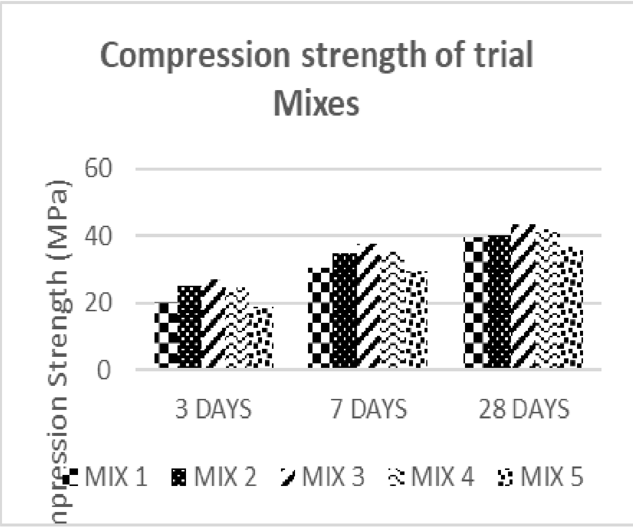

Fig 1: Compression strength of trial mixes

B. Split tensile strength

Cylindrical specimens were subjected to splitting testing to determine the split tensile strength. Split tensile strength results are proportional to compressive strength. At 30% replacement of m-sand by pulverized plastic aggregates, maximum strength is achieved at 28 days. Figure 2 depicts the variation of split tensile strength of concrete specimens at different ages and replacement levels.

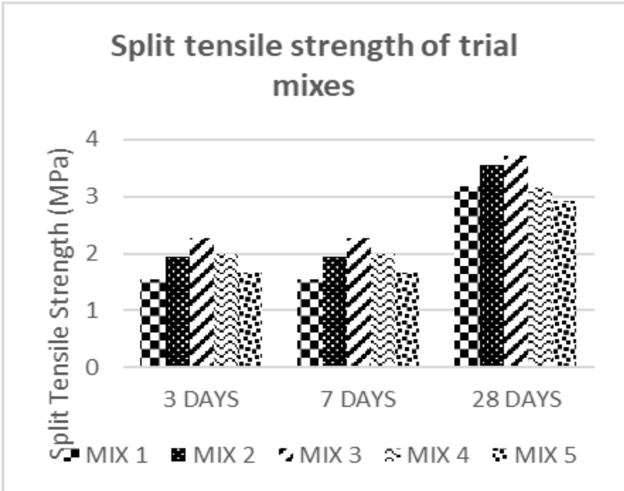

Fig 2: Split tensile strength of trial mixes

C. Flexural strength

Flexural strength of beams was determined by subjecting the specimens to two-point loading at 28 days of age. Specimens containing 15% of pulverized plastic aggregates exhibited maximum flexural strength as represented in figure 3. From this it can be noted that, with the increase in the replacement levels, concrete becomes brittle and hence the flexural strength decreases.

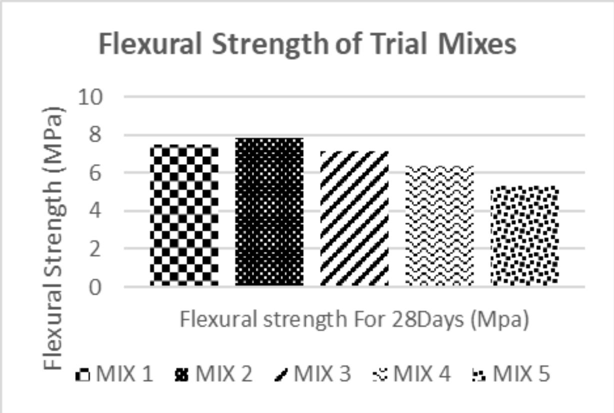

Fig 3: Flexural strength of trial mixes

D. Sorptivity test

Sorptivity of the material represents the porosity of the specimen. Sorptivity and porosity are directly proportional. As the sorptivity reduces, porosity also reduces. Lesser sorptivity represents presence of minimum voids in the matrix. From the figure 4, it can be observed that, porosity and sorptivity is minimum for the mix containing 30% of pulverized plastic as fine aggregates. The concrete with 30% of pulverized plastic would exhibit better durability over other mixes.

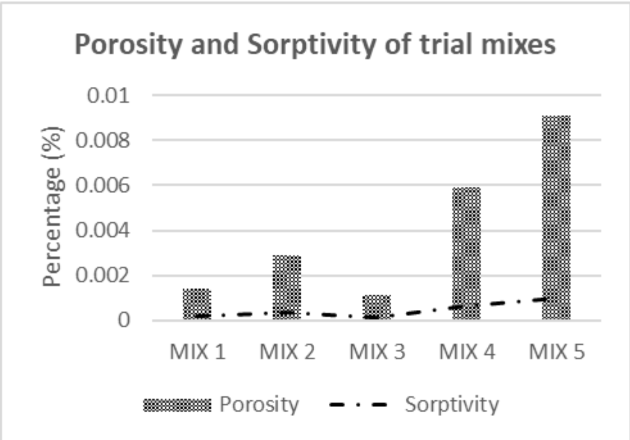

Fig 4: Porosity and Sorptivity of trial mixes

From figure 5, it is evident that concrete containing 30% of pulverized plastic aggregates as fine aggregates depicts optimum properties and hence, the same can be adopted in the constructions also to make the concrete sustainable.

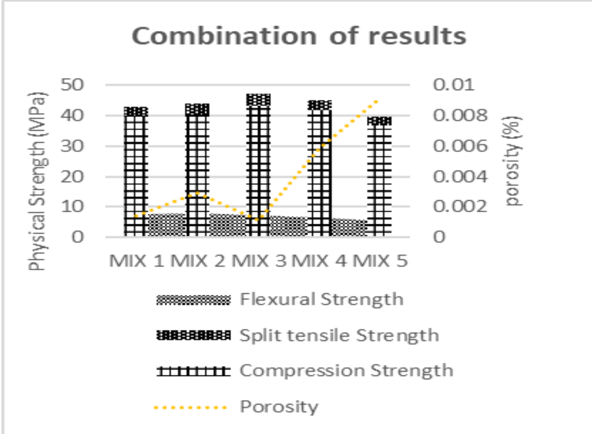

Fig 5. Combination of results

5. CONCLUSIONS

1. Pulverized plastic is smooth with minimum voids. Hence, workability enhances with increase in levels of plastic aggregates replacement.
2. Compression strength and split tensile strength is maximum at 30% replacement.
3. The flexural strength reduces at increased replacement levels. It is because of reduced adhesion between the surface of plastic particles and the cement paste. Maximum flexural strength if depicted at 15% replacement.
5. Porosity is minimal at 30% replacement. Sorptivity values remain minimum at 30% replacement, thus that mix can be considered as the durable mix.

Problem of land fill and environmental issues can be suppressed by encouraging the use of recycled product like pulverized plastic aggregates in concrete. By replacing conventional fine aggregate by pulverized plastic aggregates by 30% optimum strength and durability can be expected along with conservation natural resources. Thus, it can be considered as a eco-friendly concrete.

REFERENCES

[1] O.E. babalola, “Mechanical and durability properties of recycled aggregate concrete with ternary binder system and optimized mix proportion,” vol. 9, no. 3, pp. 6521–6532, 2020, doi: 10.1016/j.jmrt.2020.04.038.

[2] A. C. Sankh, P. M. Biradar, S. J. Naghathan, and M. B. Ishwargol, “Recent Trends in Replacement of Natural Sand With Different Alternatives,” *IOSR J. Mech. Civ. Eng.*, vol. 2014, no. February, pp. 59–66, 2014, [Online]. Available: www.iosrjournals.org.

[3] D. P. K. Wellala, A. K. Saha, P. K. Sarker, and V. Rajayogan, “Fresh and hardened properties of high-strength concrete incorporating byproduct fine crushed aggregate as partial replacement of natural sand,” *Front. Struct. Civ. Eng.*, vol. 15, no. 1, pp. 124–135, 2021, doi: 10.1007/s11709-020-0673-9.

[4] S. T. Ramesh, R. Gandhimathi, P. V. Nidheesh, S. Rajakumar, and S. Prateepkumar, "Use of furnace slag and welding slag as replacement for sand in concrete," *Int. J. Energy Environ. Eng.*, vol. 4, no. 1, pp. 2–7, 2013, doi: 10.1186/2251-6832-4-3.

[5] M. B. Hossain, P. Bhowmik, and K. M. Shaad, "Use of waste plastic aggregation in concrete as a constituent material," vol. i, no. 3, pp. 383–391, 2016.

[6] F. Pacheco-torgal, Y. Ding, and S. Jalali, "Author ' s personal copy Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): An overview," doi: 10.1016/j.conbuildmat.2011.11.047.

[7] S. Das and M. T. Alam, "utilization of plastic waste in concrete as a partial replacement utilization of plastic waste in concrete as a partial replacement of fine aggregate," January, 2019.

[8] A. J. Babafemi, B. Šavija, S. C. Paul, and V. Anggraini, "Engineering Properties of Concrete with Waste Recycled Plastic : A Review," 2018, doi: 10.3390/su10113875.

[9] M. T. G. A. S. Benosman and H. Taïbi, "Improving the properties of waste plastic lightweight aggregates - based composite mortars in an experimental saline environment," *Asian J. Civ. Eng.*, 2018, doi: 10.1007/s42107-018-0089-1.

[10] I. Almeshal, B. A. Tayeh, R. Alyousef, and H. Alabduljabbar, "Use of recycled plastic as fine aggregate in cementitious composites : A review Use of recycled plastic as fine aggregate in cementitious composites : A review," *Constr. Build. Mater.*, vol. 253, no. June, p. 119146, 2020, doi:10.1016/j.conbuildmat.2020.119146.

[11] A. M. B. T, "Partial replacement of E-plastic Waste as Coarse-aggregate in Concrete," *Procedia Environ. Sci.*, vol. 35, pp. 731–739, 2016, doi: 10.1016/j.proenv.2016.07.079.

[12] I. Almeshal, B. A. Tayeh, R. Alyousef, H. Alabduljabbar, and A. M. Mohamed, "Eco-friendly concrete containing recycled plastic as partial replacement for sand," *Integr. Med. Res.*, vol. 9, no. 3, pp. 4631–4643, doi: 10.1016/j.jmrt.2020.02.090.

[13] P. Suganthy, D. Chandrasekar, and S. K. P. K, "Utilization Of Pulverized Plastic In Cement Concrete As Fine Aggregate," pp. 1015–1019, 2013.

[14] IS 2386 (Part I)- "Methods Of Test For Aggregates For Concrete Particle size and shape," *Indian Stand.*, vol. 2386, no. Part VII, 1997.

[15] IS 383 2016 "Coarse and Fine Aggregate for Concrete - Specification Indian Standard, (Third Revision)," January, 2016.

[16] IS-4031-1988, "Methods of physical tests for hydraulic cement," Indian Standard, vol. 4031, no. August 1988, 1995.

[17] IS 269 : 2015 - "Indian Standard - Ordinary Portland Cement- Specification (Sixth Revision)," vol. 41, no. December 2015, 2017.

[18] IS 456, "Concrete, Plain and Reinforced," *Bur. Indian Stand. Dehli*, pp. 1–114, 2000.

[19] "IS 10262 -2019." Guidelines for concrete mix design proportioning.

[20] "IS : 1199-1959: Indian Standard Methods of sampling and analysis of concrete," *Indian Stand.*, pp. 1199–1959, 2004.

[21] IS 516:2014, "Method of Tests for Strength of Concrete," *IS 516 - 1959 (Reaffirmed 2004)*, p. New Delhi,India, 2004.

[22] "IS : 10086 - 1982 - Indian Standards - Specifications for use in tests of cement and concrete," vol. 1882, no. August 1982, 1999.