A Study on mechanical properties of standard concrete with Partial Replacement of Sand By Plastic Waste

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Abstract — In present the construction cost as lack of sand is enhancing day by day in order to counteract this problem, sand is partially replace in form of plastic wastes material. Plastic waste is recycled in form of the production of new material which may be used as optional component in concrete & is one of the best ways for discarding of plastic waste. Also these techniques proved to be highly cost effective than ordinary method. The objective of this dissertation is to utilize plastic waste as an optional replacement (0%, 10%, 20%, 40% & 60 %) of innate river sand and test it for compressive strength, tensile strength, flexure strength and sustainability.

Keywords— Recycle, plastic, concrete, strength.

I. INTRODUCTION

Concrete is a popularly used material in the world. More than 10 billion tonnes of concrete are consumed annually. Depend on widely usage it is settled at second position after water. Conventional concrete, a dynamic material is a blend of cement, sand, aggregate and water. Aggregate content is the factor, which are direct and far-reaching effects on the property of concrete. Unlike water and cement, which don't amalgam any particular characteristic except the number during which it's used, the mixture component is infinitely variable in terms of shape and grading. Top quality aggregate, both coarse and fine for concrete, is of very extreme importance. Aggregates consume 60 to 80% of the total base volume of concrete and affect on the fresh and hardened particles of concrete. Out of the total composition of concrete, the fine aggregate consumes around 18 to 30% of the volume.

Drawbacks of Using Natural River Sand:
Natural Sand (NS) is deficient in many aspects when used directly for concrete production. Extraction of the sand from river bed in excess quantity is hazardous to the environment. It is a standard sight that well foundations of the bridges are exposed considerably, due to excessive extraction of sand around the sub structure endangering the sub structure of the bridges. Excessive mining of the sand from river beds reduces the water head. This is due to the less percolation of rainwater in the ground.

II. RECYCLE PLASTIC

Plastic is one of the materials showing immense potential in our daily lives as it possess low density, high strength, user friendly designs, fabrication capabilities, long life, light weight and low cost characteristics are the factors behind such extraordinary growth. Although, plastics have been used in very large and useful applications, it bestows to an ever increasing amount in the solid waste stream. Polyethylene forms the largest fraction, which is followed by Polyethylene Concrete is the most widely used construction material in the world due to its high compressive strength, long service life, and low cost. In field of concrete technology, India as well as other nation now is seeking for an alternative for conventional aggregate that may be recognized as use plastic waste, for it might be realized as PET phase capacities. As per the estimates, India produces 500,000 tons of pet waste every
year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The PET bottles cannot be disposed of by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation. At present, the total recycling capacity in India is around 145,000 TPA its use in concrete mix will prove a better option for landfill that, being non-degradable, remain for long years and cause problem before us. Nowadays, unfortunately, the recycling rate of PET bottles is much less than the sales of virgin PET production for common uses, a possible application is to utilize waste PET pieces as replacement of fine aggregates in concrete. Plastics Packaging totals 42% of total consumption and every year little of this is recycled.

III. LITERATURE REVIEW

Researchers are going in and around the world for the utilization of various wastes for different purposes. Here some of the previous studies to replace fine aggregate in concrete with various Recycle plastic wastes are discussed.

Shyam, Drishya (2018) in their work a study on the partial replacement of M sand with High Density Polyethylene powder is carried out. A comparison between conventional concrete and concrete with HDPE powder is carried out to study the strength and durability parameters. In this work 5, 10, 15 and 20 percentage replacement of M sand with HDPE powder is experimented. Based on the results and observations of the experimental work conducted, the following conclusions are drawn: that plastic waste can be disposed by using them as a construction material in concrete. Workability decreases with increase in HDPE powder. Compressive strength, flexural strength and split tensile strength of concrete decreases with increase in HDPE powder. The optimum percentage of replacement by HDPE powder in terms of workability and strength is obtained as 5%. Compressive strength increases up to 16.6% for 5% replacement of HDPE powder. Split tensile strength increases up to 22.815% for 5% replacement of HDPE powder. Flexural strength increases up to 46.34% for 5% replacement of HDPE powder.

Charudatta P. Thosar, Dr.M.Husain(2017) In their experimental investigation replaced the natural river sand by using the plastic waste which is recycling from PET or PP waste. Partial replacement of sand by plastic waste material is done with M20 grade of concrete. Plastic waste were used to replace 20%, 40% & 60% of natural river sand in the concrete mixes and tested after 28 days for compressive strength, tensile strength, flexural strength and modified density of concrete. The experiment revealed that the partial replacement of plastic waste material can be done to a limit of 20% to 40% for the satisfactory properties of concrete which is acceptable limit for the constructional purpose in the civil industry.

M.Guendouz, Farid Debieb (2016) investigated the utilization of two type of waste plastic (Polyethylene Terephthalate (PET) and Low Density Polyethylene (LDPE) used for bags manufacture) as a plastic waste and fine aggregates (powder) in sand concrete. Various volume fractions of sand (10%, 20%, 30% and 40%) were substituted by the same volume of plastic aggregates, and various amount of plastic waste (0.5%, 1%, 1.5%, and 2%) were introduced by volume in sand concrete mixes. The physical and mechanical properties of the composites produced were studied. The results showed that the use of plastic waste as partial replacement of sand contributes to reduce the bulk density, decrease the air content, causing an increase in compressive and flexural strength and especially for 10% and 20% of replacement. In addition, the reinforcement of the cementing matrix with plastic waste induced a clear improvement of the tensile strength. This study insures that reusing waste plastic in sand concrete gives a positive approach to reduce the cost of materials and solve some environmental problem. (Ref.-5)

Saikia and Brito, (2014) presented the effects of size and shape of recycled polyethylene terephthalate
Three types of PET aggregate, collected from a plastic recycling plant, were shredded and separated fractions of similar types of PET bottles and one was a heat-treated product of the same PET bottles with sieve size from 0.5-11.2 mm. 5%, 10% and 15% in volume of natural aggregate in the concrete mix were replaced by an equal volume of three differently shaped and sized PET aggregates with different W/C ratios. Test results showed that density of fresh concrete decreased as the content of plastic aggregate increased. Differences in the size and shape of PET-aggregates affect the slump of fresh concrete mixes, which ultimately change the mechanical behavior.

The study also observed a reduction in the compressive strength of concrete due to the addition of PET-aggregates to replace natural aggregates. For 5% replacement the 28-day compressive is more than 75% of the compressive strength of reference concrete. For concrete with 10% and 15% plastic aggregate are respectively 71% and 59%. According to the authors, natural aggregates and PET-aggregate cannot interact with cement paste and therefore the interfacial transition zone in concrete containing PET-aggregate is weaker than that in the reference concrete, which lowers the resulting compressive strength. (Ref.-8)

Rahmani et al. (2013) investigated the effects of replacing 5%, 10% and 15% substitution of sand with PET processed particles. To determine the effect of the percentage of sand replacement with PET on concrete flexural strength, some beam specimens with dimensions of 50 × 10 × 10 cm³ were casted. (Ref.-6)

Hannawi et al. (2010) investigated the effect of using Non-biodegradable plastic aggregates made of polycarbonate (PC) and polyethylene terephthalate (PET) waste as partial replacement of natural aggregates in mortar. Various volume fractions of sand 3%, 10%, 20% and 50% are replaced by the same volume of plastic. The authors found a decrease in compressive strength when the plastic aggregates content increases. The drop in compressive strength seems to be not proportional to the volume fraction of sand replaced by plastic aggregates. A decrease of 9.8%, 30.5%, 47.1% and 69% for mixtures containing, respectively, 3%, 10%, 20% and 50% of PET aggregates, and of 6.8%, 27.2%, 46.1% and 63.9% for mixtures containing, respectively, 3%, 10%, 20% and 50% of PC aggregates is observed. According to authors the drop in compressive strengths due to the addition of plastic aggregates can be attributed mainly to the poor bond between the matrix and plastic aggregates.

The study presented the variations in the flexural strength of different mixtures as a function of the percentage of sand (in volume) replaced by the same volume of plastic aggregate. By comparing to control mixture, no significant changes are observed for mixtures containing up to 10% of PET-aggregates and up to 20% of polycarbonate (PC) aggregates. According to the authors, a decrease of 9.5% and 17.9% for mixtures with, respectively, 20% and 50% of PET-aggregates is observed. For mixtures with 50% of PC aggregates, a decrease of 32.8% is measured.
The authors found that the calculated flexural toughness factors increase significantly with increasing volume fraction of PET and PC aggregates. Thus, addition of PC and PET plastic aggregates in cementitious materials can give a good energy absorbing material which is very interesting for several civil engineering applications like structures subjected to dynamic or impact.

IV. RESULT AND DISCUSSION WORKABILITY OF CONCRETE

Workability of concrete is an important property to determine before placing of concrete. Concrete with high compaction factor is said to be more workable.

Table 1.1: Compaction Factor of Concrete W.R.T. Plastic waste Percentage

| Plastic waste Percentage | Compaction Factor |
|--------------------------|-------------------|
| 0%                       | 0.94              |
| 10%                      | 0.88              |
| 20%                      | 0.86              |
| 40%                      | 0.85              |
| 60%                      | 0.84              |

Table 1.1 shows values of compaction factor for the different values of plastic content in concrete. Concrete without plastic has high compaction factor whereas concrete with maximum plastic content showed lowest compaction factor.

Compaction Factor of Concrete with plastic waste

The comparison of Compaction factor for various plastic content percentages. It is observed that as the polypropylene plastic content in concrete increases compaction factor of concrete decreases accordingly hence the workability decreases. So concrete with 0% plastic has high workability and concrete with 2.0% has lowest workability.

Slump Test

Table No. 1.2 Slump for Control mix of M25 & M30 Grade

| S. No. | Control Mix | Slump (mm) |
|--------|-------------|------------|
| 1      | M25         | 75         |
Table No. 1.3 Slump with Plastic waste

| S. No. | Plastic waste % | Slump (mm) |
|-------|-----------------|------------|
| 1     | 0.0             | 70         |
| 2     | 10              | 68         |
| 3     | 20              | 64         |
| 4     | 40              | 61         |
| 5     | 60              | 59         |

Compressive Strength of Concrete
Compressive strength of concrete is utmost property of concrete. Cubes of dimensions 150×150×150 mm were cast and tested for compressive strength on compression testing machine.

Table 1.4 Compressive strength of M25 grade

| Plastic waste % | Compressive Strength (N/mm²) |
|-----------------|------------------------------|
|                 | 14 Days                     | 28 Days |
| 0.0             | 21.5                        | 26.83   |
| 10              | 23.8                        | 29.94   |
| 20              | 26.8                        | 33.65   |
| 40              | 27.86                       | 34.83   |
| 60              | 22.4                        | 27.8    |

Comparative Compressive Strength of M25 Grade

Split Tensile Strength of Concrete
Concrete is weak in tension so the testing of cylinder specimen for tensile strength is required. Cylinders of dimension 150mm (dia.) and 300mm (length) were cast and tested for split tensile strength on universal testing machine.
### Table 1.5 Splitting Tensile Strength of M25 grade

| Plastic waste % | Splitting Tensile Strength (N/mm²) | 14 Days | 28 Days |
|-----------------|-----------------------------------|---------|---------|
| 0.0             |                                   | 1.78    | 2.25    |
| 10              |                                   | 1.95    | 2.42    |
| 20              |                                   | 2.19    | 2.74    |
| 40              |                                   | 2.7     | 3.27    |
| 60              |                                   | 1.9     | 2.28    |

**Comparative Splitting Tensile Strength of M25 Grade**

### Flexural Strength of Concrete

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. For flexural strength test beams of dimensions 100×100×500 mm were cast and tested on flexural testing machine.

### Table 1.6 Flexural Strength of M25 grade

| Plastic waste % | Flexural Strength (N/mm²) | 28 Days | Percentage Increased |
|-----------------|---------------------------|---------|----------------------|
|                 |                           | 28 Days | Percentage Increased |
| 0.0             |                           | 2.7     | -                    |
| 10              |                           | 2.8     | 11.53                |
| 20              |                           | 3.4     | 26.92                |
| 40              |                           | 3.5     | 30.77                |
| 60              |                           | 2.8     | 3.84                 |
General Result Discussion
In this research, Experimental work was done.
Accomplish Compressive strength test, split tensile test and flexural strength on concrete having different Percentage (0%, 10%, 20%, 40% and 60%) of plastic waste.

**Results:** In this experiment, Mix-Design of M-25 grade concrete; reference IS 10262: 2009, having water-cement ratio 0.45 is considered. Percentage of plastic aggregates (0%, 10%, 20%, 40% and 60%) is added in concrete. Specimens plastic aggregate Concrete were cast with great precision and were cured for 14 days and 28 days. During concreting/casting of cubes, compaction factor test and slump test on fresh concrete was conducted for verification of workability with above percentage (%) addition of plastic waste i.e. (0% to 60%). After completion of maturity period of concrete Compressive strength test, split tensile test and flexural strength test were conducted on all the specimens with respective date of casting. From the study it was observed that compressive strength increased as increase the percentage (%) of plastic aggregate (0% to 40%) after 40% of plastic aggregate compressive strength decreases for both 14 days & 28 days cube strength. It was also observed that optimum percentage increment in compressive strength of concrete was 40% for 14 days and 28 days.

The optimum percentage increment in split tensile strength was 51.68 % for 14 days curing and 45.33% for 28 days at 40% plastic aggregate.
It was also noted that flexural strength of concrete increase gradually with addition of plastic aggregate and minimum flexural strength was obtained at 0% (2.7 N/mm2). 3.5 N/mm2 optimum flexural strength was obtained with addition of 40% plastic aggregate after 28 days of curing.

The study of strength and durability of concrete made with using alternate material such as plastic aggregate in different percentages as part replacement of fine aggregate (sand) is concluded that up to 40 % of these material quantity can be used in concrete formation to achieve designed characteristic compressive strength in 28 days. The use of alternate materials, exceeds beyond 40 % results in gaining strength below the specified designed strength. However, The concrete made of such combinations is may use for construction of mass concrete foundation works, embankment filling works, sub surfaces of roads, floorings, landfills with lean concrete, and other concrete works where durability is of prime factor and strength is secondary issue.
**Recommendations for Future Studies**

Many studies were carried out on the utilization of plastic aggregate Concrete. Most of the studies are focused on the enhancement of physical and mechanical properties of concrete. For hardened concrete chemical attack is the main reason for the corrosion in concrete so plastic aggregate concrete is observed by experimental studies. After increasing its tensile strength, it can be used for dynamic structures also.

- After increasing tensile and flexural strength of concrete it be can replace mechanically compacted concrete.
- There is a huge scope in cost comparison of plastic aggregate concrete with different additives as fly ash, furnace slag etc.
- After increasing the strength of concrete it can also be used in heavy structure as bridges, dams, foundation work etc.
- Similarly, after strength of concrete increases it can also be used for precast structures.
- Plastic aggregate concrete can also use in rigid pavement for impact load resistance on express way and highways which can use for landing of military tanks and aircraft landing.

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