WASTE PLASTIC FIBRE REINFORCED CONCRETE USING RECYCLED COARSE AGGREGATE

N. MAMATHA S. SANDEEP M. VENKATESH Y. RAMAKRISHNA

Mrs. B. SONY REDDY(Assistant Professor) Department of Civil Engineering

SREE DATTHA INSTITUTE OF ENGINEERING AND SCIENCE

ABSTRACT

In the present scenario, no construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. As it is widely used for construction of various structures, the economy is depended upon the cost of material used in making concrete.

On the other hand, due to rapid urbanization and industrialization all over the world, huge quantities of plastic waste and demolished waste are being generated. The disposal of these wastes is a very serious problem because, it requires huge space and also it causes environmental pollution. In this situation construction industry is in need of finding cost effective materials for increasing the strength of concrete.

So, in this project it is dealt with the possibility of using the plastic waste and demolished waste as the partial replacement of fine aggregate and coarse aggregate in concrete mix. In this perspective, it is aimed at comparing the properties of conventional concrete mix with the concrete mix prepared using plastic waste and demolished aggregate.

In the present experimental investigation, plastic waste is used as replacement of fine aggregate partially by 10% and coarse aggregate is replaced with demolished aggregate partially by 0%, 10%, 20%, 30%, 40% and 50%. The conventional mix has been designed for M25 grade concrete and is adopted with a water-cement ratio of 0.45. In this investigation seven mixes are prepared; the specimens used are cubes of size 150mm x150mm x 150mm, cylinders of size 150mm x 300mm and impact moulds of size 150mm x 75mm.

Initially Conventional mix is prepared by using conventional materials (cement, natural sand, natural aggregate and water) and their physical and mechanical properties were evaluated. Now, the concrete with recycled wastes are prepared and these are also tested for their properties, likewise all the seven mixes were prepared. For every mix 18 specimens (6 cubes, 6 cylinders, 6 impact specimens) were casted and thus totally 126 specimens were prepared. Specimens of every mix were tested for compressive strength at 7 and 28 days after curing.

With constant percentage replacement of plastic waste in place of sand and varying percentage replacement of coarse aggregate with demolished aggregate, it is found that the density of concrete can be varied from 2500 to 2100 kg/m3. The workability of fresh concrete was decreased with increase in addition of recycled aggregate. From the results it is found that by replacing the natural sand and coarse aggregate by plastic waste and recycled

aggregate in the normal concrete, compressive strength (fck) and split tensile strength (ft) increases upto 10% and then decreases with increase of recycled wastes.

From the experimental investigation, it is concluded that fine aggregate replaced with 10% of plastic waste and coarse aggregate replaced with 10% of recycled aggregate, the properties of fresh concrete were good and also it reached the target mean strength of conventional concrete.

1. INTRODUCTION

Now-a-days infrastructure development across the world created demand for construction materials. Concrete is the premier civil engineering construction material, concrete contains ingredients like cement, aggregates, water and admixtures. At present, huge quantities of construction materials are required in developing countries due to continued infrastructural growth and also huge quantities of plastic wastes and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because on one side it requires huge space for its disposal while on the other side it pollutes the environment. It is also necessary to protect and preserve the natural resources like stone, sand etc. Continuous use of natural- resources, like river sand is another major problem and this increases the depth of river bed resulting in drafts and also changing the climatic conditions.

So, the sustainable concept was introduced in construction industry due to growing concern about the future of our planet, because it is a huge consumer of natural resources as well as waste producer. This has created what we call the biggest problem of the world, demolished waste and plastic waste accumulation. Hence there is a need to recycle these waste into something more useful and environment friendly. To achieve this, major emphasis must be laid on the use of waste from various industries. The use of aggregates from construction and demolition waste in pavement beds is the most usual way of reusing this material. . It has been shown that the crushed concrete rubble, after separated from other construction and demolition wastes and sieved, can be used as a substitute for natural coarse aggregates in concrete. Even though considered as a valid re-use technique, it is not the best economic valorization of this resource and it is considered by many researchers to be a down-cycling process that depreciates the capacities of the material. But the production of structural concrete with recycled aggregates, however, offers great potential and recycles the materials viably and effectively. Research into new and innovative use of waste materials being undertaken world-wide.

Research into new and innovative use of waste materials being undertaken world-wide and innovative ideas that are expressed are worthy of this important subject.

In addition to the environmental benefits in reducing the demand of land for disposing the waste, the recycling of plastic and demolition wastes can also help to conserve natural materials and to reduce the cost of waste treatment prior to disposal. The largest proportions of demolition waste are concrete rubbles and plastic wastes are covers, polythene bags, PVC pipes etc. It has been shown that the crushed concrete rubble, after separated from other construction and demolition wastes and sieved, can be used as a substitute for natural coarse aggregates in concrete. Re-use of bulky wastes is considered the best environmental alternative for solving the problem of disposal.

2. LITERATURE:

Tomas U. Ganiron Jr. [1] has reported that Plastic as a substitute to fine aggregate to concrete mixture has shown unusual characteristic upon accumulation of water in the mixture for the material had floated on the surface of the water, nevertheless, upon the completion of mixing the material has suitably bonded to the mixture. In the analysis of its grain particle, in comparison to sand, which is one of the major components of concrete mixture, plastic, implies significant lightness in terms of its mass evaluation. Overall, the effect of the plastic on the properties of the specimen was acceptable. Stated that there is a considerable increase in the compressive strength as well as flexural strength of concrete when the aggregates are fully or partially replaced with construction debris. However maximum strength was shown by concrete mix having 25% recycled debris aggregates and 75% natural aggregates.

Shodolapo Oluyemi Franklin, Mmasetlhomo Tommy Gumede, [2] stated that it is obvious that structural compressive strengths may be developed in concretes incorporating up to 100% recycled aggregates based on standard mix design procedures. They also noted that the compressive, split tensile and flexural strengths, as well as the modulus of elasticity of recycled aggregate concretes, are generally lower than that of conventional concretes made entirely from natural aggregates.

Ganesh Tapkire1, Satish parihar, et al.,[3] reported that by using the plastic in concrete mix reduces to the weight of cube upto 15% and it is possible to use the plastic in concrete and bonding admixture in concrete and also increase the percentage of plastic in concrete.

Shiva Kumar. M, Nithin K, B.M Gangadharappa, [4] reported that aggregate ratio of 1:8 with 50 % of CA and 50% of Building Demolished Waste (BDW) is recommended for low traffic volume. Similarly mix design with w/c ratio of 0.40 and 0.45 with 50% of CA and 50% of BDW is suitable for intended use.

Youcef Ghernouti, Bahia Rabehi, et al.,[5] stated that the bulk density has decreased considerably for all concrete's with the content of replacement of sand by plastic waste that also becomes lighter than conventional concrete with 40% of plastic waste. Being given that the concrete must have good workability, fluidity is significantly improved by the presence of this waste.

Ashraf M. Wagih, et al., [6] stated that concrete rubble could be transformed into useful recycled aggregate used in concrete production with properties suitable for most structural concrete applications. stated recycled aggregate concrete may be an alternative to the conventional concrete and water required producing the same workability increases with the increase in the percentage of demolished waste.

Mohd. Monish et al., [7] stated recycled aggregate concrete may be an alternative to the conventional concrete and water required producing the same workability increases with the increase in the percentage of demolished waste.

Nitish Puri, Brijesh Kumar, Himanshu Tyagi, [8] stated that there is a considerable increase in the compressive strength as well as flexural strength of concrete when the aggregates are fully or partially replaced with construction debris. However maximum strength was shown by concrete mix having 25% recycled debris aggregates and 75% natural aggregates.

Mohan Reddy, Bhavani and Ajitha [9] reported that the present study reveals that concrete can be successfully produced using Recycled Coarse Aggregate (RCA) that have been produced from demolition and construction waste. Concrete produced by RCA does not perform as well as concretes produced by CA in terms of strength. However, the concrete still has a strength that would make it suitable for some applications.

3. OBJECTIVE AND SCOPE OF INVESTIGATION

The specific objectives of the present investigation are as listed below.

- To conduct the feasibility study of producing concrete with plastic waste and demolished aggregate.
- To study the effect of various replacements of fine aggregate by plastic waste with a constant percentage of 10% and replacement of natural aggregate by demolished aggregate in different percentages (0%, 10%, 20%, 30%, 40% and 50%) on workability properties, 28 days compressive strength, split tensile strength, modulus of elasticity etc.,
- To find an alternative construction material which can be effectively used in construction industry.
- To decrease the production cost of conventional concrete.
- To reduce the impact of plastic waste and demolished waste on environment.
- To reduce the overall cost of concrete i.e. to make concrete economical.

4. EXPERIMENTAL INVESTIGATION

To start with mix design has been conducted for M_{25} concrete making use of ISI method of mix design using normal constituents of concrete. In the course of investigation, natural sand has been replaced by 10% (constant for all the mixes) of plastic waste and also coarse aggregate has been replaced by 0%, 10%, 20%, 30%, 40% and 50% of demolished aggregate. For the study of various properties different specimens has been cast and tested. Here a constant water-cement ratio of 0.45 has been adopted. The experimental part of the investigation has been planned in the following three stages.

Stage I: Selection of Materials and their testing

Main constituents of concrete viz., fine aggregate, coarse aggregate, cement, water, plastic waste and demolished aggregate have been procured from various places. Fine aggregate has been procured from local river, coarse aggregate (20mm) has been procured from plant. Potable water is used for mixing and curing of concrete. Plastic waste (1-4mm sizes pieces) which is produced from households, factories, commercial places etc., has been procured from Estate (Bellary Bypass) and the demolished aggregate is obtained from demolished buildings, tested concrete specimens from laboratory are procured and made into pieces and they are sieved to 20mm size. It contents;

- Cement
- Fine Aggregate
- Coarse Aggregate
- Plastic Waste
- Demolished Aggregate

Stage II: Casting of specimens and curing

- **Casting of Specimens:** After the completion of workability tests, the concrete has been placed in the standard metallic moulds in three layers and has been compacted each time by tamping rod. Before placing the concrete inside faces of the mould are coated with the machine oil for easy removal after wards. The concrete in the moulds have been vibrated for 30 seconds using the table vibrator and the surfaces of the specimens have been finished smoothly.
- **Slump cone test:** Slump cone is a mould of 1.18 mm thick galvanized metal in the form of the lateral surface of the height 300 mm. The base and the top shall be open and parallel to each other and at right to the axis of the cone. The mould shall be provided with a foot piece on each side for holding the mold in place, and with handles for lifting the mould from the sample. Tamping rod around, straight steel rod 16 mm in diameter and approximately 600 mm in length. The tamping end shall be a hemisphere 16 mm in diameter.
- **Density of concrete:** The density of concrete varies, depending on the density of the aggregate used to mix the concrete and the amount of air within it. Floors, bridges and other structural components use high-density concrete, while low-density concrete works in areas with harsh weather and in some roads. Density is defined as mass divided by volume. Kilogram per cubic metre is the typical unit for measuring concrete density. The unit weight is determined by the formula below.

$$D = (M_c — M_m)/V_m$$

Where,

D = Density of the concrete in N/m3

Mc = Weight of the measure holding the concrete in N

Mm =Weight of the empty concrete measure in N

Vm = Volume of the measure in m3

Curing Procedure: After the casting of cubes, cylinders and impact specimens, the moulds are kept for air curing for one day and the specimens are removed from the moulds after 24 hours of casting of concrete specimens. Marking has been done on the specimens to identify the percentage of plastic waste and percentage of Demolished aggregate. Then they are placed in water tank for curing. All the specimens have been cured for desired age. The identification of the specimens is as follows:

1. N-100% Natural aggregate concrete or Conventional concrete

2. A -10 % Plastic waste, 90% Natural Sand and 100% Natural coarse aggregate concrete

3. B - 10% Plastic waste, 90% Natural Sand, 10% Demolished aggregate and 90% Natural coarse aggregate concrete

4. C-10% Plastic waste, 90% Natural Sand, 20% Demolished aggregate and 80% Natural coarse aggregate concrete

5. D-10% Plastic waste, 90% Natural Sand, 30% Demolished aggregate and 70% Natural coarse aggregate concrete

6. E-10% Plastic waste, 90% Natural Sand, 40% Demolished aggregate and 60% Natural coarse aggregate concrete

7. F-10% Plastic waste, 90% Natural Sand, 50% Demolished aggregate and 50% Natural coarse aggregate concrete

8. G-10% Plastic waste, 90% Natural Sand, 60% Demolished aggregate and 40% Natural coarse aggregate concrete

Stage III: Testing of specimens

The compressive loading tests on concretes were conducted on a compression testing machine of capacity 2000KN. For the compressive strength test, a loading rate of 2.5 KN/s was applied as per IS:516-1959[12]. The test was conducted on 150mm cube specimens at 7 and 28 days. The strength is calculated by dividing the max load by the cross-sectional area, with results usually reported as an average of three specimens. Curing after 24 hours, cubes are removed from molds and kept submerged in water at to ensure proper hydration until the testing age. Acceptance Criteria: The average of three tests should ideally meet the specified characteristic strength, with individual variations typically restricted within of the average. Significance**:** 7-day tests check for early strength (often of 28-day strength), while 28-day tests confirm the final design strength (e.g.,).

$$\text{Compressive strength} = \frac{\text{Load}}{\text{Area}} \text{ in N/mm}^2$$

Testing of Cylinders for Split tensile strength :

$$F_t = \frac{2P}{\pi DL}$$

Where,

P= Compressive load on the cylinder

L= Length of the cylinder

D= Diameter of the cylinder

FT= Splitting tensile strength (MPa)

Testing of specimens for Impact Resistance:

$$\mathbf{EI = N \times m \times g \times h}$$

Where,

EI is Impact Energy (N m),

N is the number of blows,

m is mass of the drop hammer (kg),

g is gravity acceleration (m/sec2) and

h is height of drop hammer (m).

Table 4.1 Sieve Analysis of Fine Aggregate

Weight of aggregate taken: 1000 gms

S.No	IS Sieve No.	Weight Retained in (Grams)	Cumulative Weight Retained in (Grams)	Cumulative Percentage Weight Retained (X)	Cumulative Percentage Weight Passing N=100-X
1.	4.75	0	0	0	100
2.	2.36	97	97	9.7	90.30
3.	2.00	45.8	142.8	14.28	85.72
4.	1.18	223.7	366.5	36.65	63.35
5.	0.6	350	716.5	71.65	28.35
6.	0.425	58.7	775.2	77.52	22.48
7.	0.3	120.7	895.9	89.59	10.41
8.	0.125	94.1	990	99.00	1.0
9.	0.09	7.8	997.8	99.78	0.22
10.	Pan	2.2	1000	100	0

Fineness modulus: 2.90

Table 4.2 Sieve Analysis of Coarse Aggregate

Weight of aggregate taken = 5000 gms

S.No	IS Sieve No.	Weight Retained in (Grams)	Cumulative Weight Retained in (Grams)	Cumulative Percentage Weight Retained (X)	Cumulative Percentage Weight Passing N = 100-X
1.	25	0	0	0	100
2.	20	1660	1660	33.2	66.8
3.	12.5	2080	3740	74.8	26.2
4.	10	1035	4775	95.5	4.5
5.	6.3	145	4920	98.4	1.6
6.	4.75	40	4960	99.2	0.8
7.	Pan	40	5000	100	0
		0	5000	100	0

Fineness modulus: 6.75

Table 4.2 - Sieve Analysis of Demolished Aggregate

Weight of aggregate taken = 5000gm

S.No	IS Sieve No.	Weight Retained in (Grams)	Cumulative Weight Retained in (Grams)	Cumulative Percentage Weight Retained (X)	Cumulative Percentage Weight Passing N= 100-X
1.	26.5	180	180	3.6	96.4
2.	20	2760	2940	58.6	41.4
3.	12.5	1920	4860	97.2	2.8
4.	10	110	4970	99.4	0.6
5.	6.3	20	4990	99.8	0.2
6.	4.75	10	5000	100	0
7.	Pan	0	5000	100	0

Fineness modulus : 5.85

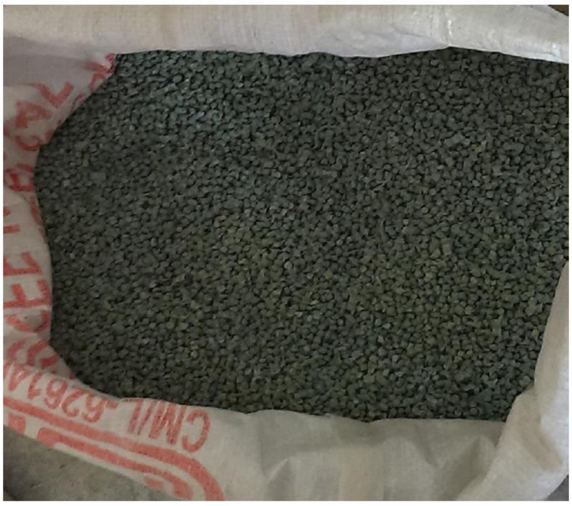

Plate 4.1 A VIEW OF PLASTIC WASTE GRANULES

Plate 4.2 A VIEW OF THE DEMOLISHED AGGREGATE USED

PLATE 4.3 A VIEW OF SET OF SIEVES FOR FINE AGGREGATE

PLATE 4.4 A VIEW SET OF SIEVES FOR COARSE AGGREGATE

PLATE 4.5 A VIEW OF SLUMP CONE TEST BEING DONE

PLATE 4.6 A VIEW OF THE MOULDS

CONCLUSIONS

From the work carried in this investigation following tentative conclusions can be drawn

1. Use of Plastic waste results in the formation of lightweight concrete.

2. The density of concrete is found to decrease with the increase in percentage replacements of sand by plastic waste and natural aggregate by demolished aggregate.
3. A small reduction in workability of resultant concrete has been observed
4. However maximum strength was shown by concrete mix having 10% plastic waste aggregates and 20% demolished aggregates. Hence this is supposed to be the best combination with respect to compressive strength. On overall basis, it is observed that compressive strength increases with increase in demolished aggregate content and reaches an optimum value of 20% (and 10% plastic waste) and afterwards it gets decreased for various contents of demolished aggregate.
5. The Split tensile strength of Plastic waste and recycled aggregate concrete is seen to decrease with increase in percentage of demolished aggregate (and also plastic waste) content and reaches an optimum value at 20% (and 10% plastic waste) and afterwards gets decreased with increase in content of demolished aggregate.
6. Use of these waste materials not only cuts down the cost of construction, but also contributes in safe disposal of waste materials.
7. It produces a sustainable concrete, with optimal performance achieved at partial replacements (typically 15%–20% plastic and 0.25–0.5% fiber)
8. Environmental benefit will successfully reduces construction waste and utilizes landfill-bound plastic waste

RECOMMENDATIONS

The following recommendations are done from the investigation :

1. This type of concrete can be effectively used in construction of simple, unimportant and non-load bearing structures.

2. This type of concrete can be used in making of lightweight concrete.

3. This type of concrete can be used in laying roads in rural areas and also for construction of footpaths.

4. In future, work should be done in such a way that the percentage of plastic waste is also to be varied in different percentages along with the demolished waste to know its characteristics and performance.

5. Optimizing the plastic replacement to 10–15% for optimal strength, using chemical treatments (NaOH) on plastic for better bonding, and employing nano-silica to mitigate strength losses.

6. It Enhancing Concrete Performance like Durability and plastic Fiber Treatment.

7. Sand and Coarse aggregate can be replaced successfully in concrete.

8. Work can be carried out on other wastes such as E-waste, PVC waste etc., for its replacement in place of fine aggregate.

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