Study on Partial Replacement of Fine Aggregate by Waste Plastic in Cement Concrete

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Abstract - *The rapid industrialization and urbanization in the country leads to lot of infrastructure development. This process leads to several problems like shortage of construction materials, increased productivity of wastes and other products. This project deals with the reuse of waste plastics as partial replacement of fine aggregate in M20 concrete. As 100% replacement of natural fine aggregate with plastic fine aggregate is not feasible, hence partial replacement at various percentage were examined. Waste plastics were incrementally added in 5, 10, 15 and 20% to replace the same amount of aggregate.*

***Key Words*: waste plastics, fineaggregate, replacement, particles, percentage**

1. INTRODUCTION

In this study the recycled plastics were used to partially replace the fine aggregates thereby providing a sustainable option to deal with the plastic waste and providing an alternative for sand in concrete. The fine aggregates used in cement concrete is replaced by shredded PET bottles in known percentages and the optimum percentage at which higher strength obtained is being calculated. M20 grade concrete is chosen for the investigation. A comparison of workability, compressive strength, splitting tensile strength and flexural strength for conventional concrete and concrete containing plastic are made and the suitability of partially replaced concrete for making masonry block is studied.The world population grows, wastes of various types are being generated. The creation of non–decaying and low biodegradable waste materials, combined with a growing consumer population has resulted in waste disposal crisis. One solution to this crisis is recycling wastes into useful products. It is necessary to develop a rational approach for the waste disposal indicating both the economy and the environmental protection.

2. MATERIALS

2.1. Concrete

Concrete is a composite material composed mainly of cement, aggregate and water. When these ingredients are mixed together they form a fluid mass that is easily moulded into shapes. Over time, the cement forms a hard matrix which binds the rest of the ingredients together in to a durable stone like material with many users.

2.2. Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. On –hydraulic cement will not set in wet conditions or under water, rather it sets as it dries and reacts with carbon dioxide in the air.

2.3. Coarse Aggregate

Coarse aggregates are particles greater than 4.75 mm. but generally range between 9.5mm to 37.5mmin diameter. They can either be from primary, secondary or recycled sources. Primary, or „virgin‟, aggregates are either land or marine –won. Gravel is a marine-won aggregate. Land won coarse aggregate includes gravel and crushed rock. Gravel constitutes the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

2.4. Fine Aggregate or Sand

Sand particle consist of very tiny grains of silica, it is formed by the decomposition of sandstones due to various effect of weather. Sand particle consist of small grains of silica. It is formed by the decomposition of sandstones due to various effect of weather.

3. METHODOLOGY

The step by step procedure for the study on partial replacement of waste plastic in concrete is as follows

- Conduct a literature study pertaining to xpartial replacement fine aggregate using waste plastic in concrete.
- Collect the materials
- Conduct tests to evaluate the properties of the materials collected
- Design the concrete mix of M20 concrete as per IS 10262:2009

- Conduct slump tests on fresh concrete which includes
- Prepare and cast the specimens for testing

4. TEST ON WASTE PLASTC

4.1. Specific Gravity

Test sample passing 90 micron sieve. Clean the pycnometer and dry it. Find the mass (m_1) of the pycnometer. Take about 100 g of shredded plastic and put it in the pycnometer. Find the mass of pycnometer plus cement (m_2). Fill the pycnometer to half its height with kerosene and mix it thoroughly with glass rod. Add more Kerosene and stir it to remove all the air bubbles. Replace the screw top and fill the pycnometer flush with hole in the conical cap. Dry the pycnometer from outside and find the mass (m_3). Empty the pycnometer, clean it thoroughly and fill it with kerosene to the whole of conical cap and find mass (m_4). Insert the thermometer in the kerosene and the record the test temperature T1. Repeat the steps for two more determination of specific gravity.

Table -1: Specific gravity of shredded plastic

Sample no	1	2
Mass of pycnometer,m_1(g	56	56
Mass of pycnometer+ Shredded plastic m_2(g)	56.883	57.006
Mass of pycnometer+ Shredded plastic+kerosene m_3(g)	198.1125	198.126
Mass of pycnometer + Kerosene m_4(g)	198	198
Specific gravity $G=(m_2-m_1)GK/((m_2-m_1)-(m_3-m_4))$	0.908	0.907
Mea specific gravity	0.9075	

5. MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing of concrete of certain minimum strength and durability as possible. The first objective is to stipulated minimum strength and durability. The second objective is to make the concrete in most economical manner. Cost wise all concrete depends primarily on two factors: namely cost of material and cost of lab our. Lab our cost by way of formworks, batching, mixing, transporting, and curing is nearly same for good concrete and bad concrete..

5.1. Mix Proportion

Cement = 297.6kg/m^3.

Water = 148.8kg/m^3.

Fine aggregate = 785.72kg/m^3.

Coarse aggregate = 1318.64kg/m^3.

Plasticizer = 2.10kg/m^3.

Water-cement ratio = 0.50.

Mix proportion = 1:2.64:4.43

Table -2: Mix proportions by replacing with various percentage of plastic by weight

Mix Name	Cement Kg/m^3	Fine AggregateKg/m^3	Plastic Kg/m^3	Coarse Aggregate Kg/m^3	Water Kg/m^3	Admixture Kg/m^3
0%	297.6	785.72	0	1318.64	148.8	2.10
5%	297.6	746.44	39.28	1318.64	148.8	2.10
10 %	297.6	707.148	78.572	1318.64	148.8	2.10
15 %	297.6	667.862	117.858	1318.64	148.8	2.10
20 %	297.6	628.576	157.144	1318.64	148.8	2.10

5. TESTS AND RESULTS

5.1. Test on Workability– Slump Test

Concrete is said to be workable if it can be easily mixed, placed, compacted and easily finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and we get concentration of coarse aggregate at one place. This result in large voids, less durability and less strength. Bleeding of concrete is said to occur when excess water comes up at the surface of concrete.

Table -3: Slump Test

Percentage of plastic	Slump value
0%	25
5%	26
10%	28
15%	30
20%	31

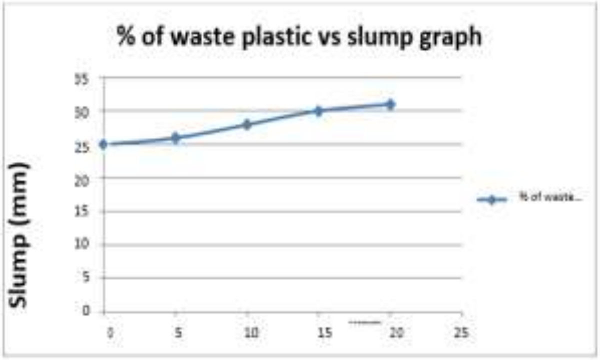

Fig (4) – slump graph

Chart -1: Slump Graph

5.2. Density of Concrete

The density of concrete is a measurement of concrete's solidity. The process of mixing concrete can be modified to form a higher or lower density of concrete end product. As concrete itself the density of concrete of normal weight is about 2400Kg/cu.m (24KN/cu.m). The concrete density varies depending on the amount and density of aggregate, how much air is entrapped or purposely entrained, the cement concentration and the maximum size of aggregate used.

Table (4) - Density of concrete cube

PLASTIC	7 DAYS(KN/cu.m)	28 DAYS(KN/cu.m)
0	2300	2382
5	2289	2312
10	2195	2211
15	2120	2188
20	2080	2100

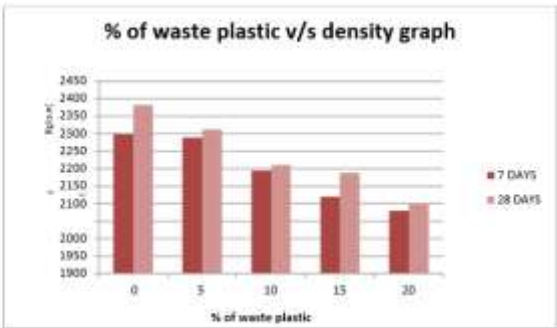

Fig (5) – Density of concrete

Chart 2: density of concrete

5.3. Compressive Strength of Concrete

In the study of strength of material, the compressive strength is the capacity of the material or structure to withstand load tending to reduce size. It can be obtained by plotting applied force against deformation in testing machine. Some material fracture at their compressive strength limit; others deform irreversibly, so given amount of deformation may be considered as limit for compressive load. Compressive value is the key value of design of a structure.

Test shall be made at recognized ages of the test specimens, the most unusual being 7 and 28 days where it may be necessary to obtain the early strengths, test may be made at the ages of 24 hours±1/2 hours and 72hours± 2 hours. The ages shall be calculated from the time of addition of water to the dry ingredients.

Table (5) - compressive strength of cubes by replacing with various percentage of shredded plastic

PERCENTAGE OF WASTE PLASTIC	AGE	
	7 DAYS	28 DAYS
0	16.59N/mm^2	22 N/mm^2
5	10.67 N/mm^2	18.41 N/mm^2
10	10.48 N/mm^2	13.88 N/mm^2
15	9.78 N/mm^2	11.98 N/mm^2
20	7.73 N/mm^2	9.71 N/mm^2

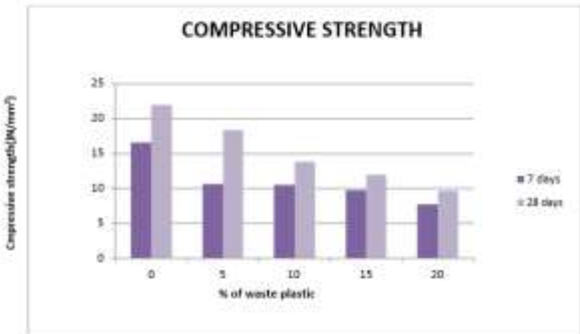

Fig (6) – Compressive strength graph by replacing with various percentages of plastic after 7& 28 day

Chart -3: Compressive Strength Graph

6. CONCLUSIONS

The study is carried out to evaluate the feasibility on the utilization of waste plastic in cement concrete for partial replacement of fine aggregate, which will help in the disposal of waste plastic. The workability of mixes was found to be increasing, as slump showed an increasing pattern with increase in plastic replacement percentage. Helped study the effect of replacing M-sand with plastic aggregate on Workability Compressive strength, Flexural strength, Split tensile strength and Durability. Determine the optimum percentage of fine aggregate that can be replaced using plastic aggregate. A reduction was found in mechanical properties with increase in plastic ratio in concrete. However for 5% replacement of fine aggregate by shredded PET bottles, the mechanical properties (compressive strength, split tensile strength, and flexure strength) remains close to the reference concrete. Waste shredded PET bottles can be used successfully to replace conventional fine aggregates in concrete without any long term detrimental effects and with acceptable strength development properties. This is not only a boon to the construction industry which faces a lot of problems due to shortage of raw materials but also a helpful measure to dispose plastic wastes which creates environmental hazards.

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