AN EXPERIMENTAL INVESTIGATION IN CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE BY PET BOTTLE CAPS

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ABSTRACT

Due to rapid growth of population in countries like India the disposing of solid waste is a major problem in our daily life. Solid waste management is one of the major environmental concerns. Among the waste material, plastic is the material that is the major concern to most of the environmental effects. There are different types of plastic which are classified on the basis of the physical property. As the plastic waste is non degradable, it must be recycled or reused. The objective of study is to study the behavior of the concrete which is made of the recycled plastic materials along with the study of the some of the physical properties that are related. Usually M20 grade of the concrete is the most commonly used in the constructional works, hence in this study M20 cement concrete is considered in which the waste plastic bottle caps is used as the replacement of coarse aggregate in the concrete. Concrete cubes were casted taking 10% , 20% and 30% of plastic as partial replacement of coarse aggregate and tested for 7, 14 and 28 days of compressive strength of concrete.

Keyword : *Plastic, Reuse and waste plastic bottle caps.*

1. INTRODUCTION

A composite material that consists essentially of a binding medium, such as a mixture of ordinary portland cement and water, within which are embedded particles or fragments of aggregate, usually a combination of fine and coarse aggregate. Concrete is by far the most versatile and most widely used construction material worldwide. It can be engineered to satisfy a wide range of performance specifications, unlike other building materials, such as natural stone or steel, which generally have to be used as they are. Because the tensile strength of concrete is much lower than its compressive strength, it is typically reinforced with steel bars, in which case it is known as reinforced concrete. The proportions of cement, aggregate, water and admixture (if required) are important in making high

quality and inexpensive concrete. Concrete is made up of about 65% - 80% aggregate and the rest is made up of water and cement using the water cement ratio which can be calculated by the formula W/C = water amount /cement weight, i.e. 20 L/ 40 kg = 0.5 The lower the ratio, the stronger the concrete.

1.1 Concrete Production

The process used vary dramatically from hand tools to heavy industry but result in the concrete being placed where it cures into a final form when initially mixed together Portland cement and water rapidly form a gel, formed of tangled chains of interlocking crystals. As the concrete sets, the chains of crystals join and form a rigid structure, gluing the aggregate particles in place. During curing, more of the cement reacts with the residual water hydration. This curing process develops physical and chemical properties.

1.2 Properties of concrete

Concrete has relatively high compressive strength and much lower tensile strength. Concrete is usually reinforced with materials that are strong in tension often steel. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures will crack to some extent due to shrinkage and tension .Concrete that is subjected to long-duration forces is prone to creep.

2. METHODOLOGY

In this project, basic tests were conducted on various materials like OPC53 grade cement, fine aggregate, coarse aggregate, spent fire bricks waste to check their suitability for making concrete. The mix proportions of concrete were modified for using plastic bottle caps waste as a partial replacement of coarse aggregate. The cubes were cast by replacing coarse aggregate with 0%, 10%, 20% and 30% of bottle caps. Specimens were cast as per mix design and the tests are conducted after proper curing, the tests are compressive strength of cubes (150mm x 150mm x 150mm).

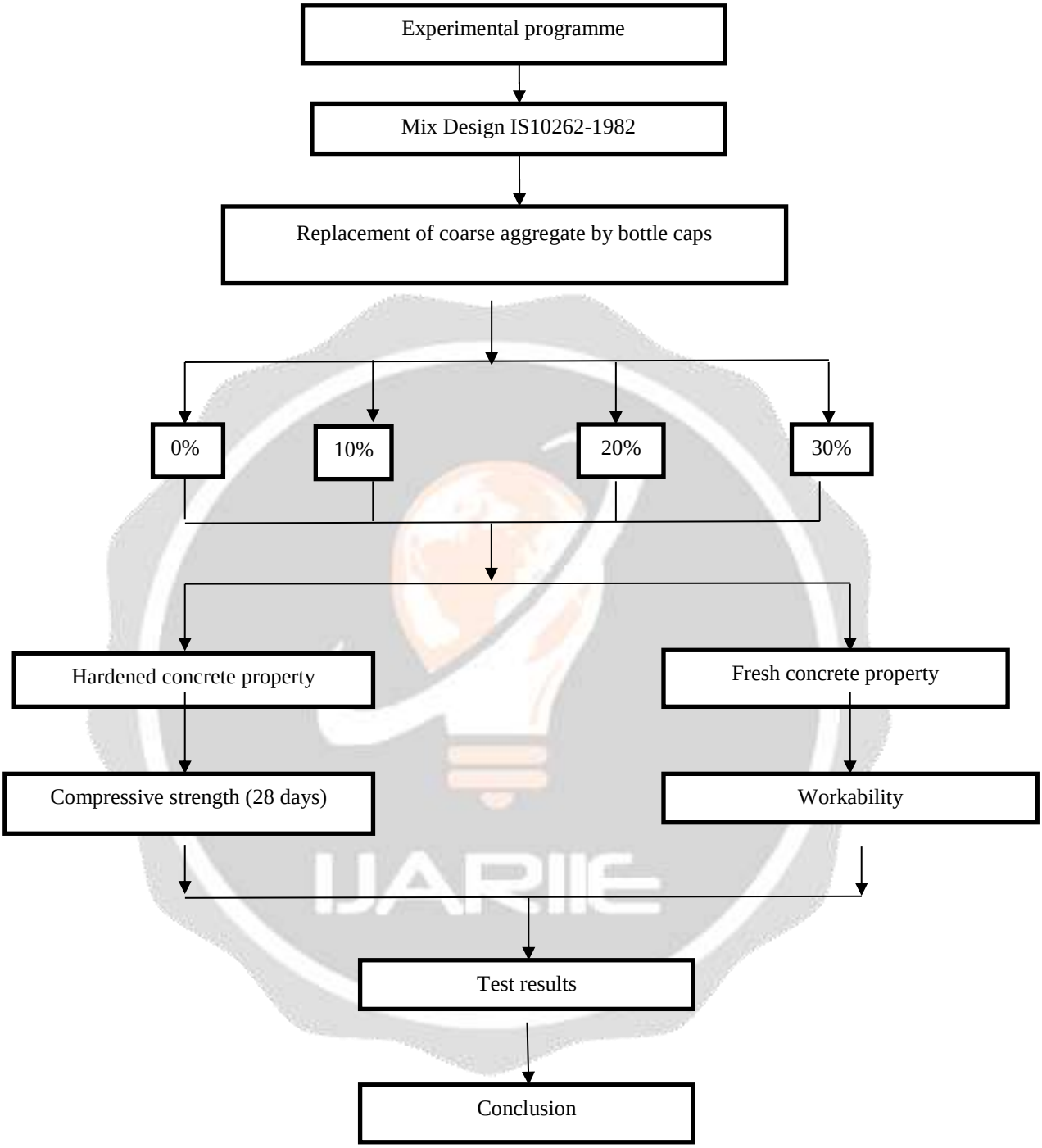

Chart -1:Methodology

2.1 Cement

Cement is defined chemical entity formed from predetermined ratios of reactants at a fairly precise temperature. Cement is obtained from limestone (calcium carbonate) and small quantities of other materials (such as clay) through a heating process in kilns, the process known as Calcinations. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum to form Ordinary Portland Pozzolana Cement also referred as PPC. This forms a basic ingredient of concrete, mortar, grout etc. and its most common use is in the production of concrete. Concrete is a composite material which consist of cement, aggregates (both coarse [gravel] and fine

[sand]), and water. It has a wide application in the construction industry since it can be cast and molded in any desired shape. After it hardens, it can be effectively used for load bearing structures.

Table -1: Composition of portland pozzolano cement

Ingredients	**Percentage (%)**	**Range (%)**
Lime (CaO)	62	62-67
Silica (SiO_2)	22	17-25
Alumina (Al_2O_3)	5	3-8
Calcium Sulphate ($CaSO_4$)	4	3-4
Iron Oxide (Fe_2O_3)	3	3-4
Magnesium (MgO)	2	0.1-3

2.2 Fine aggregate

Fine aggregate consist of mainly sand which may be natural, manufactured or a combination of both. It consists of clean and durable particles generally spherical or cubical in shape. The use of flat or elongated fine aggregate particles should be restricted and also care should be taken to ensure that there are no contaminating substances - dirt, dust, mud, and construction debris - present in fine aggregates. Fine aggregates particle size varies from 0.075 to 0.425 mm. The specific gravity of sand is 2.5.

2.3 Coarse aggregate

Coarse aggregates consist of aggregates larger than fine aggregates and their sizes vary from 20 to 4.75mm. These tend to improve quality and bond characteristics and generally results in a higher flexural strength of concrete. It also helps in reducing shrinkage. These aggregates occupy 70-80% of volume of the concrete. The specific gravity of sand is 2.7.

2.4 PET bottle caps

Plastics are polymers, a very large molecule made up of smaller units called monomers which are joined together in a chain by a process called polymerization. The polymers generally contain carbon and hydrogen with, sometimes, other elements such as oxygen, nitrogen, chlorine or fluorine. Plastics have become an integral part of our lives. The amount of plastics consumed annually has been growing steadily.

Fig -1: PET bottle caps

3. MIX DESIGN

3.1 Design stipulations

Unit weight of cement = 1440 kg/m^3
Unit weight of fine aggregate = 1540 kg/m^3
Unit weight of coarse aggregate = 1680 kg/m^3
Unit weight of bottle caps = 119.8 kg/m^3
Unit weight of water = 9.8 kg/m^3
M20 grade concrete is used.

Partial replacement of waste bottles caps in concrete

M20 grade concrete mix
Ratio of M20 grade = 1 : 1: 5 : 3::water : cement : fine aggregate
Wet volume of the concrete = 1 m^3
Sum of the ratio = 1+1.5+3 = 5.5
Dry volume of the concrete = wet volume of the concrete x 1.57
= 1 x 1.57
= 1.57 m^3

Calculation of cement content:

Volume of cement = (1/sum of ratio) × unit weight of cement × dry volume of concrete
= (1/5.5) x 1440×1.57
= 411.05 kg/m^3
1 bag = 50 kg
Number of bags = (411.05/50)
= 8 bags/ m^3

Calculation water content:

Water content required = 0.45 x volume of cement
= 0.45 x 411.05
= 184.97 l/m^3

Calculation of fine aggregate:

Volume of sand = (1/sum of ratio) × unit weight of FA × dry volume of concrete
= (1/5.5) x 1540 x 1.57
= 439.6 kg/m^3

Calculation of waste bottle caps:

Volume of bottle cap
(10% of replacement) = (10/100) x 3
= (0.3/5.5) x 119.8
= 6.53 kg
= 6.53×0.0405
= 0.26kg/m^3

Volume of bottle caps
(20% of replacement) = (20/100) x 3
= (0.6/5.5) x 119.8
= 13.06kg
= 13.06×0.0405
= 0.52kg/m^3

Volume of bottle caps
(30% of replacement) = (30/100) x 3
= (0.9/5.5) x 119.8
= 19.60kg
= 19.06×0.0405
= 0.77kg/m^3
Total Volume of bottle caps = 0.26 + 0.52 + 0.77
= 1.55kg/m^3

Calculation of coarse aggregate:
Volume of coarse aggregate
(10% of replacement) = (90/100) x 3 x unit weight of CA
= (2.7/5.5) x 1680

= 824.72kg
= 824.72 x 3.375 x 10^{-3}
= 2.78 x 3

= 8.35kg/m^3

Volume of coarse aggregate
(20% of replacement) = (80/100) x 3 x unit weight of CA
= (2.4/5.5) x 1680

= 733.09kg
= 733.05 x 3.375 x 10^{-3}
= 2.47 x 3

= 7.42kg/m^{-3}

Volume of coarse aggregate

(30% of replacement) = (70/100) x 3 x unit weight of CA
= (2.1/5.5) x 1680
= 641.45kg
= 641.45 x 3.375 x 10^{-3}
= 2.164 x 3

= 6.49kg/m^3

4. RESULTS

Compressive Strength of Concrete Specimens is tested in the 28th day. The test is done using Compression Testing Machine.

Table 2. Compressive strength of concrete using 10% adding PET bottle caps

specimen no	size of the specimen (mm)	compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	150X150X150	16.68	22.09	25.87
2	150X150X150	15.23	21.23	22.44
3	150X150X150	16.35	20.38	21.01
Average compressive strength(N/mm^2)		16.08	21.23	23.10

Table 3: Compressive Strength of concrete using 10% adding PET bottle caps

specimen no	size of the specimen (mm)	compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	150X150X150	16.38	20.37	21.45
2	150X150X150	15.26	21.24	22.81
3	150X150X150	16.69	22.01	24.68
Average compressive strength (N/mm^2)		16.13	21.23	22.81

Table 4 Compressive Strength of concrete using 20% adding PET bottle caps

specimen no	size of the specimen (mm)	compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	150X150X150	13.85	15.86	18.87
2	150X150X150	12.69	14.55	17.53
3	150X150X150	11.98	13.69	18.05
Average compressive strength (N/mm^2)		12.84	14.7	18.15

Table 5 Compressive Strength of concrete using 30% Adding PET bottle caps

specimen no	size of the specimen (mm)	compressive strength (N/mm^2)		
		7 days	14 days	28 days
1	150X150X150	12.24	12.94	17.02
2	150X150X150	11.52	13.87	16.85
3	150X150X150	11.03	14.69	15.72
Average compressive strength (N/mm^2)		11.59	13.83	16.53

4. DISCUSSION

It is determined that the above graph that compressive strength of the concrete at 28 days is decreased when we add 30% of PET bottle caps and then it is gradually decrease in the strength with the increase of PET bottle caps. Thus we conclude that the value of compressive strength is 16.53 N/mm^2 for 30% of PET bottle caps.

5. CONCLUSIONS

The test conducted on materials like cement, sand, aggregate having all the results within permissible limits as per IS codes. The compressive strength values of all waste plastic concrete mixture tend to decrease below the values for the references concrete mixtures with increasing the waste plastic ratio at all curing ages. This trend can be attributed to the decrease in adhesive strength between the surface of waste plastic particles and the cement paste.

Main benefit of this project is workability it will be increased because the plastic have been less absorbing water content. And reduce the pollution of environment, scarcity of fine aggregate and also reduce the cost of material.

6. REFERENCES

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