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Experimental Study on Partial Replacement of Course Aggregate by Recycled Plastics and Cement by Glass Powder in Concrete

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Abstract – The use of plastic and Glass is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy conditions for human and animals. Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of greenhouse gases, such as CO2, to the atmosphere. Among the greenhouse gases, CO2 contributes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing, there is a need to develop alternative binders to make concrete. A Part from cement for manufacturing of concrete the coarse aggregate constitute 40 to 50 % by weight of the concrete. This lead to increase the cost of the concrete. To reduce the cost an alternate materials are used. A healthy and sustainable reuse of plastics and glass offers a host of advantages. The suitability of recycled plastics as coarse aggregate and glass powder which is a unique inert material that could be recycled many times without changing its chemical properties which are used as partial replacement in concrete and its advantages are discussed here. The initial questions arising of the bond strength and the heat of hydration regarding plastic aggregate were solved. Tests will be conducted to determine the properties of plastic aggregate such as density, specific gravity and aggregate crushing value.

In this Study we have casted M20 Grade concrete replacing partially the cement with glass powder and a coarse plastic aggregate at a various percentages (3% +5% , 3%+10% , 3% + 15% , 5% +5% ,5%+10% ,5%+15% , 10%+5% ,10%+10%,10%+15%). The percentage substitution that gave higher compressive strength. Has been noted after testing M20 grade concrete samples under compressive loading condition.

Keywords – Coarse Aggregate, Plastic Aggregate, Partial Replacement, Grade Substitution Glass Powder.

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1. INTRODUCTION

Concrete is the most widely used man made construction material in the world and its second only to water as the most utilized substance in the planet. Seeking aggregates for concrete and to dispose of the waste from various commodities is the present concern. Today sustainability has got top priority in construction industry. In the present study the recycled plastics were used to prepare the coarse aggregates there by providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. Most of the failures

in concrete structures occur due to the failure of concrete by crushing of aggregates. The plastic coarse aggregates(PCAs) which have low crushing values will not be crushed as easily as the stone aggregates. These aggregates are also lighter in weight when compared to stone aggregates. Since a complete substitution for NCA was not found feasible, a partial substitution with various percentages of PCA was done. Both volumetric and grade substitution was employed in this investigation Generation of plastic waste is one of the fastest growing areas. Every year more than 500 billion plastic bags are used (nearly one million bag per minute). Hundreds of thousands of sea turtles, whales and other marine mammals die every year from eating discarded plastic bag for mistaken food. On land many animals suffer from similar fate to marine life. Collection, hauling ad disposal of Plastic bag waste creates an additional environmental impact. In a landfill or in environment, Plastic bags take up to 1000 year to degrade. Many researches were conducted to use industry by products such as fly ash, silica of concrete. Flume, glass cullet, coir fibers, e-plastic waste in concrete to improve the properties. (17%) is higher than for the plastic industry elsewhere in the world. India has a population of over 1 billion and a plastic consumption of 4 million tones. One third of the population is destitute and may not have the disposable income to consume much in the way of plastics or other goods. The virgin industry does not target this population to expand its markets. However, one third of the population is the middle class whose aspirations could be molded to increase consumption. Plastic manufacturers create needs for this segment of population. The rising needs of the middle class, and abilities of plastics to satisfy them at a cheaper price as compared to other materials like glass and metal, has contributed to an increase in the consumption of plastics in the last few years

Fig 1.1 Waste Plastic And Waste Glass

2. MATERIALS USED

- Cement
- Fine Aggregate (FA)
- Coarse Aggregate (CA)
- Recycled Plastic Aggregate (RPA)
- Glass Powder (GP)

Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world. 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989 is used. Specific gravity of cement = 3.12

Description of test	Test results obtained	Requirements of IS: 8112 1989
Initial setting time	64 minutes	Min. 30minutes
Final setting time	260 minutes	Max. 600minutes
Fineness	410.94 m2/kg	Min. 225 m^2/kg

Table 2.1 physical properties of cement

Fine Aggregate

Locally available clean and dry manair river sand conforming to Grading zone II of IS: 383 –1970.has been used. The sand passing through IS 4.75mm Sieve has been used for casting all the specimens.

The specific gravity =(w2-w1)/(w2-w1) - (w3-w4)=2.6

Water absorption =6.7%

Fines modulus = 3.63

Coarse Aggregate

The crushed 20 mm size aggregate were used

The specific gravity = 2.68

Water absorption = 1%

Fines modulus =6.52

Recycled plastic Aggregate

Plastics collected from the disposal area were sorted to get the superior one. These were crushed into small fraction and washed to remove the foreign particles. Then they are sieved to get 20mm size plastic aggregate.

Figure 2.1 Plastic Aggregate

Properties of Plastic

According to the Indian standard specifications the property of aggregates such as specific gravity, aggregate crushing value and density were determined. From Table ..... comparing the properties of aggregate for both NCA and PCA it is observed that the specific gravity and density for PCA is much lower than NCA which offers a light weight concrete. A lower crushing value indicates the complexity with which a PCA concrete could be crushed under compressive stresses.

Property	NCA	PCA
Specific gravity	2.64	0.9
Crushing value	28	2
Density	3.14	0.81
Melting point (0c)		75-100

Table 2.2 Properties of NCA & PCA

Glass powder

The glass waste available locally in shops has been collected and made into glass powder. Glass waste is very hard material. Before adding glass waste to the concrete it has to be powdered to the desired size. In the present studies glass waste was powdered by grinding in a ball/ mill .The glass waste pulverized for a period of 30 to 6o minutes which resulted powder of particle sizes ranging from 75 µm -150 µm.

Fig 2.2 glass powder

Properties of glass powder

S. No	Property	Glass powder
1.	Specific gravity	2.6
2.	Fineness passing 150µm	99.4
3.	Fineness passing 90µm	98.1

Table 2.3 physical properties of glass powder

Constituent	Composition %	
	Glass Powder	OPC
Silica (SiO_2)	67.33	22.00
Calcium Oxide (CaO)	12.45	62
Aluminum Oxide (Al_2O_3)	2.62	5.05
Ferrous Oxide (Fe_2O_3)	1.42	4.64
Magnesium Oxide (MgO)	2.738	2.06
Sodium Oxide (Na_2O)	12.05	0.19
Potassium Oxide (K_2O)	0.638	0.40
Sulphite (SO_3^{2-})	0.751	1.43

Table 2.4 Chemical Composition of Glass Powder and OPC

3. EXPERIMENTAL PROCEDURE

In the present experimental work. First, the material, mix proportions, manufacturing and curing of the specimens are explained. This is then followed by description of types of specimens used, test parameters, and test procedures. Development of the process of making Plastic and Waste glass powder concrete. In this mix we are used only crushed plastic. To achieve the objectives of the investigation the experimental program was planned to cast around 27 cubes with different percentages of PCA and GP.

Mix Design: The concrete mix design was proposed by using Indian Standard for control concrete. The grade was M20.The mix proportion of materials is 1:1.5:3 as per IS 10262-2009. Then natural fine aggregate was used. cement with glass powder and coarse aggregate with plastic at various percentage (3% +5% , 3%+10% , 3% + 15% , 5% +5% ,5%+10% ,5%+15% , 10%+5% ,10%+10%,10%+15%) were going to do. Chemical admixture is not used here.

Fig3.1 Mixing

Casting

The Plastic Waste and glass powder concrete is manufactured by as similar to the classical concrete. Initially the dry materials Cement, Aggregates & Sand are mixed. The liquid component of the mixture was then added to the dry materials and the mixing continued for further about 3-6 minutes to manufacture the fresh concrete. The fresh concrete was cast into the moulds immediately after mixing, in three layers for cube specimens. For compaction of the specimens, each layer was given 60 to 70 manual strokes using a tapping rod, and then vibrated for 12 to 15 seconds on a vibrating table. Before the fresh concrete was cast into the moulds, the slump value of the fresh concrete was measured.

Fig 3.2 Casting

S. No.	Percentage	Slump Test In mm	Compaction Factor Test	Weight of cube	Density Kg/m^3
1	GP3+PCA5	30	0.89	8.064	2389.33
2	GP3+PCA10	40	0.90	7.966	2360.29
3	GP3+PCA15	45	0.90	7.602	2252.44
4	GP5+PCA5	45	0.89	8.026	2378.07
5	GP5+PCA10	45	0.89	8.008	2372.74
6	GP5+PCA15	50	0.89	7.606	2253.62
7	GP10+PCA5	50	0.89	7.922	2347.25
8	G10+PCA10	55	0.89	7.780	2305.18
9	G10+PCA15	55	0.89	7.66	2269.62

Table 3.1 values of slump, compaction factor, weight and density

4. TESTING PROCEDURE

An intensive experimental program is performed to study the effect of internal curing on different types of concrete properties: (i) Fresh properties (Slump, Compaction factor and Density); (ii) Mechanical properties like compressive strength,. The cubes were tested under 200 tons compression testing machine to study the compressive strength of the cubes.

Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block has been noted. From the noted values, the compressive strength has been calculated by using formula:

Compressive Strength = Load / Area

Size of the test specimen = 150mm x 150mm x 150mm

TEST RESULT

Ratio for Special Concrete

RATIO –I

Plastic Waste–5% by replacement of Aggregate and glass powder 3%,5% and 10% by cement

RATIO - II

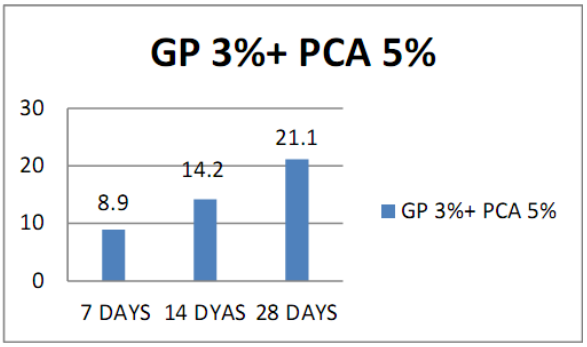
Plastic Waste – 10% by replacement of Aggregate glass powder 3%,5% and 10% by cement.

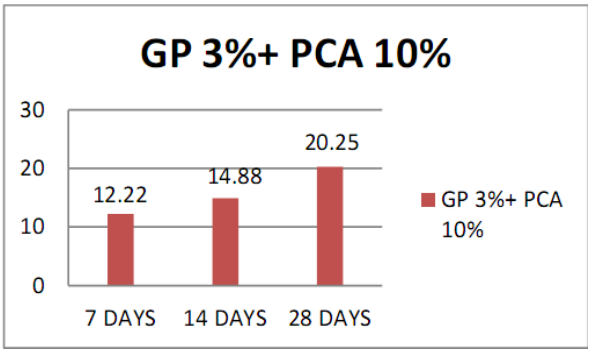
RATIO – III:

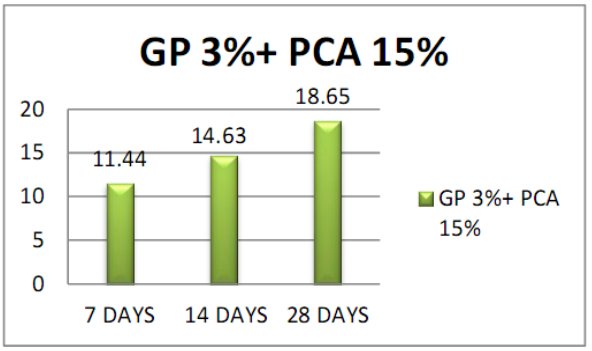
Plastic Waste – 15% by replacement of Aggregate and glass powder 3%,5% and 10% by cement.

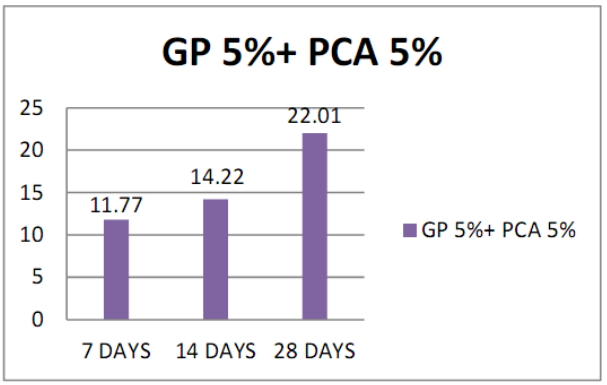
S. No	% Replacement		Compressive Strength N/MM^2		
	GP	PCA	7 Days	14 Days	28 Days
1	0%	0%	11.15	16.48	20.8
2	3%	5%	8.9	14.2	21.1
3	3%	10%	12.22	14.88	20.25
4	3%	15%	11.44	14.63	18.65
5	5%	5%	11.77	14.22	22.01
6	5%	10%	13.14	16.43	20.1
7	5%	15%	11.02	12.65	17.12
8	10%	5%	12.11	16.31	24.8
9	10%	10%	9.33	14.33	20.1
10	10%	15%	8.6	13.22	18.12

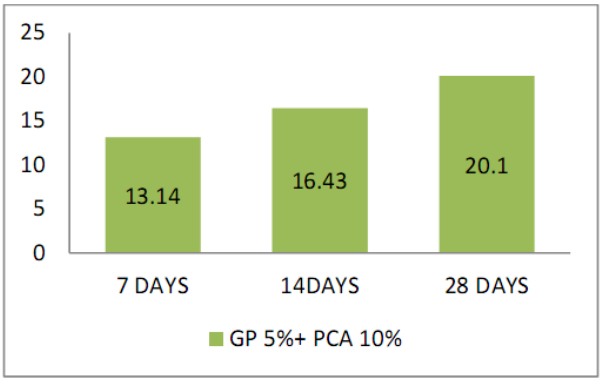
Table 4.1 Compressive Strength Test Result

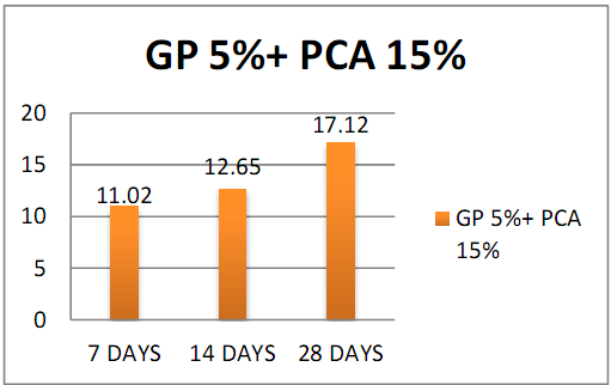


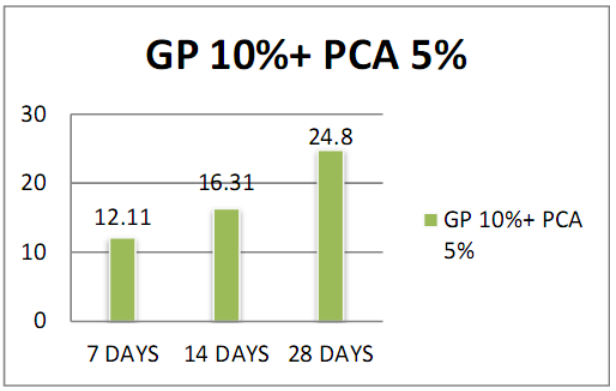


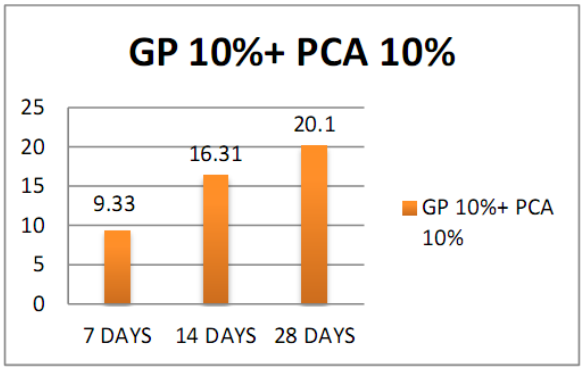


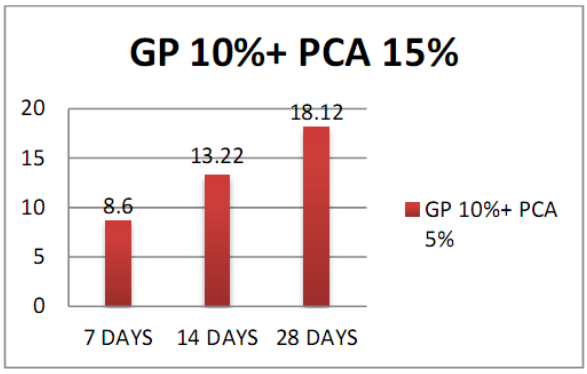


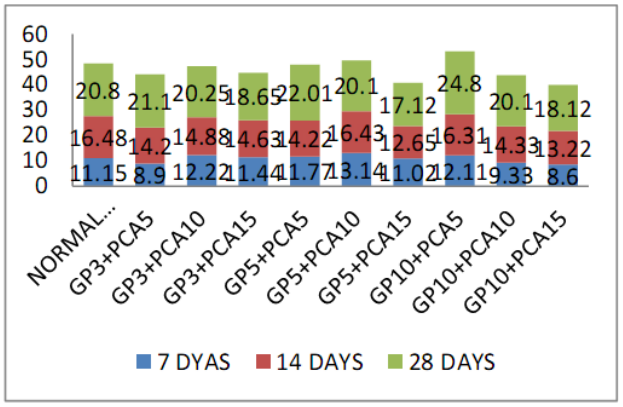




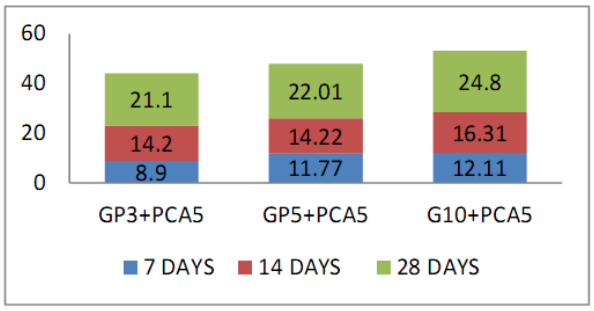








ALL PERCENTAGES WITH FINAL RESULT



GRADULLY INCREASING PERCENTGES

CONCLUSION

From the above Experimental Study we conclude that the increasing percentage of PCA and Glass powder in concrete shows that the increase in percentage of compressive strength.

By replacement of Cement and Coarse aggregate with Glass powder (GP) and Plastic Coarse Aggregate (PCA) i,e G3 +PCA5 ,G5+PCA5 and G10+PC5 in concrete shows the increasing in compressive strength by 21.1N/mm^2 , 22.01 N/mm^2 and 24.8 N/mm^2,slump Value increases for above percentage and Density of concrete decreases.(2389.33 kg/m^3, 2378.07 kg/m^3 and 2347.25 kg/m^3).

By Seeing the results analysis it is observed that the increasing in Percentage of PCA Result the decreasing in compressive strength and Density. Therefore the increasing percentage of glass powder as partial replacement of cement in concrete for PCA 5 Which shows higher strength compared to Normal concrete (M20) for 28 days.

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