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Effect of Using Water Hyacinth Extract and Glass Powder in Concrete

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Abstract - *Use of recycled waste glass in concrete as partial replacement of Ordinary Portland Cement has attracted a lot of interest worldwide due to the increased disposal cost and environmental concern. Waste glass when ground to very fine powder shows pozzolanic property which improves the strength of the concrete. But the workability of waste glass replaced in concrete decrease as the amount of glass powder increases due to reduction in fineness modulus of cementitious material. Chemical admixtures and mineral admixtures are commonly used to increase the workability of concrete. This study evaluates the effect of bio-admixture, Water Hyacinth plant extract as a replacement for Conplast SP430 admixture. The waste glass powder is replaced at 10% to 25% with an increment of 5% of cement and Water Hyacinth extract at 10% to 25% with an increment of 5% of Conplast SP430 has been studied. It is tested for compressive strength and split tensile strength at 7 and 28 days. Workability and water absorption also conducted and compared with those of conventional concrete. Result shows that replacement of 20% cement by glass powder and 20% of Conplast SP430 by water hyacinth extract was found to have higher strength. Using bio admixture and waste glass in concrete will make the concrete economical and environmentally friendly. Presence of fatty acids and pozzolanic materials in water hyacinth extract and glass powder will results in increased compressive strength of concrete. On other hand, the absorption of water by fresh concrete enhances adhesion of cement paste to aggregate and thus the tightness of hardened concrete. It results in higher strength and better durability of concrete so that it can be used in exposed surface.*

Key Words: **Glass powder (GP), Water hyacinth extract (WH), Workability, Water absorption, Cement**

1. INTRODUCTION

Today, concrete is the most consumed material in the world. Across the world 30 billion tons of concrete is used each year and the biggest reason it is so popular around the world is that it is extremely durable. Concrete is weatherproof, it can withstand almost all elements. It is also resistant to erosion that it will last longer than other building materials. Cement is the main ingredient used to make concrete and it comprises from 10 to 15 percent of the concrete by volume. But cement is manufactured through the chemical combination of many ingredients. The most unbelievable thing about cement is that the manufacturing of these material is responsible for 7% of global carbon dioxide emissions. Thus, cement replacement in concrete results in substantial reduction in carbon footprint and it also reduce cost of raw materials used for cement manufacturing.

Glass powder as a cement replacement was discovered by many scientists[1]. Glass is mainly composed of silica. Use of recycled waste glass in concrete as partial replacement of Ordinary Portland Cement has attract a lot of interest worldwide due to the increased disposal cost and environmental concern. Waste glass when ground to very fine powder shows pozzolanic property which improves the strength of the concrete[2]. Use of grounded waste glass in concrete as partial replacement of cement could be an important step toward development of eco-friendly, energy-efficient, and economical system.

Water hyacinth is an aquatic plant native to South America and is known as the "terror of Bengal" due to its extremely rapid growth tendencies. One of the fastest-growing plants known, water hyacinth can produce thousands of seeds each year, and these seeds can remain viable for more than 28 years. Water-hyacinth blocks waterways and limits boat traffic, causes destruction of fish habitant thus killing fish and provision of a suitable breeding ground for mosquitoes[3]. Water hyacinth does not produce oxygen as compared to other submerged vegetation and phytoplankton. This leads to low levels of dissolved oxygen concentration thus negatively affecting water quality. Research on effective methods for controlling water hyacinth is still going on.

Concrete admixtures are used to improve the behavior of concrete under a variety of conditions. The use of admixtures in now the concrete industry is increasing days, especially the use of bio-admixtures. The market size for concrete admixture had surpassed United States Dollar 17.78 billion in 2020. It is evident that the cost of concrete will be reduced if admixtures are cheaper and easily available. Water hyacinth extract can be used for this purpose. Gas Chromatography-Mass Spectrometer analysis revealed concentrations of lingo cellulose, saturated and unsaturated fatty acids which make the extract a suitable bio admixture[4]. Water hyacinth extract was added at 0, 10, 15, 20 and 25% replacement of conplast sp430, and the mechanical properties of the concrete were determined.

1.1. Aim

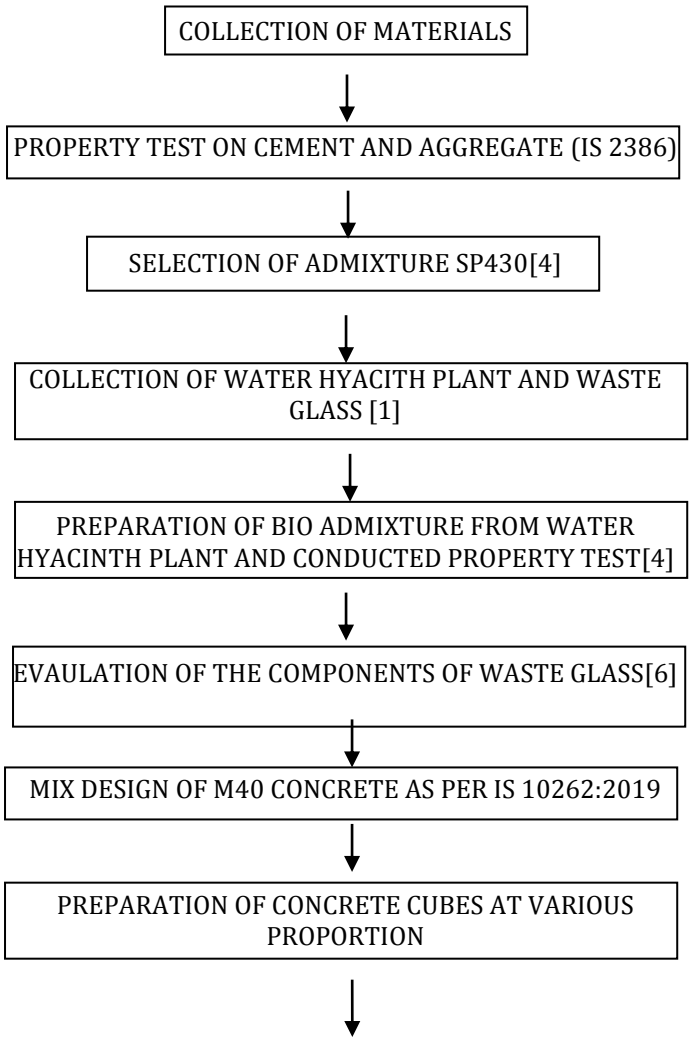
To study the effect of water hyacinth extract as a bio admixture for replacing Conplast SP430 to increase the workability of cement replaced glass concrete.

1.2. Scope

As concrete is most widely used material in the world the disposal of waste glass as a partial replacement for the cement is considered. During this process the workability will decreases, and it can be increased by adding admixture. Replacing chemical admixture by a bio admixture from an aquatic weed water hyacinth makes concrete more economical and eco-friendlier.

2. METHODOLOGY

Based on the literature review [5]M40 mix is prepared in different proportion with glass powder and water hyacinth extract and analyzed the properties of concrete. The various process involved in the execution of the works is given in the flow chart below.



3. MATERIALS AND PROPERTIES

3.1. Glass Powder

Waste glass powder is collected and grinded into thin powders. Figure 1 shows the picture of glass powder prepared.

Figure 1 Glass Powder

3.2. Cement

Ordinary Portland cement of 53 grade is being used in the present investigation. The cement was tested for various physical properties according to relevant Indian Standard IS 8112. Table 1 shows the chemical composition of cement and glass powder prepared.

Table 1 Chemical composition of cement and glass powder

Composition	Cement (% by mass)	Glass powder (% by mass)
Silica (SiO_2)	20.2	72.5
Alumina (Al_2O_3)	4.7	0.39
Iron oxide (Fe_2O_3)	3.0	0.21
Calcium oxide (CaO)	61.9	9.64
Magnesium oxide (MgO)	2.6	3.3
Sodium oxide (Na_2O)	0.19	13.2
Potassium oxide (K_2O)	0.82	0.13
Sulphur trioxide (SO_3)	3.9	-
Fineness % passing (sieve size)	97.4(45 µm)	80 (45 µm)
Loss of ignition	1.9	0.36
Unit weight, kg/m^3	3140	2573
Specific gravity	3.14	2.57

3.3. Coarse Aggregates

Crushed grinded angular aggregate from local source, having maximum size 20 mm was used for the study. Figure 2 shows the coarse aggregate sample.

Figure 2 Coarse Aggregate Sample

3.3.1. Sieve analysis

The grain size analysis of the aggregate sample was conducted according to the procedure conforming to the IS 2720 Part IV of BIS. Gradation analysis shown in Table 1 and the gradation curve is shown in Figure 3.

Table 2 Observation of Gradation Analysis of Aggregates

Particle size (mm)	Percentage weight retained (%)
40	0.0
20	11.45
10	87.0
6.3	1.24
4.75	0.0
2.36	0.0
1.18	0.0
PAN	0.15

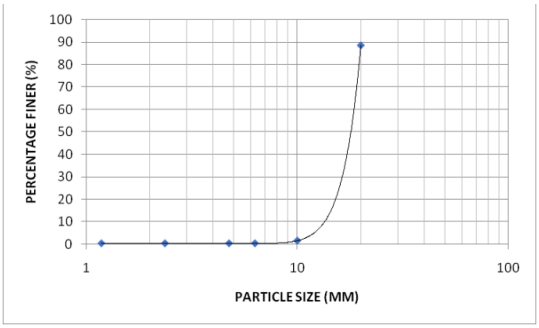


Figure 3 Gradation Curve of Aggregates

Tests are conducted to evaluate the properties of coarse aggregates.

Table 3 shows the properties of coarse aggregates.

Table 3 Properties of Coarse Aggregates

TEST	RESULT
Specific gravity	2.8
Uniformity coefficient	1.587
Coefficient of curvature	1
Water absorption	0.719

3.4. Fine aggregates

Fine aggregate is the inert or chemically inactive material. The fine aggregate serves the purpose of filling all the open spaces in between the coarse particles. The fine aggregate used for the present study in manufactured sand. Table 4 shows the properties of fine aggregates.

Table 4 Properties of Fine Aggregates

TEST	RESULT
Specific gravity	2.75
Zone	Zone II
Uniformity coefficient	8.057
Coefficient of curvature	0.97
Water absorption	1.9%

3.5. Water hyacinth extract

Water hyacinth plant is harvested from Kochi. It is then cleaned, washed, and dried under shade. The dried water hyacinth plant is powdered. 500g of the powder is wetted by 1 litre of clean potable water and soaked in 30 ml of ethanol for 24 hours. The extract obtained is filtered and stored. To identify the components of water hyacinth extract Gas Chromatography-Mass Spectrometer (GCMS) analysis is performed[4]Figure 4, Figure 5 and Figure 6 are shows various steps in the preparation of water hyacinth extract. Table 5 shows the organic compounds identified from GCMS test of water hyacinth extract.

Figure 4 Drying of water hyacinth plants

Figure 5 Water hyacinth powder

Figure 6 Water hyacinth extract

Table 5 Organic compounds in the water hyacinth extract

Component	Formula	Molecular Weight (g/mole)
1 -Ethyl-2-pyrrolidinone	$C_6 H_{11} NO$	113
2-Pentenal (E)	$C_5 H_5 O$	84
Piperidine,2,3-dimethyl	$C_2H_{15}N$	113
Pantolactone	$C_6 H_{10} O_5$	130
1-Butanol,2-methyl acetate	$C_7 H_{24}O_2$	130
Octanoic acid, o-hydroxyphenyl ester	$C_{14}H_{20} N_5$	236
Hexadecenoic acid, methyl ester	$C_{17} H_{54} O_2$	270
9-Hexadecanoic acid	$C_{16}H_{50}O_2$	254
n-Hexadecanoic acid	$C_{18} H_{22} O_2$	256
9,12-Octadecadieonic acid (z, z)	$C_{18} H_{52} O_2$	280
6-Heptene-2-one,7-phenyl	$C_{15} H_{150}$	188

3.6. Conplast SP430

Conplast SP430 significantly improves the workability of site and precast concrete without increasing water demand. Table 6Table 6 Properties of Conplast SP430.

Table 6 Properties of Conplast SP430

Appearance	Brown liquid
Specific gravity	1.18 @ 25°C
Chloride content	Nil to BS 5075 / BS: EN934
Air entrainment	Less than 2% additional air is entrained at normal dosages.

3.7. Water

The common specifications regarding quality of mixing water are water should be fit for drinking. Such water should have inorganic solid less than 1000 ppm. This content led to a solid quantity 0.05% of mass of cement when w/c ratio is provided 0.45 resulting small effect on strength[3].

4. MIX DESIGN

Concrete mix design is prepared as per IS 10262:2019. The mix design obtained contain desired properties like workability, durability, strength etc.

4.1. Mix Design Samples of Glass Powder Concrete

Mix design for the cement replaced by glass powder concrete at various proportions are evaluated. Table 7 shows the various samples prepared in different proportions[2]

Table 7 Mix Design of Glass Powder Concrete

Sample	1-0%	2-10%	3-15%	4-20%	5-25%
Cement (kg)	11	9.9	9.35	8.8	8.25
Coarse Aggregate (kg)	39.25	39.25	39.25	39.25	39.25
Fine Aggregate (kg)	19.6	19.6	19.6	19.6	19.6
Glass powder (kg)	0.0	1.1	1.65	2.2	2.75
Water (Litre)	3.7	3.7	3.7	3.7	3.7

4.2. Mix Design Samples of Glass Powder and Water Hyacinth Concrete

Mix design for the partially replaced glass powder and water hyacinth extract concrete at various proportions are shown in Table 8.

Table 8 Mix Design of Glass Powder and Water Hyacinth Concrete

Sample	1-0%	2-10%	3-15%	4-20%	5-25%
Cement (kg)	11	9.9	9.35	8.8	8.25
Coarse Aggregate (kg)	39.25	39.25	39.25	39.25	39.25
Fine Aggregate (kg)	19.6	19.6	19.6	19.6	19.6
Glass powder (kg)	0.0	1.1	1.65	2.2	2.75
Water (Litre)	3.7	3.7	3.7	3.7	3.7
Conplast sp 430 (ml)	60	54	51	48	45
Water Hyacinth extract (ml)	0.0	6	9	12	15

5. TESTS ON CONCRETE

5.1. Slump Test on Fresh Concrete

The test was conducted as per IS 1199. The test is performed at various mix proportions. Figure 7 shows slump cone prepared.

Figure 7 Slump cone

5.2. Compressive Strength Test on Concrete Cubes

The test was conducted as per IS 516. The specimens are tested by compression testing machine after 7 and 28 days of curing. Figure 8 shows compression testing of concrete cubes.

Figure 8 Compression testing

5.3. Split Tensile Strength on Concrete Cubes

The test was conducted as per IS: 5816 and IS:456. The specimens are tested by compression testing machine after 7 and 28 days of curing. Split tensile strength test is illustrated in Figure 9.

Figure 9 Split tensile strength test

5.4. Water Absorption Test on Concrete

The test was conducted as per IS 1124.Water absorption is used to determine the amount of water absorbed under specified conditions. The dry weight of the sample is taken and then it is immersed in water for 48 hours is shown in Figure 10.

Figure 10 Immersing concrete cubes in water for 48 hours

6. RESULTS AND DISCUSSION

6.1. Workability

The workability of concrete is measured from slump test. The Figure 11 shows the slump cone value of various mixes.

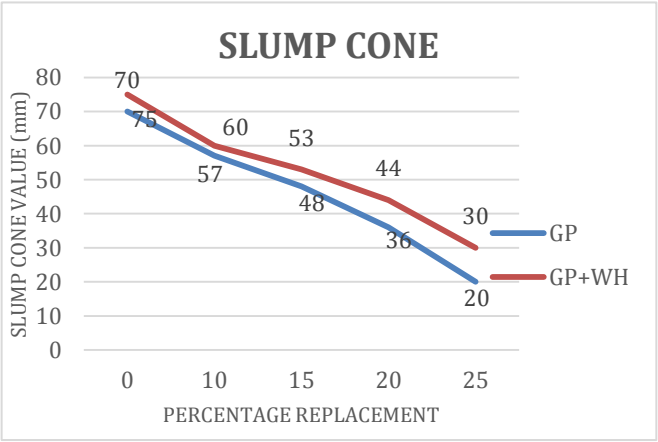


Figure 11 Slump cone

The workability of waste glass replaced concrete will decreases as amount of glass powder increases due to reduction in fineness modulus of cementitious material. This effect can be compensated by adding admixtures. This study evaluates the effect of bio-admixture, Water Hyacinth plant extract as a replacement for Conplast SP430.It can also be observed that as the amount of the water hyacinth extract increases, workability also increases. This indicates that the water hyacinth extract retards the hydration rate and hardening making the concrete to flow longer hence high flowability and filing ability.[4]

6.2. Compressive strength

The compressive tests were conducted, and the results obtained for different mixes tested after curing periods of 7 day and 28 days are illustrated in Figure 12.

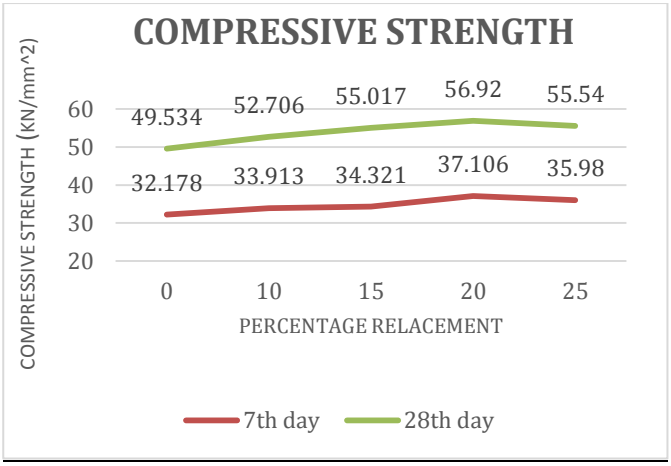


Figure 12 Compressive Strength

Waste glass when ground to very fine powder shows pozzolanic property which improves the strength of the concrete. The presence of fatty acids in the water hyacinth extract could be the reason of increased compressive strength with the increase in the amount of water hyacinth extract. After 20% replacement, compression strength decreases due to high fluidity causing segregation and bleeding of the matrix[1]

6.3. Split tensile strength

The split tensile strength tests were conducted on concrete cylinders. The results obtained for different mixes tested after curing periods of 7 days and 28 days are illustrated in Figure 13.

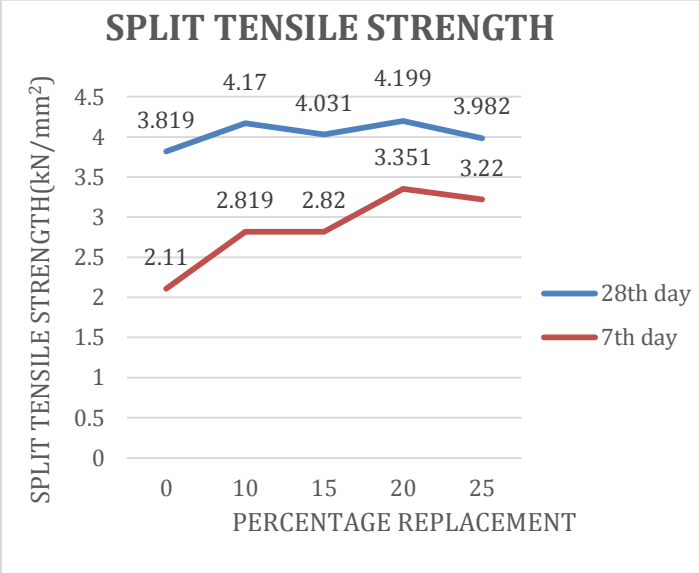


Figure 13 Split Tensile Strength

Here concrete with 20% Water hyacinth extract and glass powder replacement has got a higher compressive and tensile strength.

6.4. Water Absorption

Water absorption is defined as the amount of water absorbed by a material and increment water absorption percentage is given in Figure 14

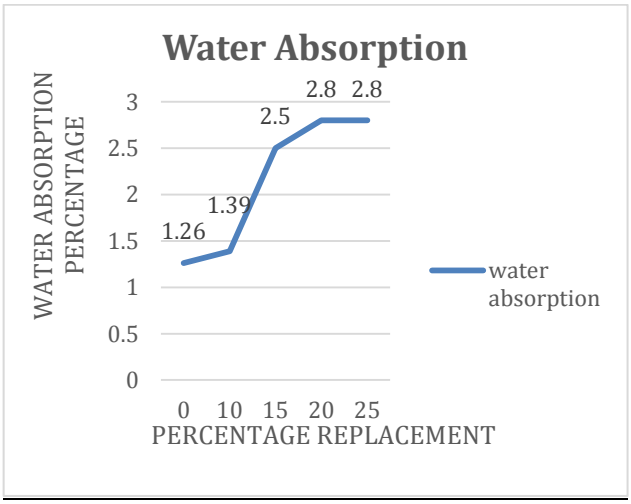


Figure 14 Increment water absorption percentage.

Water absorbing property of Water hyacinth extract and cement powder replaced concrete cube is less than normal concrete [Figure 14]. Higher water absorption decreased the resistance to sulfate attack of concrete and hence is more durable than the normal concrete.

7. CONCLUSIONS

Conclusions that made from this study: -

- Optimum value for addition of water hyacinth was obtained as 20% of admixture.
- Optimum value of addition of glass powder was obtained as 20% of cement
- Compressive and tensile strength for the above two criteria sample is greater than the normal concrete.
- Water absorbing property of the Water hyacinth glass concrete is greater than the normal concrete hence it can be used in exposed surfaces[5].
- Weight of water hyacinth glass concrete is less than that of the normal concrete, hence can be used for light weight concrete structures[4].
- With the addition of glass powder, the strength of concrete increases, but the workability of concrete decreases[2]. Addition of water hyacinth will compensate the same[4].

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