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Fascinate in approaching pH Water Consequences on Mechanical and Durability Properties

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Abstract

Potable water is a treasurable and unusual commodity in emerging and advanced countries. Due to its limited availability, some waters not fit for drinking may be suitable for concrete making, provided they satisfy the acceptance criteria. One viable approach is to employ these non-potable waters with altered pH as a substitute for tap water in concrete.This study assessed the effect of mixing water's pH on concrete's mechanical and durability properties. Diverse mixing waters with pH1.9, pH3.2, and pH8.9 were obtained and subsequently compared mechanical and durability properties with the concrete mix of the same grade with normal mixing water of pH7.4 for the 7, 28, and 270 days.The maximum design compressive strength of 33.26 N/mm^2, flexure strength of 3.02 N/mm^2, and splitting tensile strength of 2.37 N/mm^2 for tap water with pH7.4 for 28 days were recorded. The result indicates that the mechanical properties of water with pH1.9 strength decreased by 45.43%, pH3.2 strength decreased by 30.58%, and pH 8.9 strength increased by 7.69%. After that, research is done to obtain an exact optimum substitution level of cement by G.G.B.S. (15 – 60% at an increment of 15%) and Waste glass (5 – 20% at an increase of 5%) combined for the O.P.C. concrete mix followed by simulation for the same. A constant water/cement ratio of 0.4 was taken to analyze the mechanical properties (compressive, flexural, and split tensile strength) of the combination of waste glass and G.G.B.S. concrete mix.

Keywords: *pH concrete, Alkalinity, Acidity, durability, mechanical Strength, permeability, Microstructural analysis, Glass waste.*

1. Introduction

Water is the basis of life and sustains all biological ecosystems and human activities. Most of the world's water is found in seas and oceans, which is not potable. Only about 2% of water is fresh, out of which 97% is tied up in the polar caps in the form of permanent snow and deep depths below the ground. The remaining 3% is renewable through the cycle of precipitation and evaporation form. Even this water will not be available when required [1]. Since concrete began to be used as one of the most durable construction materials, potable water has been and is still being used as the mixing water. Research has shown, however, that water not fit for human consumption might also be used for mixing concrete. Potable water resources are not inexhaustible for urbanized cities; with limited water resources coupled with rapid industrial and construction growth, the need to conserve potable water becomes increasingly more urgent each year. Increasingly social affluence in cities also exerts a taxing effect on the potable water supply. Using water unfit for human consumption in the industry can be beneficial [2].

Concrete is one of the most durable and widely used construction materials, and pH is an essential parameter in studying the properties of concrete. pH is an approximate measure of acidity or alkalinity of a solution and is defined as the negative logarithm of the hydrogen ion (H+) concentration. As the pH of a solution increases, the number of free hydrogen ions decreases and a change in the pH of one reflects a tenfold change in the H+ concentration [3]. Hence the characteristic of the water plays a significant role in manufacturing concrete. Adulteration in water may hinder the setting of the cement and may adversely affect the durability and strength of the concrete. The performance of concrete in the fresh and hardened state is related to the critical parameters for the characteristic of mixing water. The chemical constituents of water may affect the setting, hardening, and strength development of concrete by taking part in the chemical reactions. Along with considering the health issues associated with the safe handling of such water, setting times and compressive strength tests can be performed to identify the fitness of water [4].

When the literature was examined, it was observed that there are limited studies about the effect of mixing water pH value on concrete. Generally, it is stated that waters with a pH level of 6–8 and not including organic material can be used as concrete mixing water. As a result, waters with a lower pH value than 5.5 were determined to have a

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substantially strong impact on concrete, while waters with a lower pH value than 4.5 were determined to have a powerful effect on concrete. When studies performed on waters with different pH values were examined, it was observed that researchers had used acidic or alkaline waters as curing water rather than mixing water and that their effects on concrete or mortar properties were examined [5]. Acidic water containing uncombined carbon dioxide of organic or inorganic acids shows vigorous nature resulting in increased acidity as the degree and rate of attack increases [6].Water having a pH less than 12.5 may be assertive because of a reduction of the alkalinity of the pore fluid, while a pH above six and less permeability slower down rate of the chemical attack, which can cause porosity, decrease in strength, cracking, and breaking into pieces [7]. It has also been found that water having a pH of 6.0 to 8,.0 which does not taste saline or brackish, is suitable for use. Still, water carrying humic or other organic acids may adversely affect the strength of concrete [8]. The degree of carbonation and pH is a function of the mix design where carbonation indicates an unexpected decrease in pH because of calcium hydroxide, potassium, and sodium oxides which control the pH of the water. Still, pH remains unchanged at the depth where carbon dioxide cannot pierce concrete [9].CFRP and G.F.R.P. specimens were subjected to varying freeze-thaw cycling and temperature with pH 10, pH 12, and pH 13.7 concentrations of NaOH solutions to enquire about the effect of the durability of F.R.P. concrete. It has been observed that the specimen exposed to high alkalinity adversely affects bond strength and freeze-thawing. In contrast, low alkalinity, most minor, has the most negligible effects on impounding properties [10].

Mineral admixtures such as ground granulated blast-furnace slag (G.G.B.S.), fly ash, and silica fume is commonly used in concrete because they improve durability and reduce porosity; they improve the interface with the aggregate. Economics (lower cement requirement), energy, and environmental considerations have had a role in mineral and usages better engineering and performance properties. The lower cement requirement also leads to a reduction in CO_2 generated by the production of cement. The engineering benefits from using mineral admixtures in concrete result partly from their particle size distribution characteristics and partly from the pozzolanic and cementitious reactivity. Granulated blast-furnace slag is a by-product of the manufacture of pig iron, and the amounts of iron and slag obtained are in the same order. The slag is a mixture of lime, silica, and alumina, the same oxides that make up Portland cement, but not in the same proportion. The composition of blast-furnace slag is determined by the ores, fluxing stone, and impurities in the coke charged into the blast furnace. Typically, silicon, calcium, aluminum, magnesium, and oxygen constitute 95% or more of the blast-furnace slag. To maximize cementitious properties, the molten slag must be chilled rapidly as it leaves the blast furnace. Rapid quenching or chilling minimizes crystallization and converts the molten slag into fine-aggregate-sized particles generally smaller than a 4.75 mm sieve, composed predominantly of glass. This product is referred to as granulated iron blast-furnace slag. G.G.B.S. is obtained by finely grinding this material. Ground granulated blast furnace slag's cementitious and pozzolanic behaviouris similar to that of high-calcium fly ash. At 40%, 50%, or 65% cement replacement by weight, Hogan and Meusel [11] found that up to 3 days of age, the strength contribution of slag to ASTM C 109 mortars was low; however, strength similar to the reference Portland cement was achieved at seven days, and higher strength after that. Hwang and Lin [12] have determined the compressive strength of G.G.B.S. mortars at different ages and various replacement levels. They showed a maximum percentage of G.G.B.S. Replacement to obtain an equivalent strength of the concrete mixture without G.G.B.S.

This shows that there is a maximum percentage for obtaining an equivalent strength (equivalent to the standard mortar at that age) and also that there is a specific percentage of G.G.B.S. at which the maximum strength can be obtained at that age. From this, it can be said that the compressive strength of G.G.B.S. concretes depend both on percentage replacement level and age [13]. Research to date suggests that these supplementary cementitious materials improve many of the performance characteristics of the concrete, such as strength, workability, permeability, durability, corrosion resistance, etc. To assess the effectiveness of G.G.B.S. in cementitious composites, some parameters like chemical composition, hydraulic reactivity, and fineness have been carefully examined much earlier. In an earlier paper, the authors summarized the details of the various chemical constituents and their effects. It was seen that among these, the reactive glass content and fineness of G.G.B.S. alone will influence the pozzolanic efficiency or its reactivity in concrete composites significantly. There have been a few attempts of this nature reported in the literature. It noted that by proper mix proportioning, G.G.B.S. concretes can be produced with strengths comparable to those with ordinary Portland cement from the 3rd day onwards. He also suggested that the total cementitious material has to be increased by 10% for 50% replacement of G.G.B.S. and by 20% for 65% replacement to attain strengths comparable to normal concretes [14].

2. Methodology

2.1Experimental work:

A total of 4 types of mixes were produced in this experiment. Specimen prepared for testing were concrete prototypes cube of 150 x 150 x 150 mm and 100 x 100 x 100 mm, the beam of 100 x 100 x 500 mm, and a cylinder of 150 x 300 mm of concrete mix of M25 and M30 grade. Three concrete specimens were cast and cured for 7 and 28 days for the cube, beam, and cylinder. The Sample was prepared for fresh and hardened concrete. These samples were used for compressive, flexural, and split tensile strength tests. Water permeability was investigated as per DIN 1048-1991. Three oven-dried concrete cube (150 mm) samples were used. Constant water pressure of 0.5 N/mm^2 was applied for 72 hours on concrete specimens. At the end of 72 h, the depth of water penetration was recorded.

2.2 Materials:

The properties of the materials used in the pH work are shown in Table 1, and the materials used in G.G.B.S. and W.G. work are shown in Table 2.

2.2.1. Cement- Portland pozzolana cement was used for this pH-related experimental work. The water-cement ratio is fixed to 0.48 accordingto mix design code I.S. 10262:2009. The admixture used was Master Polyheed 8102 as 0.8% by weight of cement. The Vicat apparatus observed the initial and final setting times, 30 and 595 minutes, respectively. The soundness of cement by Le-Chetelier was 4 mm. For G.G.B.S.-related work,O.P.C. 43-grade cement was produced at the Kufa factory. This cement complied with Iraqi Specification No.5 (1984). For water with a pH value of 6.5, the ratio of w/c was prepared to 0.4 [19].

2.2.2. G.G.B.S.-The blast furnace slag (specific gravity of 2.69) was obtained from Gujarat through the local seller. A particular test of sincerity was directed at this waste slag.

2.2.3. Aggregates- For pH work,sand size range from 150µm to 4.75mm. In the present work, Banas River sand from district Tonk was used with a % finer 99.4 with a specific gravity of 2.62, and coarse aggregates are more significant than 4.75mm. In this case,a rough aggregate range of 20mm and 10mm particle size was used with a specific gravity of 2.66. While for the replacement of cement by G.G.B.S. and F.A. by W.G., Crushed basalt (specific gravity of 2.76) having a maximum aggregate size of 10 mm and river sand (specific gravity of 2.60) were used as a coarse and fine aggregate.

2.2.4. Waste-Glass-Waste glass (specific gravity of 2.39) was obtained by mechanical grinding of different colored beverage bottles. The crushed waste glass was passed through 600 microns and retained on a 150-micron sieve.

2.3 Mix Proportioning:

In the present study work, the little mix is taken M25 and M30 for two differentresults, and it is mixed as per design code I.S. 10262:2009 [16]. The mix proportions chosen for this study are given in Table 2 for concrete. As discussed earlier, the W/C ratio is fixed to 0.48, and a suitable 0.8 % by weight of cement admixture is used to maintain the slump [29-31].A constant dosage of superplasticizer was utilized to get the wanted workability 0.1% admixture by weight of cement was added in concrete for the M30 mix. G.G.(G.G.B.S.) mix GG0, GG1, GG2, GG3, and GG4 are prepared by substituting cement with B.F. slag in proportions of 0 %, 15%, 30%, 45%, and 60%. After getting an optimum quantity of G.G.B.S., for G.W.(G.G.B.S. and W.G.) mix GG5, GG6, GG7, and GG8, fine aggregate is replaced by the waste glass in a proportion of 5%, 10%, 15% and 20% to get the optimum result [19].

Table 1: Properties of raw materials

S. No.	Material	Description	Specific Gravity
1	Cement (P.P.C.)	PPC	3.14
2	Sand	Zone 2	2.62
3	Coarse aggregate	10, 20 mm	2.66

Table 2: Properties of materials

Material	Specific Gravity	Colour	pH
Cement (OPC)	3.15	Grey	-
Fine Aggregate	2.60	Light Brown	-
Coarse Aggregate	2.76	Greyish White	-
Water	-	Colourless	6.5-7

Table 3: Control Mix Proportion for M25 and M30

S. No.	Material	M25-Weight(kg)	M30-Weight(kg)
1	Cement (P.P.C.)	360	383
2	Coarse aggregate (20mm)	632.38	784.14
3	Coarse aggregate (10mm)	415.54	522.76
4	Fine aggregate	822.90	634.27
5	Water	173	153
6	Admixture	2.88	0.383
7	W/C ratio	0.48	0.40

3. Results and Analysis

3.1 Density

Average density values of cement mortar samples obtained by waters with different pH values are shown in Figure 2.

The densities of cubes were measured before testing the cubes. To calculate the density of cubes first external surface of the cube is cleaned and wiped with the help of any cotton cloth. From Table 4, it was observed that no significant difference occurred in the densities of hardened concrete samples. Figure 1 shows the graphical representation of densities for dissimilar pH waters.The bulk density of G.W. concrete mixes is shown in Table 5.It has been observed from figure 2 that with the increase in W.G., fresh bulk density of concrete mix decreases [20-23].

At 5% W.G., bulk density remains constant; after that,the reduction in new bulk density in GG6, GG7, and GG8 is 0.21%, 0.38%, and 0.43%. As the specific gravity of waste glass is 2.39, which is lesser than the specific gravity of fine aggregate (2.60), this might be the reason forthe decrement in fresh bulk density.

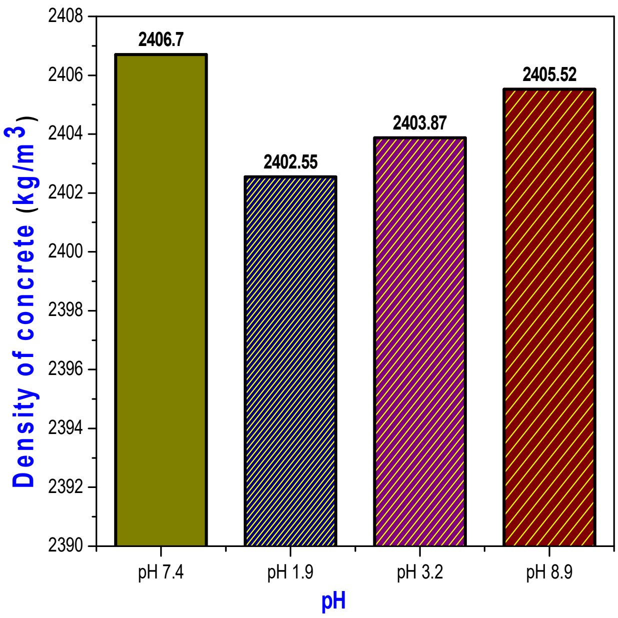

Figure 1: Density of mixing waters

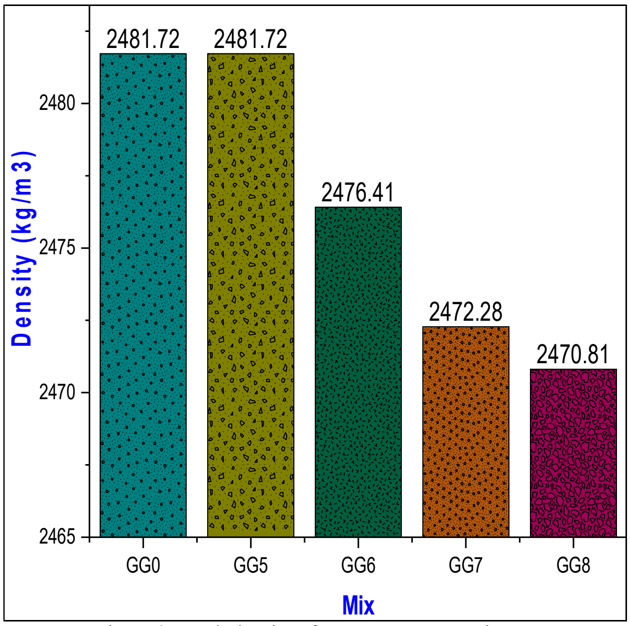

Figure 2: Fresh density of G.G. concrete specimens

Table 4: Densities of concrete mix

S. No.	pH	Density (kg/m^3)
1.	pH 7.4	2406.70
2.	pH 1.9	2402.55
3.	pH 3.2	2403.87
4.	pH 8.9	2405.52

Table 5: Density of G.W. mix

Mix	Density (kg/m^3)
GG0	2481.72
GG5	2481.72
GG6	2476.41
GG7	2472.28
GG8	2470.81

3.2 Compressive strength

Descriptive statistics about the compressive strength of concrete samples obtained by waters with different pH values in different curing periods (7, 28, and 270 days) are shown in Table 6. The graphical comparison is shown in Figure 3. When compressive strength of 7 days cured specimens are examined, the highest strength is 23.88 MPa, and it is observed in samples produced by water, the pH value of which was adjusted to pH 8.9. According to the control mix (reference sample), it is observed that strength is increased by 7.72% in series with pH8.9 while decrement by 45.43 and 30.58% is observed in series with a pH value of

Table6: Compressive Strength for 7, 28, and 270 days

S. No.	pH	Compressive Strength (N/mm^2)		
		Curing days		
		7	28	270
1.	pH 7.4	22.17	33.26	39.74
2.	pH 1.9	12.10	18.15	09.89
3.	pH 3.2	15.39	23.09	26.93
4.	pH 8.9	23.88	35.82	45.13

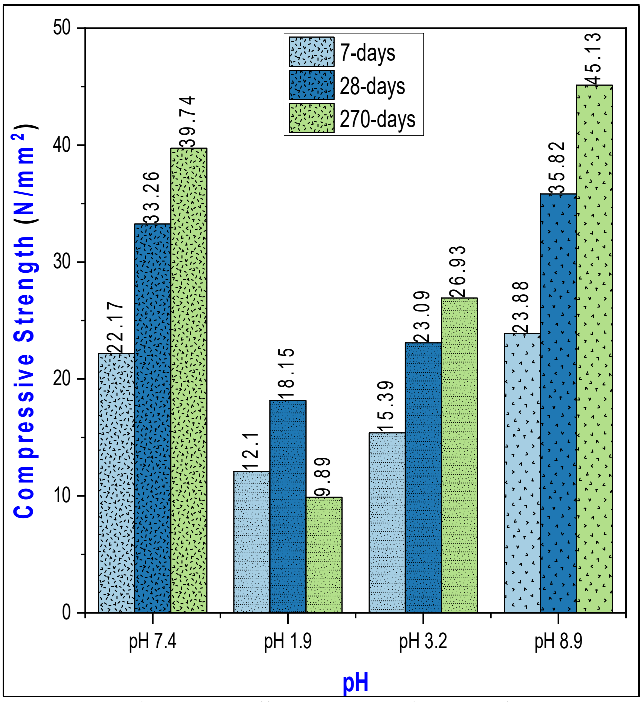

Figure 3: pH Effect on Compressive Strength

pH1.9 and pH3.2, respectively. When compressive strength of 28 days cured specimens are examined, it is celebrated according to the reference sample that strength is increased by 7.69% in series with pH8.9 while decrement by 45.43 and 30.58% is observed in series with a pH value of pH1.9 and pH3.2 respectively. The highest strength is 35.82 MPa, celebrated in samples produced by water, the pH value was adjusted to pH8.9, and the lowest strength is 18.15 MPa in series with pH1.9. When compressive strength of 270 days cured specimen is examined, it is observed according to the reference sample that strength is increased by 13.56% in series with pH8.9 while a decrement by 75.11% and 32.23% is observed in series with a pH value of pH1.9 and pH3.2 respectively [24-28]. The highest strength is 45.13 MPa which is 25.99% higher than 28 days' strength and is observed in samples produced by water, the pH value of which was adjusted to pH 8.9,making the alkaline water most beneficial,and the lowest strength is 9.89 MPa in series with pH1.9 making the acidic water most unproductive.

The trend of compressive strength of concrete mixes with G.G.B.S. and the combination of G.G.B.S. and W.G. after 7 and 28 days are presented in Table 7**.** It has been seen from Figure 4 that when cement is partially replaced by G.G.B.S. (15 - 60% at an increment of 15%), an increase in compressive strength is observed at 7 and 28 days up to GG3,i.e., 45 % replacement after that for GG4at 60% replacement of cement by G.G.B.S.compressive strength showed a decrement. From the compressive strength test at 7 and 28 days, we obtained an optimum mix in which cement is partially replaced by G.G.B.S. Replacement of 45 % of cement by G.G.B.S. in concrete mix results in a 10.18% and 19.5% increase in compressive strength for 7 and 28 days cured samples. Incorporating 60% G.G.B.S. in

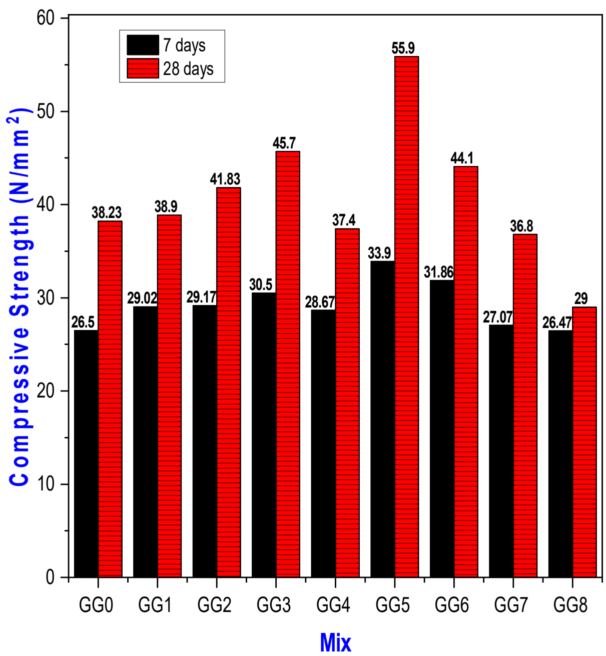

Figure 4: Compressive strength of G.G. and G.W. mix

Table 7: Compressive Strength of G.G. and G.W.Concrete mix

Mix	Compressive Strength (N/mm^2)	
	7 days	28 days
GG0	26.50	38.23
GG1	29.02	38.90
GG2	29.17	41.83
GG3	30.50	45.70
GG4	28.67	37.40
GG5	33.90	55.90
GG6	31.86	44.10
GG7	27.07	36.80
GG8	26.47	29.00

the concrete mix leads to a decrement in compressive strength. Decrement is observed at 28 days of curing compared to the control mix. With an increase in fixing, there is a rise in compressive strength for all combinations.

As we get optimum at 45% replacement of cement, in our other mixes, GG5, GG6, GG7, and GG8, we obtain an optimum result at the replacement of 5%, When W.G. replaces 5% of fine aggregate. At the same time, 45% G.G.B.S. is made constant, an increment of 16% and 22.5% is obtained when compared to GG3 at 7 and 28 days, and this increment in strength is much higher if compared with the control mix, 27.9%, and 46.22%, higher stability is observed at 7 and 28 days. After that decrease in strength is found with the increase in percentages of W.G. compared with the GG5 mix. The maximum decrement in strength is observed for GG8, about 24.14%.

A decrease of 6%, 20.09%, and 21.92% is noticed in GG6, GG7, and GG8 at seven days, and 21.1%, 34.14%, and 48.12% decrement is observed at 28 days when compared with the GG5 mix. As G.G.B.S. has a slower pozzolanic reaction, its initial strength is not as high as its ultimate strength; it shows higher maximum strength. With an increase in the curing period, strength also increases. G.G.B.S. has reactive silica, and it has pozzolanic properties, which makes it compatible with cement. Another reason for the rise in compressive strength is the denser microstructure and better bonding of cement, G.G.B.S., and waste glass. A fall in compressive strength might be due to the non-availability of calcium hydroxide, which is further needed for the pozzolanic reaction of G.G.B.S., and an increase in void content and crack width because of the presence of excessive fine waste glass.

3.3 Flexural Strength

I.S. 516:1959 describes standard specifications for testing concrete with center and third point loadings [15]. Centre point loading was adopted, and the test was carried out for flexural strength. Testing beams determined the flexural strength results.

The results of flexural strength after 28- days of water curing are reported in Table 8, while graphical representation is shown in Figure 5. It has been observed from the exact figure that the highest flexural strength of 3.25 MPa was achieved for the concrete with alkaline water, i.e., in samples produced by water, the pH value of which was adjusted to pH8.9, compared to tap water for 28 days and lowest strength is 1.65 MPa in series with pH1.9.The trend of flexural strength of concrete mixes with or without waste glass after 28 days is presented in Table 9. It has been observed from Figure 6 that the optimum result in flexural strength is obtained for GG5. After this, in GG6, GG7, and GG8,a decrement in flexural strength is observed, respectively, when compared to GG5. An increase of 56.20% of flexural strength is seen in GG5 compared with GG0 at 28 days after curing [32-34].

Table 8 and Table 9: Flexural strength Results for 28 days

pH	Flexural strength (N/mm^2)
pH 7.4	3.02
pH 1.9	1.65
pH 3.2	2.10
pH 8.9	3.25

Mix	FlexuralStrength (N/mm^2)
GG0	5.60
GG5	6.95
GG6	7.15
GG7	6.10
GG8	5.15

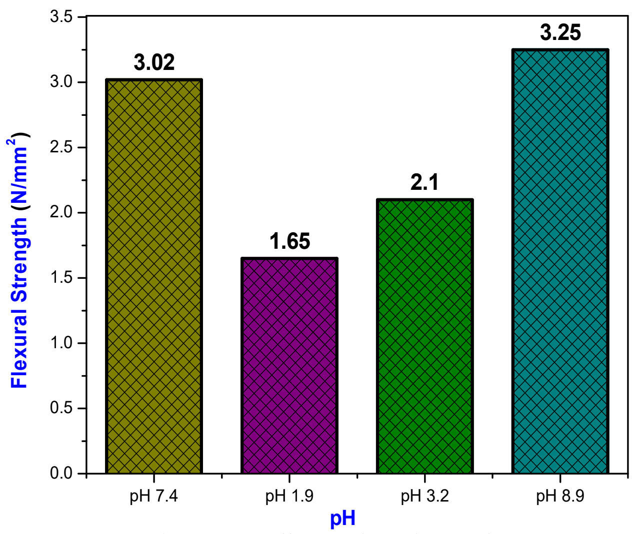

Figure 5: pH Effect on Flexural Strength

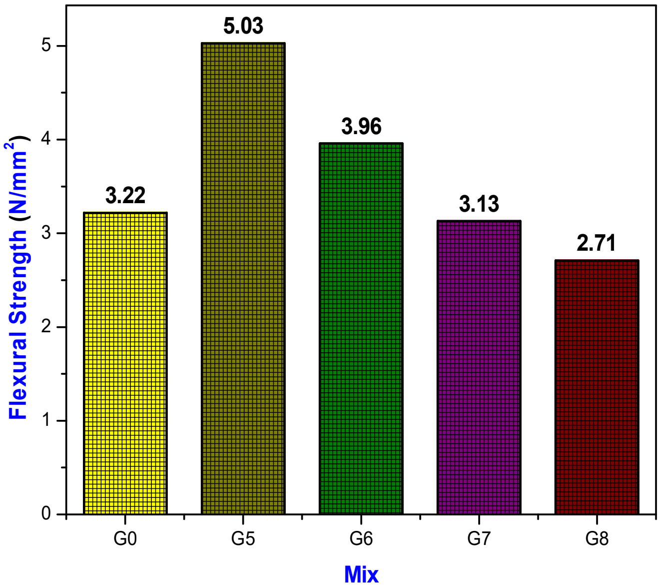

Figure 6: Flexural strength of G.W.mix

This increase in flexural strength might be due to strong bonding between cement phase G.G.B.S. and W.G. phase at the interstitial transition zone in the WG5 mix. The reduction of crack width and drop in void size is observed in the GG5 blend, leading to better bonding. It might be due to dense microstructure obtained in a combination of G.G.B.S. and W.G. The decrease in flexural strength is observed as W.G. percentages are increased, a decline of 21.27%, 37.77%, and 46.12% is observed in GG6, GG7, and GG8 respectively when compared with GG5. In GG7 and GG8 fall of 37.77% and 46.12% is noticed, respectively, compared with GG0. It might be due to the sharp edges of W.G., which leads to weaker bonding. With the increase in W.G. percentages, the generation of voids also increases, eventually leading to a decline in flexural strength.

3.4 Splitting Tensile Strength

The results of split tensile strength after 28- days of water curing are reported in Figure 7 [17]. It has been observed from the exact figure that the highest flexural strength of 2.56 MPa was achieved for the concrete with alkaline water compared to the control mix (tap water), and the lowest strength was 1.30 MPa in series with pH1.9.

In a split tensile test, an increase in strength is obtained for GG5 after that decrement is observed in GG6, GG7, and GG8, respectively, when compared to GG5. A rise of 13.46% in strength is found in GG5 compared to GG0 at 28 days after curing. This rise in force might be due to the solid interconnecting bond between cement, G.G.B.S., and W.G [35].

After GG5, there is a decrement in strength; a decrement of 4.76% and 19.05% is observed in GG8 mixes compared to the control mix. This might be because of the sharp edges in waste glass and the increase in crack width and void size [36].

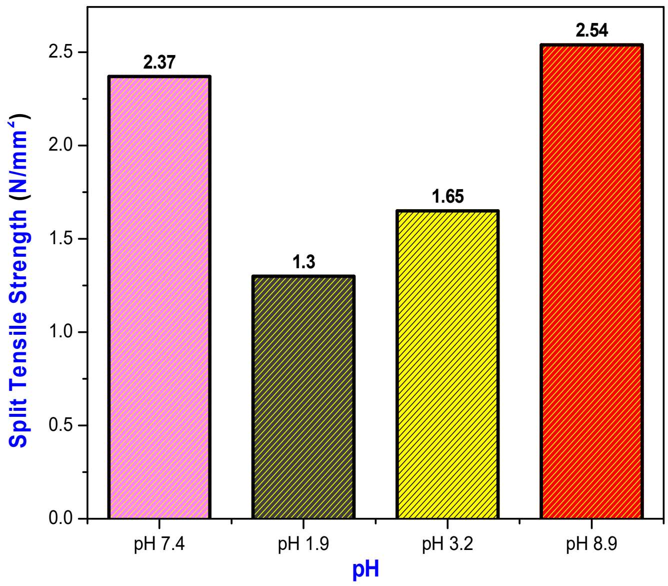

Figure 7: pH Effect on Split Tensile Strength

Table 10 and Table 11: Split Tensile strength Result for 28 days

pH	Split tensile strength (N/mm^2)
pH 7.4	2.37
pH 1.9	1.30
pH 3.2	1.65
pH 8.9	2.54

Mix	Split tensile strength (N/mm^2)
GG0	4.2
GG5	5.0
GG6	4.5
GG7	4.0
GG8	3.4

The higher percentage of waste glass due to weakening bonding between aggregate and cementitious material might reduce split tensile strength. The trend of split tensile strength is shown in Figure 8.

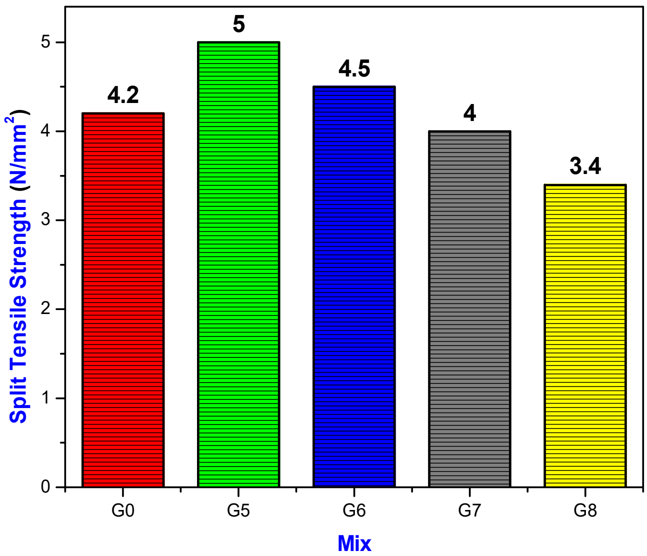

Figure 8: Split Tensile strength of G.W. mix

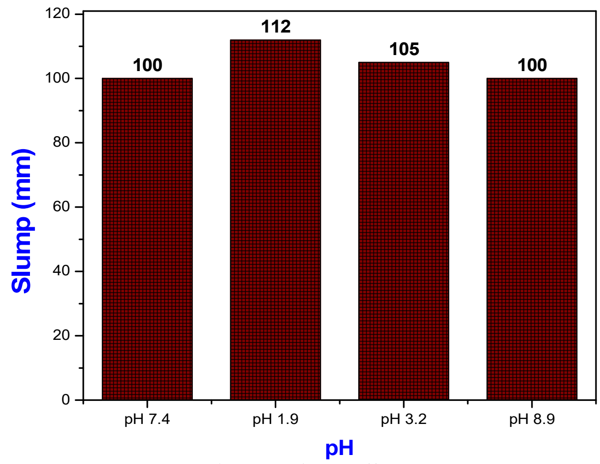

Figure 9: Slump Effect

Table 12: Slump results for pH waters

S. No.	pH	Slump (mm)
1.	pH 7.4	100
2.	pH 1.9	112
3.	pH 3.2	105
4.	pH 8.9	100

3.5 Workability

A slump test was done per the guidelines of I.S. 1199:1959 to identify the workability of fresh concrete samples. In the present work, the amount of superplasticizer added to concrete mixes was strictly scrutinized to maintain the slump, as shown in Figure 9. Accordingly, it was determined that workability increases as the acidity of water increases, but it is identical for alkaline water when compared with the control mix (tap water). The workability identified using the slump test is presented in Table 12 [18].

3.6 Water permeability

Water permeability was determined in terms of the depth of water penetration. To find the water permeability DIN 1048 test was performed on the cubes.

This test was executed according to DIN 1048 (Part 5). Water permeability has been presented in terms of water penetration depth in concrete samples in Table 13, along with a graphical representation in Figure 10. With an increase in the acidity of water, penetration increases when compared with the control mix. Increment of 33.33% and 25% of water penetration are observed in pH1.9 and pH3.2 combination when compared to pH7.4 (tap water) mix. This increase in water penetration in higher percentages maybe because of the formation of voids and an increment in crack width. It should be noted that in the pH8.9 water mix, the penetration depth is significantly lower, 16.67%, compared to the pH7.4 water mix.

Table 13 and Table 14: Water permeability results

pH	Permeability (cm)
pH 7.4	6.0
pH 1.9	8.0
pH 3.2	7.5
pH 8.9	5.0

Mix	Permeability (cm)
GG0	5.0
GG5	6.0
GG6	6.5
GG7	7.0
GG8	7.5

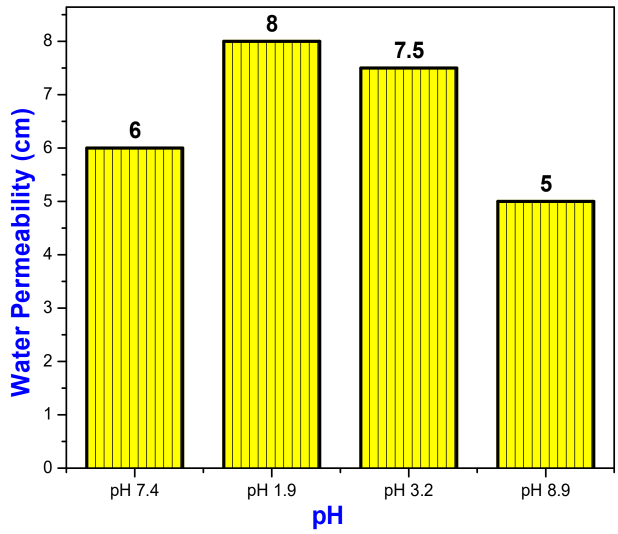

Figure 10: pH Effect on Water Permeability

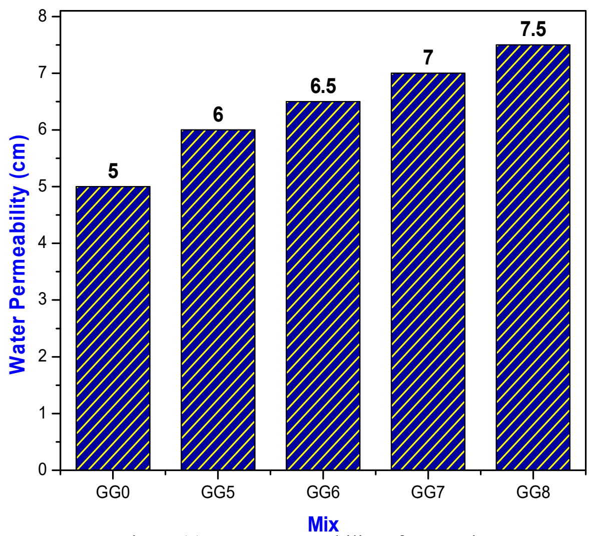

Figure 11: Water Permeability of G.W.mix

The percentage of waste glass water penetration increases compared to the control mix GG0, as shown in Table 14. An increment of 40% and 50% in water penetration is observed (from Figure 11) in GG7 and GG8 mix compared to the GG0 mix. This increase in water penetration in higher percentages maybe because of the formation of voids and an increment in crack width. It should be noted that GG3 and GG5 mix penetration depth is significantly less, 20% decline in water penetration compared to GG0 mix because G.G.B.S. responds with the excess of calcium hydroxide to frame a finely scattered gel, which fills the more prominent pores.

4. Conclusions

This paper inspects the usage of unlikepH waters as an alternative to tap water in concrete through experimental examination. Based on the practical work and literature review following conclusions are drawn:

- The workability, which is analyzed by the concrete slump test, shows that it increases as the acidity of water increases, i.e., for pH<7 but remains within the target slump value (100-125mm) for every mix and is more workable mixtures were obtained.The slump values of concrete having acidic water, i.e., pH1.9 and pH3.2,are observed to be more than the mix with tap water and alkaline water, i.e., pH7.4.

- No significant difference occurred in the densities of hardened concrete samples.
- The fall in bulk density is observed as the percentage of W.G. increases. This decrement is linked with the lower specific gravity of W.G. and G.G.B.S.compared to the fine aggregate and cement.
- Compressive strength increased at 28 days for a concrete mix with water having pH8.9. The percentage variation achieved was 7.69%.
- The maximum design compressive strength of 33.26 N/mm^2, flexure strength of 3.02 N/mm^2, and splitting tensile strength of 2.37 N/mm^2 for tap water with pH7.4 was recorded.
- In two hundred seventy days, compressive strength was observed to increase for alkaline water compared to tap water.
- Concrete mixes' flexural strength and split tensile strength show the same compressive strength pattern.
- On the assessment of compressive strength in G.G.B.S. concrete mix, at 45% substitution level of cement by G.G.B.S., maximum compressive strength is obtained compared to the control mix. After receiving the optimum percentage of G.G.B.S., and keeping it constant, when W.G. substitutes fine aggregate, then 5% W.G. produced the highest performance.
- Flexural strength also increases at W.G's fine aggregate substitution level at a 5% substitution level.
- Split tensile strength increases to the same substitution level cited for compressive and flexural strength. This increment is due to the solid interconnecting bond between cement, G.G.B.S., and waste glass.
- Water permeabilityhas been observed to rise with decreased pH compared tothe controlmix.
- An increase in water permeability (at constant pressure) of the W.G. concrete mix has been observed compared with the control mix.
- A study on the use of wastewater with alkalinity and a survey ofthe addition of natural fibers to improve upon the toughness and crack resistance of M25 grade concrete with the addition of alkalinity and acidic water can also be done.
- The durability and microstructure analysis study of M25 grade concrete with the addition of alkaline water can be further studied.
- It can be said that alkaline waters are usable as mixing waters where tap water supply is insufficient and provide a positive contribution to workability and strength.

Disclosures

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