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Evaluation of Water Hyacinth Extract of Nepalese Lakes as an Admixture in Concrete Production

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Abstract
Concrete is an essential infrastructure material. During the construction of concrete various admixtures are used before mixing or during mixing. It is used as a component of concrete to modify one or more properties of concrete. Chemical admixtures are normally added to the concrete during the mixing period, to produce high strength concrete with good rheology. However, toxic gases such as CO_2 are emitted to the environment during chemical production which accelerate global warming. Plant extract contains wide range of organic matters and they have been used as bio admixture since ancient times. The aim of this study is to evaluate the effect on concrete due to the partial replacement of Water Hyacinth mixed in the form of powder and liquid extract. GCMS (Gas Chromatography Mass Spectrometry) analysis of Water Hyacinth shows content of lignin which is a water reducing agent. Compressive strength and workability tests were performed on concrete made with different percentage concentration of solution. Result showed that workability in concrete increases with the increase in replacement of Water Hyacinth extract in the form of liquid whereas compressive strength of concrete with the 0.25% and 0.5% concentration replacement of Water Hyacinth was not significantly different as that of control one.

Keywords
Bio admixtures, Compressive strength –Concrete mix design, Lignin, Water Hyacinth, Workability

1. Introduction

Concrete is an artificial material which is composed of cement, fine aggregates, coarse aggregates and water. It is considered the world's largely adaptable and well-liked material produced each year in the construction [1]. During the construction of concrete various admixtures are used before or during mixing to modify one or more properties of concrete in plastic or hard state. However, toxic gases such as CO_2 are emitted to the environment during chemical production which increases global warming [2]. Therefore, researchers are currently studying for the development of new construction methods and materials to open the chance for better stability, environmentally friendly, economical and efficient admixture.

Bio admixtures have been used in concrete and mortar since ancient times [3]. History shows that various bio admixtures such as milk, blood, molasses, rice paste, mud, straw, fruit juices, casein, bullock's blood, egg whites, cactus juice, boiled bananas etc. were used for altering certain properties like setting time, workability, compressive and tensile strength of concrete and mortar [3][4][5]. Plant extracts contain a wide range of organic components. According to Hewlett, lignin is a water reducing agent which can be used in concrete[3].

Water hyacinth is an aquatic weed that grows at a very rapid pace and its production is about 2 tons per acre [6]. Some of its negative impact in the environments are destructing waterways, deteriorating fish habitat thus killing fish, reducing oxygen dissolved in water, increasing water loss due to evapotranspiration, causing impossible of breeding land for mosquitoes and degrading the quality of water used for swimming and fishing [7]. In context of Nepal, this weed is deteriorating natural beauties of Lakes like Fewa, Begnas, Rupa and causing much problem in the field of irrigation by reducing speed of flowing water [8]. If not controlled, this aquatic weed may possibly dry up Fewa Lake and disappear from our sight in the

coming near days.

Previous study shows that Water Hyacinth can be used as a bio admixture in concrete in the form of fine powder, liquid extract, horizonal and vertical fibers. G.D.O Okwadha et al in 2018 performed a test to evaluate performance of concrete with Water Hyacinth extract from Nairobi Dam, Kenya as admixture. Result showed increase in compressive strength, setting time and water permeability [9]. In 2014, A. Sathya et al studied influence of Water Hyacinth extract from Thanjavur district, India as bio admixture in cement and concrete. It revealed the progressive increase in setting time and compressive strength with the increase in replacement of Water Hyacinth extract. Moreover, GCMS(Gas Chromatography Mass Spectrometry) analysis performed by same author showed concentration of ligno cellulose which is water reducer in concrete [3]. However, the evidence regarding concrete behavior of Water Hyacinth in context of Nepal was not found yet. So it was necessary to evaluate of influence of Water Hyacinth from lakes of Nepal mixed in concrete as designed by Indian Standard concrete mix design. In this experiment, partial replacement of Water Hyacinth of Nepalese lake in the form of powder and complete replacement of water by different concentration of Water Hyacinth solution were used to study the properties of concrete. Workability was checked in a fresh concrete using slump test and compressive strength test of various concrete cubes made by partial replacement of Water Hyacinth were done after 7, 14 and 28 days.

2. Methods and Methodology

2.1 Extraction of Water Hyacinth

At first, Water Hyacinth from Fewa Lake was identified by botanist, collected and washed to remove mud and debris. It was then cut into small pieces and kept for shade drying for a week in order to prevent chemical changes due to sunlight. About 3 kg of dried pieces of Water Hyacinth was ground to make fine powder for partial replacement of cement. Similarly, 1.5 kg of Water Hyacinth was submerged in water to have liquid extract. Submerged Water Hyacinth was ultrasonicated for 30 mins, kept undisturbed for 24 hours and and then again ultrasonicated for 30 mins. Ultrasonication helps in assisting better extraction of compounds present in plants [10]. Ultrasonicated Water Hyacinth was kept for filtration. It was then evaporated using rotary evaporator which was used for solvent removal in the laboratory [11]. The crude Water Hyacinth was used to make solution of different concentration by using law of dilution.

Figure 1: Extraction of Water Hyacinth

2.2 Cement

Cement used for this experiment was Arghakhachi cement confirming to the Indian Standard according to IS 4031 and IS 650. Various tests of cement such as specific gravity, fineness, consistency were checked. The physical properties of the cement used are given in following Table 1.

Table 1: Physical Properties of Cement

Properties	Content
Grade	53
Specific gravity	3.15
Fineness of cement	5.56%
Normal Consistency	32%
Initial Setting Time	50 min
Final Setting Time	420 min

2.3 Fine Aggregate and Coarse Aggregate

The coarse aggregate used in our investigation was crushed gravel with maximum size of 20 mm obtained in crusher of Kotre source. The fine aggregate with maximum size of 4.75 mm was used which was also obtained from crusher of Kotre source. The shape and texture of aggregates used was angular and rough respectively. Various tests on fine and coarse aggregate used in our experiment confirming to IS 383 were done. Physical properties of Fine and coarse aggregate are shown in Table 2.

Table 2: Physical Properties of Coarse and Fine Aggregates

Property	Values obtained	
	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.80	2.70
Fineness Modulus	7.22	2.85
Water Absorption	0.83%	0.20%

2.4 Concrete Mix Design

Concrete mix design of 1: 1.78: 2.77 (Cement: Fine aggregate: coarse aggregate) with water cement ratio of 0.45 obtained from Indian Standard mix design was used as control. Concrete cubes with 1%, 2%, 5% and 10% partial replacement of cement with Water Hyacinth powder were casted. Similarly, cubes with partial replacement of water by 0.25%, 0.5%, 0.75% and 1% concentration of Water Hyacinth solution were casted. In order to determine compressive strength, test specimen of concrete cubes of size 150mm*150mm*150 mm were used for casting.

3. Result and Discussion

3.1 Workability Test

The workability of fresh concrete was measured using slump test. Result shows that with the increase in percentage concentration of Water Hyacinth solution slump value increased at great rate as shown in Figure 2. In an experiment performed by G.D.O. Okwadha et al in 2018, it was found that workability of fresh concrete increased with the increase in percentage replacement of cement by Water Hyacinth powder [9]. Similarly, experiment performed by V. Murugesh in 2017 revealed that workability increased with the increase in percentage replacement of cement by powder of Water Hyacinth obtained by burning in oven at 800°C [2]. In an evaluation of influence of bio admixture on mechanical properties of concrete performed by A. Sathya in 2014, it was found that workability increased with the replacement of cement by Water Hyacinth powder as well as liquid extract [3]. According to M Olivia et al, addition of biopolymers such as lignosulphonate and cellulose increases workability, water retention property of concrete [12]. In 2014 Otoko et al found that palm liquor increases workability of fresh concrete with maximum performance at 16 % water replacement by palm liquor [13]. Water Hyacinth can be used as superplasticizer in self compacting concrete [9]. Moreover, superplasticizer gives highly negative charges to cement particles which causes deflocculation of cement particles causing particles to move apart. This reduces water to great extent increases workability [14].

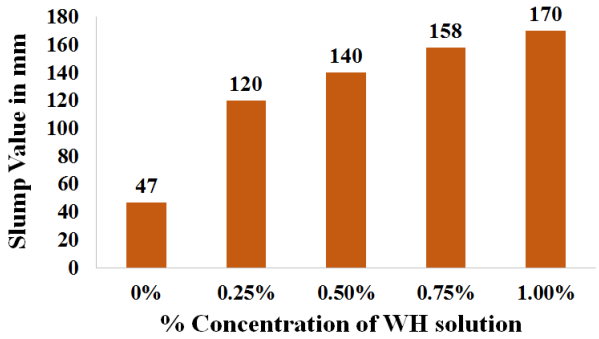

Figure 2: Workability Test

3.2 Compressive Strength

3.2.1 Powder Form

After 7 days of casting and curing it was found that cubes replaced with 5% and 10% of cement by Water Hyacinth powder have not gained any binding characteristics. Those cubes were not set till 7 days. Likely, the cubes with cement replacement of 1% and 2% was set slowly but was fully porous in appearance. The fineness of Water Hyacinth powder was maintained to equivalent of wheat grinder of mesh size 212 micrometer (Mesh no 70). The reason behind this could be fineness of Water Hyacinth powder that was not made as that of fineness of cement. The fineness of cement is measured with respect to sieve of 90 micro meter whereas powder obtained from Water Hyacinth was obtained by grinding in a wheat grinder machine of 212-micron mesh size. Due to unevenness in fineness between cement and Water Hyacinth powder, powder acted as a foreign material in concrete cubes. Study shows that finer is the cement particle greater is the strength of concrete [15].

3.2.2 Liquid Extract Form

After proper curing for 7, 14 and 28 days, compressive strength test of cubes with partial replacement of water by 0.25%, 0.5%, 0.75% and 1% concentration of Water Hyacinth solution were carried out. The result obtained is tabulated in Table 3. Result

shows that the compressive strength of concrete shows insignificant increase from 0% to 0.25% concentration. It goes insignificant decrease to 0.5% concentration and goes on large significant decrease after the concentration of 0.5% solution.The gain in strength of concrete is increased with the increase in days of curing. According to test performed by G.D.O. Okwadha et al in 2018, compressive strength of concrete increased up to 25% replacement of cement by Water Hyacinth powder [9]. Likely, V. Murugesh et al in 2017 revealed that 10% replacement of cement by powder ash of Water Hyacinth increased compressive strength [2]. In an experiment performed by A. Sathya et al in 2014, compressive strength increased with the increase in addition of both powder and liquid extract of Water Hyacinth up to 20% [3]. K. Akil et al replaced cement by Water Hyacinth fiber and result showed increase in compressive as well as tensile strength up to 4% replacement by weight of cement [16]. In the study performed by Ahmed Shaban et al in 2015, compressive strength was maximum at 2% Water Hyacinth ash powder replacement [17]. In the GCMS analysis done in 2014 by A. Sathya it was found that there is presence of ligno cellulose, saturated and unsaturated fatty acids that increases strength of concrete. In the experiment done by Neelu Das et al regarding evaluation of Water Hyacinth stem ash as pozzolanic material, compressive strength decreased as that of control one, but optimum result was obtained at 10% replacement [18]. Amrita Hazarika et al imparted that addition of bio admixtures in cement and concrete increase compressive strength [19]. Similarly, in 2017 according to Juby Mariam Boban et al, compressive strength increased up to 0.5% replacement of fine aggregate by dry fiber of Water Hyacinth[20].

Table 3: Compressive Strength of Different Concentration of Solution with Ages

% Concentration of Water Hyacinth solution	Compressive strength 7 days in MPa	Compressive strength 14 days in MPa	Compressive strength 28 days in MPa
0	18.9	26.5	28.6
0.25	19.1	26.9	29.1
0.5	18.8	26.3	28.5
0.75	10.2	14.27	14.9
1	5.8	9.4	10.2

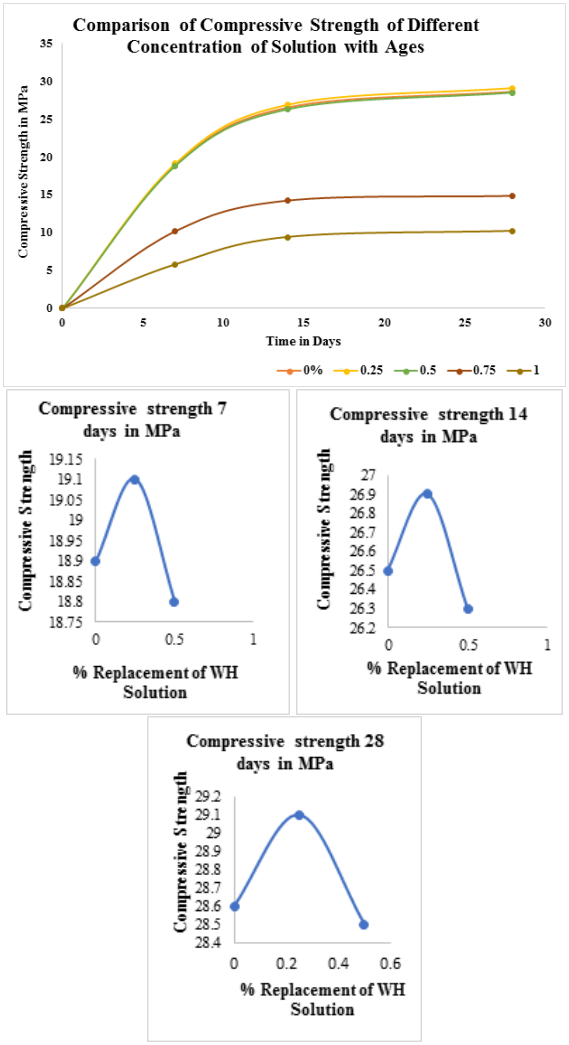

Figure 3: Compressive Strength with different percentage concentration of solution

4. Conclusion and Recommendation

4.1 Conclusion

Based on the experimental result, it can be concluded that Water Hyacinth in the form of liquid extract increases workability of concrete with the increase in percentage replacement of concentration of solution. The gain in workability in concrete might be due to the small fragments of lignocellulose and hemicellulose dissolved in Water Hyacinth extract. The compressive strength of concrete shows insignificant increase from 0% to 0.25% concentration, goes insignificant decrease to 0.5% concentration and goes on large decrease after the concentration of 0.5% solution. The strength properties were lacked in concrete replaced with powder form which could be due to uneven in fineness of cement and fineness of Water Hyacinth

powder. Since with the addition of Water Hyacinth extract dose in concrete results in gain of slump value, it can be revealed that Water Hyacinth can be used as superplasticizer in concrete of lower water cement ratio[21].

4.2 Recommendation

This experiment was limited to liquid extract of Water Hyacinth. Replacement of cement with powder form of Water Hyacinth ground to much finer as that of cement could be area of further research. Moreover, since Water Hyacinth extract behaved like a water reducer, further study could be done on the effect of Water Hyacinth on flexural and splitting tensile strength of the concrete by maintaining constant workability with different percentage replacement of additives.

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