INTERNATIONAL JOUNAL OF: BUILT ENVIRONMENT AND EARTH SCIENCE

TIMBOU-AFRICA ACADEMIC PUBLICATIONS
INTERNATIONAL JOURNAL, MAY, 2022 EDITIONS
VOL. 9 NO. 4 ISSN: 1881-2167

EFFECT OF PH ON THE STRENGTH OF LOCALLY MADE EFFECTIVE MICROORGANISM CONCRETE

ADAMU SANI ABUBAKAR[1], SAGIR ISHAQ[2] AND IBRAHIM ADAMU KWAMI[3]

[123]Department of Building, Abubakar Tafawa Balewa University Bauchi, Nigeria

ABSTRACT

Various researches have been carried out to improve the technology of concrete, some of which include the introduction of admixtures in concrete production which include effective microorganisms. The main objective of this research is to experimentally assess the effect of pH on the strength of locally made Effective Microorganism concrete. The Effective

Introduction

Concrete is an artificial conglomerate stone made essentially of Portland cement, water and aggregate. Coarse and fine aggregates, cement and water are mixed together in a suitable designed mix ratio and this matrix placed and compacted wherever required, solidifies after a lapse of time into what is known as concrete (Michael & John, 2011).

According to Shetty, (2005) concrete is being used for wide varieties of purposes in different conditions. In these conditions ordinary concrete may fail to exhibit the required quality performance or durability. In such cases, admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation.

Neville (2011) defines an admixture as 'a chemical product which, except in special cases, is added to the concrete mix in quantities no larger than 5 per cent by mass of cement during mixing or during an additional mixing operation prior to the placing of

Microorganisms were produced locally through the process of natural fermentation of fruits and vegetable wastes. A microbiological analysis was carried out and the compositions of the locally made Effective Microorganisms were identified which are Bacillus spp,; Lactobacillus spp; PseudomonasSpp; Aspergillus niger; Saccharomyces specie; Penicillionspp; Botrytis spp and Rhizopus Spp. The pH values of locally made effective microorganism used were pH 3.9 pH 3.7, pH 2.8 and pH 2.3. 3% of locally made effective microorganism used to replace the mixing water required. 120 cubes were produced for compressive strength, water Absorption and Ultrasonic pulse velocity tests. The results of the tests indicate that the locally made effective microorganisms retards the setting time of cement, and also enhances the workability of concrete. It also indicated that the concrete specimens with of locally made EM-A of pH 3.7 possessed the highest compressive strength than the control specimens by 6.14%, 3.70%, 9.82%, 10.42 and 11.62% at 7, 14, 28 and 90 days respectively. The water absorption of EM concrete specimens decreased with the increase in maturity age and also with decrease in pH values of EM-A used. Ultrasonic pulse velocity increases with the increase in maturity age and also with decrease in pH value of EM-A use. The research recommends that locally sourced fruits can be used to produced effective microorganisms which can further be used as an admixture in concrete production.

Keywords: *Concrete, Admixture, Effective Microorganisms, Compressive strength, workability, setting time and Ultrasonic Pulse Velocity*

concrete, for the purpose of achieving a specific modification, or modifications, to the normal properties of concrete.

One of the many different admixtures is the Effective Microorganisms (EM), which is economically, environmental-friendly, sustainable, easy to obtain and locally produced material.

The Effective Microorganisms (EM) was discovered by Teruo Higa, a Professor of horticulture at the College of Agriculture, University of the Ryukyus in Okinawa, Japan. EM comes in a liquid form and consists of a wide variety of effective, beneficial and non-pathogenic microorganisms of both aerobic and anaerobic types coexisting (Higa and Wood, 1998). Effective Microorganisms (EM) is a peculiar way of turning waste in to valuable resources right at home. It is produced through a natural process of fermentation and not chemically synthesized or genetically engineered. According Jamaludin et'al (2012), effective microorganisms contain a large number of microorganisms that when acted together create a greatly beneficial effect on the environment in which they are placed.

By recycling fruits and vegetable wastes, the amount of greenhouse gas emissions caused by rotten fruits can be reduced. Because these fruits are organic they decompose quickly, releasing methane in to the atmosphere. The United State Environmental Protection Agency (USEPA, 2014) explains that methane is more dangerous to the environment than carbon dioxide because of its global warming potential.

The technology of Effective Microorganisms is growing tremendously and its usage is widespread in many industries. Unfortunately, the usage of Effective Microorganisms (EM) as an admixture in concrete is still at a low level. The practice of using EMC is still at low level as the knowledge about the existence and advantages of Effective Microorganisms (EM) is still limited (Jamaludin, et al, 2012). Therefore, research on the properties of concrete produced using effective microorganisms as an admixture is vital in order to understand its effect on the concrete performance.

Researches carried out across the world have shown that application of EM as an admixture in concrete has greatly improved the strength of the concrete alongside other properties such as workability. In Japan, a research carried out by Sato et'al (2000) proved that the effective microorganism is highly effective in solving deterioration problems of concrete, they are on the opinion that the admixture has fairly powerful surface activity, the effect of air entraining (AE) agent and the effect of water reducing agent. Their research also proved that the admixture improves the compressive strength of concrete with about 30-50% than that of the control.

Influence of the EM on strength of concrete was due to the fact that the microbed concrete has denser pores structures than the ordinary concrete. According to Isma'il and Saman (2014), microbed cement specimens are denser compared to the specimens without microbes,

Before application of effective microorganisms, the EM has to be activated. The activation of EM is achieved by adding sugarcane molasses and water which allow the EM to start multiplying.

The pH of any solution is the measure of its hydrogen-ion concentration. The higher the pH reading, the more alkaline and oxygen rich the fluid is. The lower the pH reading, the more acidic and oxygen deprived the fluid is. Therefore, 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. The pH scale ranges from 0 to 14, and a pH of 7 is considered to be neutral. Substances with a pH less than 7 are acidic and substances with a pH greater than 7 are basic.

The pH level adversely affects the strength characteristics of EM concrete (Neal *et al.,* 2012). Since the development of EM as an admixture, a lot of researches have been carried out on the strength and durability of EM concrete. Therefore, there is need to carry out research on the optimum pH level that will be suitable on EM concrete and make it competitive with that of ordinary concrete in terms of strength and durability

Materials and Methods

Materials

The materials used for the purpose of this study included, Portland lime cement, Aggregates, water and locally made effective microorganisms.

Cement

The cement employed for the study was Portland lime cement of grade 42.5 of Ashaka brand owing to its relative cheapness and availability in the study area. The cement conforms to the requirements of BS 12 of

1991. It was obtained from cement supplier within Yelwa area of Bauchi metropolis.

Aggregate

The coarse aggregate used for the study was crushed rock of nominal size not exceeding 20 mm, obtained from the Department of Building Abubakar Tafawa Balewa University Bauchi. Similarly, the fine aggregate was river sand also obtained from the consignment made available by the Department of Building

Water

The water used for the study was potable and fresh water obtained from the tap of concrete laboratory of the department of Building, Abubakar Tafawa Balewa University, Bauchi.

Locally made effective microorganisms

The effective microorganisms used in the study were cultivated in the concrete laboratory of Building Department Abubakar Tafawa Balewa University Bauchi. They were produced through the natural process of fermentation of fruits and vegetable wastes.

Methodology

Production of locally made effective microorganisms

The fruits and vegetable wastes were cut into small pieces and chlorine free water was obtained from a well near Faculty of Environmental Technology Abubakar Tafawa Balewa University Bauchi. Eight liters of the water was measured, 250ml of molasses was added to it, the fruits and vegetable wastes were thrown into the container containing the water, after the container was full, and the lid was then put on it and was allowed to ferment for 28 days. After the fermentation period, the water was sieved and then poured in to plastic bottles.

Enumeration of microorganisms

The viable cell count of the sample was determined using spread plate method. The sample was shaked to mix thoroughly. 10 ml was then pipette into 90ml of sterile normal saline to form a stock solution. Serial dilutions of the stock solution were carried out to obtain dilutes of 10^{-1} to 10^{-3}. Then 0.1ml of 10^{-3} dilution was aseptically transferred into sterile nutrient agar and potato dextrose agar plates respectively in duplicate. A sterile bent glass rod was used spread inocula on the surface of the culture media. The inoculated nutrient agar plates were incubated at 37°C for 24 hours while the potato dextrose agar plates were incubated at 25 – 27°C for 72 hours.

After the incubation period, the nutrient agar plates were observed for bacterial growth while the potato dextrose agar plates were observed for fungal colonies, the number of bacterial and fungal colonies were counted and the results of the count was expressed as colony forming unit per milliliter (cfu/ml).

Activating the locally made effective microorganisms

The locally made EM produced was activated with molasses before used in concrete mixture, this is to boost the microorganisms and to provide immediate food for them. Activation of locally made effective microorganism is the mixing of the locally made EM with water and molasses. The mixture is called EM Activated (EM-A). The materials used were: air tight container; locally made EM; sugarcane molasses and chlorine free water.

The locally made EM-A was then taken to Laboratory after 7 days of fermentation to carry out pH value test. The effective microorganism can only be used when its pH value falls below 4.0 this is because the effective microorganisms are more effective in acidic environment. Therefore, the EM-A was subjected to different pH value test, it is expected that the concretes will possess different strengths due to the effects of different pH values.

Concrete Mix Design

The concrete of grade adopted was M-30 IS. The proportion of each ingredient for 45 cubes was shown in table 1 and 2

TIJBEES
ISSN: 1881-2167

Table1: Concrete Mix Design for 0% replacement of EM-A for 45 cubes

Quantity	Cement (kg)	Water (kg)	Coarse aggregate(kg)	Fine aggregate(kg)
1m^3	416.96	191.58	1212.96	587.97
0.045m^3 (45no.cubes)	18.76	8.62	54.58	26.46

Source: Laboratory work (2018)

Table2: 3% replacement of EM-A required for 45 cubes.

Quantity	Cement (kg)	EM-A (kg)	Water (kg)	Coarse aggregate (kg)	Fine aggregate (kg)
1m^3	416.96	0.00	191.58	1212.96	587.97
0.045m^3 (45no.cubes)	18.76	0.21	8.41	54.58	26.46

Source: Laboratory work (2018)

Preparation of Test Cubes

To achieve the objective of the study, 60 cubes of size 100 x 100 x 100mm were produced according to BS 1881: Part 108: 1983, Method for Making Test Cube from Fresh Concrete, using the activated locally made effective microorganisms (EM-A) as partial replacement to the mixing water. 12 cubes were also produced with 0% activated locally made effective microorganisms (EM-A) as control specimens. The activated locally made effective microorganisms (EMA) was added in 3% as partial replacement to the mixing water required at pH level 3.9, 3.7, 2.8 and 2.3. The choice of the percentage replacements was due to the fact that 3% was identified as an optimum dosages in the researches carried out by M N Isa (2014). The compressive strength test was carried out at 7, 14, 28 and 90 days according to BS 1881: Part 116: 1983, Method for Determination of Compressive Strength of Concrete Cube.

Tests on Fresh Concrete

Setting time test

Due to the sucrose content of the molasses used in activating the locally made EM, there is a high expectation that the locally made EM-A may

retard the setting time of cement, because sugar was identified as a set retarder. Therefore, both initial and final setting time test were carried out to proof the above statement. Initial setting time was determined by the use of vicat apparatus. The needle was lowered and brought in contact with the surface of the test block and quickly released allowing it to penetrate in to the test block. The time between when water was added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taking as initial setting time.
The final setting time was determined by replacing the needle of the vicat apparatus by a circular attachment. The final setting time was taken after, upon lowering the attachment gently, the center needle makes an impression while the circular edge of the attachment failed to do so.

Workability test
The slump test was conducted in accordance with specified fresh concrete standard, BS 1881: part 102: 1983, Method for Determination of Slump.

Mixing, molding and compaction of concrete cubes
The concrete was mixed in accordance with BS1881: Part 108: 1983, Method for Making Test Cube from Fresh Concrete. Cast iron moulds of 100 x 100 x 100 were used to produce the concrete cubes. The molds were oiled to allow for easy removal of concrete cubes. The concrete was placed in approximately three equal layers and each layer was rammed with 25 strokes of 50mm round ended rod.

Curing of specimens
It was observed from the setting time test carried out that the locally made EM-A delays setting time of cement. For this reason, the cubes were allowed to stay for 24 hours before demolding, this is to avoid the damaging of cubes during demolding. The concrete cubes were completely immersed in a curing tank for the required period of hydration (7, 14, 28 and 90 days).

Tests on Hardened Concrete

The following are the test conducted on hardened EMC

Density test

The density test for harden concrete cubes prepared for compressive strength test were determined in accordance with BS EN 12390, part 7 (2000). The densities were calculated using equation (1).

$$Density = \frac{Mass\ in\ kg}{Volume\ in\ m3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Compressive strength test

The test was carried out in accordance with BS 1881: Part 116: 1983 Method for Determination of Compressive Strength of Concrete Cube. 60 concrete cubes of 100 x 100 x 100 were crushed at saturated surface dry condition. The crushing was carried out at 7, 14, 28 and 90 days respectively, using the hydraulic crushing machine of 2000kN capacity in the civil Engineering Department concrete laboratory ATBU Bauchi

Water absorption test

Water Absorption test was carried out in accordance with Indian Standard (IS) 3495. Dry cubes were put in an oven at a temperature of 105°C to 115°C till constant mass is attained. The weight (W_1) of each cube was recorded after cooling them to room temperature. The cubes were then immersed in water for 24 hours. The specimens were then taken out of water and allow attaining surface dry, thereafter it was weighed again and recorded as W_2

The water absorption in % =

$$\frac{W2-W1}{W1} \text{ x } 100\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Ultrasonic Pulse Velocity Test

The test was conducted at the curing ages of 28 and 90days according to the requirement of ASTM C 597 and BS 1881: Part 203. The test was conducted to determine how well the particles of concrete are packed under normal curing condition. The cubes were subjected to ultrasonic pulse and the transmitting time taken by the wave to pass through the

TIJBEES
ISSN: 1881-2167

specimen was measured and recorded. The pulse velocity was calculated using equation below:

$$Pulse\ Velocity\ (V) = \frac{Distance\ Move\ by\ Pulse\ (D)}{Time\ Taken\ (T)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Results and discussion

Physical properties of locally made EM

The locally made EM is in liquid form and brownish in colour and has a sweet smell. The liquid has to be activated before it can be used. Molasses was used in activating the locally made EM. The molasses was blackish colour and very thick texture just like honey.

Composition of locally made EM

Identification of isolates

Various bacterial colonies were observed and later identified based on their colonial morphology, cell morphology, a grou's reaction and reaction to some biochemical tests which included catalase, coagulase and spore staining. While the fungal colonies were identified microscopically using lactophenol cotton blue after observing their colonial morphology. The microbiological analysis of the sample is shown in table 3 below.

Table 3: Microbiological analysis of sample

Sample Code	Mean Bacterial Count cfu/ml	Mean Fungal Count cfu/ml	Bacteria Isolated	Isolated Fungi
S_1	8.9×10^4	2.32×10^5	Bacillus spp	Aspergillus Niger
			Lactobacillus spp	Saccharomyces specie
			Pseudomonas Spp	Penicillionspp
				Botrytis spp
				Rhizopus Spp

Source: Laboratory Work (2018)

Setting time test

The amount of water required to make a standard cement paste is equal to 31% by weight of ordinary Portland cement used. This shows that the water cement ratio used in constituting the paste on which the test was conducted was 0.31.

From the result of the setting time shown in figure1, the locally made EM-A increases the initial and final setting time of cement paste compare to the control paste at all the pH values with the exception of pH 3.7 which shows a decrease in initial setting time compare to the control, but higher final setting time. From the percentage increase in the initial and final setting time shown in figure 1, it can be clearly seen that the higher the pH value of locally made EM-A the higher the setting time of the ordinary Portland cement.

The increase in the setting time can be attributed to the fact that the locally made EM-A contain molasses, and which has sugar. According to "precipitation theory", the addition of sugar in cement/concrete mixture increases the concentration of calcium, aluminum and iron in concrete. The combination of sugar molecules and these metals formed insoluble chemical complexes that coat the cement grain thereby hindering the chemical processes that harden the concrete. As the hydration process slow down, the concrete takes longer to set. For this reason, sugar is known as retarder.

For all the pH values of locally made EM-A used, both the initial and final setting times satisfy the requirements of BS12: 1991[1] which requires that the initial and final setting time of ordinary Portland cement should not be less than 45 minutes, and not greater than 10 hours respectively. The increase in setting time of OPC due to addition of locally made EM-A depict locally made EM-A as a set retarding admixture. Therefore, locally made EM-A can be used as an admixture in concrete.

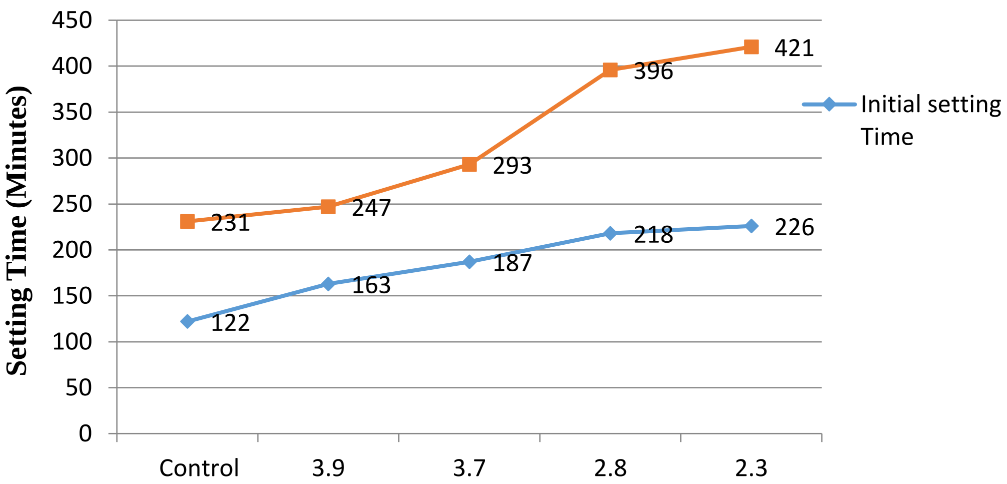

Figure1: setting time versus pH values of locally made EM-content

TIJBEES
ISSN: 1881-2167

Properties of fresh concrete

Physically the fresh concrete containing locally made EM-A has no clear color variation when compare with the control specimen. As reported by Andrew Tan (2012) workability increases with the addition of EMC in concrete. The workability test in this study also proves the above statement, the slump test shows that the concrete containing locally made EM-A possessed higher workability than the control specimen, this is due to the sucrose content of molasses which was used to activate the locally made effective microorganism. Figure 2 shows the results of the slump test for all the specimens. The increase in the slump was attributed to the sucrose content of the locally made EM-A. Gindhar, Gnaneswar and Kishore (2013), stated that the addition of sugar and jiggery to concrete greatly influenced the setting property and the workability of the concrete, this is because the sugar acts as a thin layer over the cement particles and it slows down the hydration process.

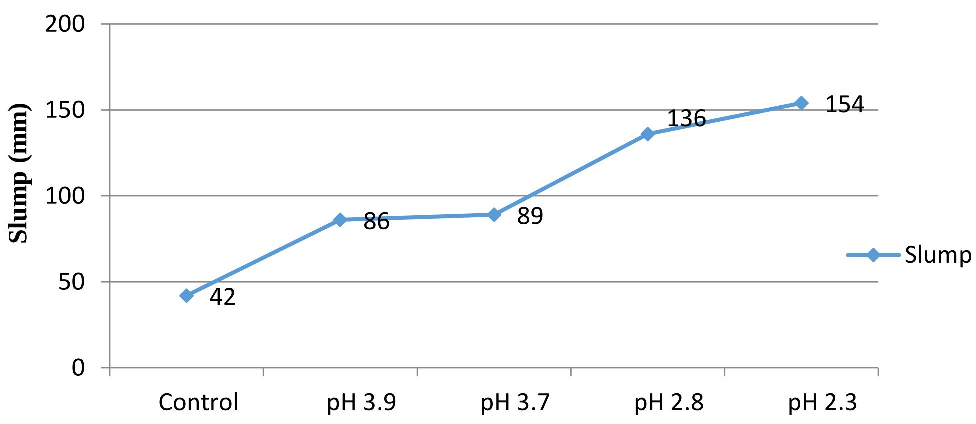

Figure 2: Slump heights versus pH values of locally made EM-A content

Presentation of Results on Hardened Concrete Test

Compressive strength of concrete cubes

The compressive strength test was conducted to compare the strength between the control and the locally made EM-A concrete cube. The EM-A used had different pH values and the percentage replacement of the locally made EM-A used was 3%, and a control specimen of 0% locally made EM-A was produced for the purpose of Comparism.

TIJBEES
ISSN: 1881-2167

To avoid spalling of hardened concrete during demoulding, the cubes were allowed to harden for 24 hours before demoulding. All the cubes were cured using immersion curing method and were tested for compression of strengths at 7, 14, 28 and 90 days respectively.

Table 4: Compressive strength of locally made effective microorganism concrete

pH	Compressive strength (KN/mm²)			
	7days	**14 days**	**28days**	**90days**
Control	22.8	24.3	28.5	31.2
3.9	23.1	26.1	29.4	33.6
3.7	24.2	25.2	31.3	34.7
2.8	22.4	23.1	27.2	29.6
2.3	20.3	20.9	24.6	28.4

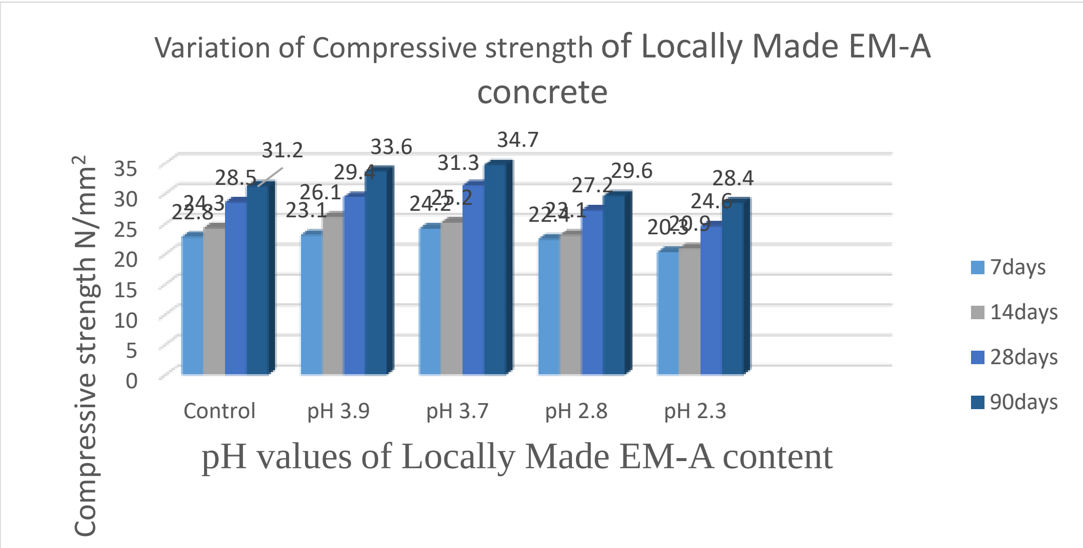

Figure 3: Compressive strength versus locally made EM-A content at different pH values

Compressive strength at 7 days.

The strength of the control specimen recorded as 22.8 N/mm². The strength of the specimens with EM-A having pH Values 3.9, 3.7, 2.8 and 2.3 recorded as 23.1 N/mm², 24.2 N/mm², 22.4 N/mm² and 20.3 N/mm² respectively. The specimens with pH 3.7 &3.9 show increment in compressive strength over the control specimen with 6.14% and 1.32% respectively. All the remaining specimens had low compressive strength compared to the control specimen

Compressive strength at 14 days

The compressive strength of the control specimen was recorded as 24.3 N/mm^2. The strength of the specimens added with EM-A having pH Value 3.9, 3.7, 2.8 and 2, 3, were recorded as 26.1 N/mm^2, 25.2 N/mm^2, 23.1 N/mm^2 and 20.9 N/mm^2 respectively. The specimen with pH 3.9 & 3.7 shows an increment in compressive strength over the control specimen with 7.41% and 3.70% differences respectively. All the remaining specimens had low compressive strength compared to the control specimen.

Compressive strength at 28 days

The compressive strength of control specimen at 28 days maturity age was recorded as 28.5 N/mm^2 which was 95% of the design strength. The compressive strength of the specimens with EM-A having pH values of 3.9, 3.7, 2.8, and 2.3 were recorded as 29.4 N/mm^2, 31.3 N/mm^2, 27.2N/mm^2 and 24.6 N/mm^2 respectively. The specimens with pH 3.7 &3.9 show an increment in compressive strength over the control specimen with 9.82% and 3.16% respectively. All the remaining specimens had low compressive strength compared to the control specimen.

Compressive strength at 90 days

The compressive strength of the control specimen was recorded as 31.2 N/mm^2. The compressive strength of the specimens added with EM-A having pH values of 3.9, 3.7, 2.8 and 2.3 were recorded as 33,6 N/mm^2, 34.7N/mm^2, 29.6 N/mm^2 and 28.1 N/mm^2 respectively. The specimen with pH of 3.7 locally made EM-content shows an increment in compressive strength over the control specimen with 11.62%. All the remaining specimens had low compressive strength compared to the control specimen.

The increase in strength of the concretes at all ages of tests was due to the presence of Bacillus Subtilis in the locally made EM-A. According to Reddy et'al, (2010), it was noted that pores in concrete are partially filled up by material growth with the addition of bacteria, reduction in pores

due to such material growth will obviously increase the material strength.
Jamaludin et'al (2012) were also on the opinion that if the optimum dosage of effective microorganisms is used in concrete production, the strength of the concrete is greatly enhanced, they show that the concrete with 10% EM-AS has the higher compressive strength than the remaining specimens and also mortar cubes with 5% EM-AS possessed the highest compressive strength. The durability test carried out by Jamaludin et'al (2012) also show that EM-AS concrete performs greatly in acidic environment compared to normal concrete, whereas in the alkaline environment both concretes (EM-AS concrete and Control) shows an increase in strength.
A normal concrete usually has a pH around 12, when the EM-AS must have a pH less than 4 before it can be used in concrete production, this shows that the concrete is alkaline and the EM-AS is acidic. When alkaline and acid react neutralization occurs and salt is produced. According to Jamaludin et'al (2012) it is expected that it was the salt that had contributed to the increment of compressive strength of the concrete containing EM.
Andrew (2013) also reported that the EM has the effect of increasing the compressive strength of concrete. He further reported that the workability of concrete increases as the EM content increases, and also concrete with EM took long time to set compared to the control. This was due to the fact that EM contains molasses (used in the activation of the EM) which has sugar and sugar as reported by Al-Kourd and Hammad (2010) severely retards the setting time of cement.
This finding is consistent with the previous study which reported that in pH level of EM affects the hydration process with attendant decrease in compressive strength (Andrew *et al.,* 2012).

Water Absorption Test Results

Table 5: Water Absorption at 28 and 90 days of locally Made EM-A concrete

pH Level	Percentage Water absorption(%) at 28 days	Water absorption (%) at 90days
Control	3.0	3.8
pH 3.9	3.2	4.3
pH 3.7	4.1	4.9

pH 2.8	4.4	5.8
pH 2.3	4.7	6.1

The results show that water absorption increases with decrease in the pH level of EM-A content. Which means that the lower the pH level, the more the acidic and therefore the more the water content The water absorption of samples containing EM-A was higher than the control samples for all the samples cured At 28 days curing period, the water absorption of the control sample was 3.0%, 3.2%, 4.1%, 4.4% and 4.7% for samples with pH 3.9, pH 3.7, pH 2.8 and pH 2,3 respectively. At the 90 days curing, the control sample recorded 3.8%. 4.3%, 4.9%, 5.8% and 6.1% for samples with pH 3.9, pH 3.7, pH 2.8 and pH 2.3.

Previous studies have shown that concrete specimen with microbes was denser compare to sample without microbes.

Therefore, the decrease in pH level of EM- A concrete in concretes leads to decrease in the amount of water absorption of concrete specimens. Ismail, N. and Saman, H. M (2014). The result generally shows that, water absorption decrease with the decrease in pH level.

Ultrasonic Pulse Velocity (UPV) test.

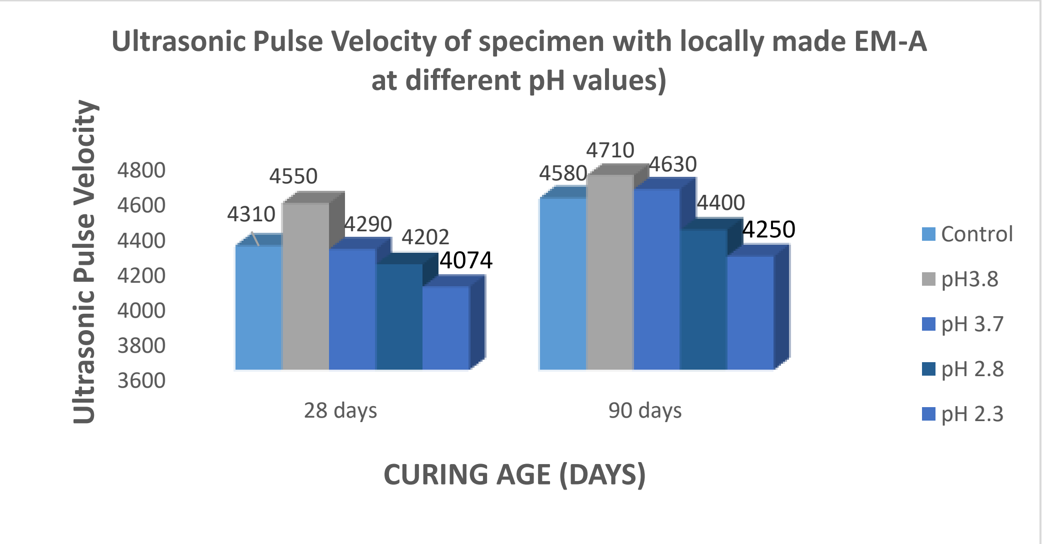

Figure4: Ultrasonic Pulse Velocity of specimen with locally made EM-A at different pH values

Figure above shows the values of UPV of the control, pH 3.9, pH 3.7, pH 2.8 and pH 2.3 conducted at 28 and 90 days age of curing of concrete. At

28 days, the entire sample was of good Concrete quality. Also at 90 days age, the specimens with pH 2.8 and 2.3 had good concrete quality while specimen with pH 3.9, pH3.7 and the control specimen had excellent Concrete Quality.

UPV result for EM concrete shows higher value than control concrete indicating denser concrete. All experimental results indicated that the use of EM has positive effects on concrete properties.

Summary, Conclusion and Recommendations

Summary of Findings

i. Fruits and vegetable wastes can be used to produce locally available effective microorganisms.
ii. The produced locally made effective microorganisms can further be used as an admixture in concrete production.
iii. The Microorganism composition of the locally made EM-A were *Bacillus spp, Lactobacillus spp* (a member of eight main genera of lactic acid bacteria),*Pseudomonas Spp Aspergillus niger* and *saccharomyces species (yeast),penecillionspp, Botrytis spp, Rhizopus*.
iv. The locally made EM-A retards the setting time of cement due to its sucrose content.
v. The workability of concrete increased with the decrease in pH value of the locally made EM-A content.
vi. There was no visible difference in the colour between the control samples and the locally made EM-A concretes.
vii. The locally made EM-A having pH value of 3.7 possessed a higher compressive strength than the control specimens by 6.14%, 3.70%, 9.82%, 10.42% and 11.62% at 7, 14, 28,56 and 90 days respectively.
viii. The water absorption of EM concrete specimens decreased with the increase in maturity age and also with decrease in pH value of EM-A used.
ix. Ultrasonic pulse velocity UPV increases with the increase in maturity age and also with decrease in pH value of EM-A used.

Conclusion

i. The Microorganism composition of the locally made EM-A were *Bacillus spp, Lactobacillus spp* (a member of eight main genera of lactic acid bacteria), Pseudomonas *Spp*, *Aspergillus niger, saccharomyces species (yeast), penecillionspp, Botrytis spp, and Rhizopus.*

ii. The locally made effective microorganisms can be used to enhance the fresh properties of concrete.

iii. The locally made effective microorganisms can be used to enhance the harden properties of concrete such as compressive when the optimum pH value is used.

iv. The optimum pH value of locally made effective microorganisms that can be used should not be less than or greater than 3.7

Recommendations

Based on the findings of this study, the following recommendations were made.

i. The locally available fruits and vegetable wastes can be used to produce Effective microorganisms locally which can further be used as an admixture in concrete production, thus reducing the amount of greenhouse gas emission caused by rotten fruits

ii. The optimum pH value of locally made EM-A as an admixture for application in concrete production is determined to be 3.7.

iii. The study would be of immense benefit to manufacturers of building chemicals in the building chemical industries.

Recommendations for Further Studies

i. Further research should be carried out to check the effect of pH on the strength of locally made EM-A concretes under different curing methods.

ii. Further research should be carried out to assess the effect of different pH values of strength of concrete produced with pozzolanic materials.

iii. Further research should be carried out to assess the long term durability of locally made EM-A concretes under elevated temperatures.

TIJBEES
ISSN: 1881-2167

iv. Further research should be carried out to assess the effect pH of locally made EM-A on steel reinforcements.

References

Al-kourd, A. & Hammad, A. (2010), *ECIV 3341 Cement and concrete technology. Course notes.* Islamic University of Gaza. Retrieved from Google scholar

Andrew, T., Ibrahim, I. S. & Mohd, Y. J. (2012). Effective microorganisms for concrete (EMC) – its effect on the mechanical properties of concrete. *Caspian Journal of Applied Sciences Research, 2(AICCE'12 & GIZ' 12), pp. 150-157.* Retrieved from http://www.cjasr.com

BS 12 (1991). *Specification for Portland Cements.* British Standard Institution, London.

BS 1881: Part 102 (1983). Testing Concrete: *Method for Determination of Slump.* British Standard Institution, London

BS 1881: Part 108 (1983). Testing Concrete: *Method for Making Test Cube from Fresh Concrete.*British Standard Institution, London.

BS 1881: Part 116 (1983). Testing Concrete: *Method for Determination of Compressive Strength of Concrete Cubes.* British Standard Institution, London.

Gindhar, V., Gnanesar, K and Kishore K. (2013). Effect of sugar and jaggery on strength properties of concrete. *The International Journal of Engineering and Science,* 2, 1-6. Retrieved from www.theijes.com

Higa, T. and Wood, M. (1998). Effective microorganisms for sustainable community development. Retrieved from http://www.envismadrasuniv.org/pdf/Effect%20

Ismail, N. and Saman, H. M (2014). Microstructure examination and strength characteristics of effective microbed cement. *International Conference on Biological, Civil and Environmental Engineering.* Retrieved from http://eprints.uthm.edu.my/5412/1/C0314161.pdf

Jamaludin M. Y. (2012). *Characterization and Effect of The Effective Microorganisms (EM) and Industrial waste (IW) Materials As Partial Mixture of Concrete.* Retrieved from http://eprints.utm.my/9710/1/78020.pdf

Michael, S. M., & John, P. Z.(2011). Materials for Civil and Construction Engineers. 3rd *edition, Pearson Publishing Ltd., New Jersey*

Neville A. M. (2005)Properties of Concrete, Pearson, Prentice Hall.

Neville, A. M. & Brooks, J. J. (2010). *Concrete Technology*. 2nd Edition, Pearson Education Limited, England.

Neville, A. M. (2011). *Properties of Concrete*. 5th Edition, Pearson Education Limited, England.

Sato, N., Higa, T., Shoya, M. and Sugita, S. (2000). *Some properties of concrete mixed with effective microorganisms and the on-site investigation of the completed structures.* Retrieved from http://www.cipremier.com/e107_files/downloads/Papers/100/28.pdf

Shetty, M. S. (2005). *Concrete Technology – Theory and Practice.* First Multicolour Illustrative Revised Edition Reprinted 2009. New Delhi, India, S. Chand and Company Ltd.

United State Environmental Protection Agency. (2014). *Basic Information about Food Waste*. Retrieved from http://www.epa.gov/foodrecovery/