Influence Of Locally Made Effective Microorganisms On The Compressive Strength Of Concrete

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***Abstract*—Several 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 assess the influence of Effective Microorganisms made from locally available fruit and vegetable wastes on compressive strength of concrete. The Effective Microorganisms were produced locally through the process of natural fermentation of fruits and vegetable wastes. The scope of the research only focused on laboratory work to obtain results. The locally made effective microorganism was added in 3%, 5%, 10% and 15% to replace the mixing water required. 60 cubes were produced for compressive strength tests. The results of the tests indicated that the concrete specimens with 3% content of locally made EM-A possessed the highest compressive strength of 28.5N/mm^2 and 34.35N/mm^2 at 28 and 56 days respectively over the control and other specimens. The research recommended that locally sourced fruits and vegetable wastes can be used to produced effective microorganisms which can further be used as an admixture in concrete production.**

Keywords—Locally Made Effective microorganisms, Compressive strength, Admixture, Fruits and vegetable wastes

I. INTRODUCTION

Concrete is a mixture of cement, aggregates and water, with any other admixtures which may be added to modify the placing and curing processes or the ultimate physical properties (Arthur, 2007). Concrete has been used for many years in civil and construction engineering works because of its strength, durability and affordable price. In the earlier time, problems were faced in the used of concrete such as workability, earlier strengths and the later strengths of concrete. A lot of research works have been carried out in order to overcome such problems and as such the technology of concrete have been improved tremendously.

The most important single property of concrete is strength this is because the major aim of structural design is that the structural elements must be capable of carrying the loads imposed on it. The maximum value of stress in a loading test is usually taken as the strength, even though under compressive loading the test piece is still whole (but with substantial internal cracking) at this stress, and complete breakdown subsequently occurs at higher strains and lower stresses. Strength is also important because it is related to several other important properties that are more difficult to measure directly, and a simple strength test can give an indication of these properties (Peter and John, 2010).

These days 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 (Shetty, 2005).

Admixture is defined as a material, other than cement, water and aggregates that is used as an ingredient of concrete and is added to the batch immediately before or during mixing (Shetty, 2005). Producers used admixtures primarily to reduce the cost of concrete construction, to modify the properties of hardened concrete, to ensure the quality of concrete during mixing, transporting, placing and curing and to overcome certain emergencies during concrete operations. This paper focused on admixture which is economically, environmental-friendly, sustainable, easy to obtained and locally produced. This admixture is locally made Effective Microorganisms (EM).

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 nonpathogenic microorganisms of both aerobic and anaerobic types coexisting. It is produced through a natural process of fermentation and not chemically synthesized or genetically engineered. Professor Higa started his development of EM in 1968 with the first batch of what would eventually be called EM produced in 1982 and thereafter further developed and refined(Higa and Wood, 1998).

EM is useful in a wide variety of fields. In Agriculture, EM has been used to enrich the soil and produce quality healthy crops at a greater yield with decreases in pest, diseases and the need for weeding and tilling and without the use of agricultural chemicals. In environment, EM has been used to clean up polluted waters in ponds, lakes, dams and seashores, including in the cleanup of soil spills; make possible the recycling of organic waste into quality fertilizer. In industrial uses, EM applied to cement mixing gave a measured rise to the cement's strength; and has been used in the plastics and meals waste separation facility to reduce the level of toxic fume emissions (Higa and Wood, 1998).

Daily generation and dumping of fruits and vegetable wastes on our roadsides, side drains, and undeveloped plots of land in residential areas causes environmental hazards. According to Mtallib and Rabiu, 2009, the resultant effects for the accumulated solid waste include unsightly surroundings, obstruction to pedestrians, air pollution, and ground water pollution due to leachates from the accumulated solid waste. Disposal and treatment of solid waste in order to free the environment and the society of the menace constituted by accumulated solid waste have been issues of serious concern to individual countries and the entire world (Mtallib and Rabiu, 2009).

Rotten fruits caused greenhouse gas emissions, because these fruits are organic they decompose quickly, releasing methane in to the atmosphere, one of the ways to reduce this gas emission is by recycling these fruits and vegetable wastes thereby promoting sustainability. The United State Environmental Protection Agency (USEPA) explains that methane is more dangerous to the environment than carbon dioxide because of its global warming potential. Effective microorganisms as stated earlier is produced through the natural process of fermentation of fruits and vegetable wastes, it is neither chemically synthesized nor genetically modified. Through technology of effective microorganisms these fruits and vegetable wastes can be recycled, thereby reducing the wastes accumulation on our environment and at the same time help to reduce the issue of unemployment which is one of the major problem in our society.

The major aim of this study is to produce the effective microorganisms using our locally available fruits and vegetable wastes and to assess its effect on the compressive strength of concrete.

II. MATERIALS AND METHOD

A. MATERIALS

The materials used in the study were cement, aggregate, water and locally made effective microorganisms.

- **Cement**

The cement used in the study was Ordinary Portland Cement of Dangote brand because is the most widely used cement in Nigeria and was assumed to conform to BS 12.

- **Coarse Aggregate**

Coarse aggregate may be either gravel or crushed stone comprised of particles greater than 0.25 inch (6.35mm) diameter. In this study single sized crushed coarse aggregate with maximum size of 20mm was used. The coarse aggregate was obtained from aggregate suppliers within Zaria town and it was in saturated surface dry condition before it was used in the mixing.

- **Fine Aggregate**

Fine aggregate used in this study was also obtained from suppliers in Zaria town and it was also in saturated surface dry condition before it was used in the mixing. The percentage passing 600µm of the fine aggregate was 40%.

- **Water**

The water used in the research was fresh tap water fit for drinking.

- **Locally Made Effective Microorganisms**

The effective microorganism used in the study was cultivated in the concrete laboratory of Building Department of A.B.U Zaria. It was produce through the natural process of fermentation of fruits and vegetable wastes and was neither genetically engineered nor chemically synthesized.

a. Fruits and Vegetable Wastes

The fruits and vegetable wastes used in the study were obtained from 'yan lemo market in Zaria town and community market in A.B.U. Zaria Samaru campus respectively. The fruits and vegetables used include: mango; pineapple; orange; water melon; green leaves; cocumba; banana and cabbage. The choice of these fruits and vegetable wastes was based on their availability at the time of the research.

b. Sugarcane Molasses

Sugarcane molasses is a by-product of the manufacture or refining of sucrose from sugarcane. It was obtained from laboratory chemical supplier in Jos, Plateau state.

B. METHODOLOGY

- **Locally made EM**

The effective microorganism (EM) was produced in the laboratory through the natural fermentation of locally available fruits and vegetable wastes. The fruits and vegetable wastes were cut in to small pieces and chlorine free water was obtained from a well in Samaru, Zaria. Eight liters of the water was measured, 250ml of molasses was added to it, the fruits and vegetable wastes were thrown in to the container containing the water, after the container was full it was then covered and allowed to ferment for 28 days. After the fermentation period, the water was sieved and then put in to plastic bottles.

- **Activating the locally made EM**

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 preparation procedure for locally made EM-A was as follows:

a. The total volume of locally made EM-A required was 1 liter.
b. Water was added in the container to make 80% which was 0.8 liters.
c. 0.05 liters of sugarcane molasses was added which was 5% of the locally made EM-A required.
d. 0.05 liters of locally made EM was added, which was also 5% of the locally made EM-A required.
e. The container was then shaken and the molasses was fully dissolved, then the remaining 10% water was added.
f. The container was then cap tightly and kept in a warm place for 7 days.

After 7 days of fermentation, the locally made EM-A was then taken to Multi User Science Research Laboratory of Ahmadu Bello University, Zaria to carry out a pH value test.

The locally made EM-A possessed the physical properties of reddish brown and sweet smell as shown in plate I, also the pH value of the locally made EM-A was found to be 3.90 as shown in plate II. These combined three properties shows that the locally made EM-A was ready to be used.

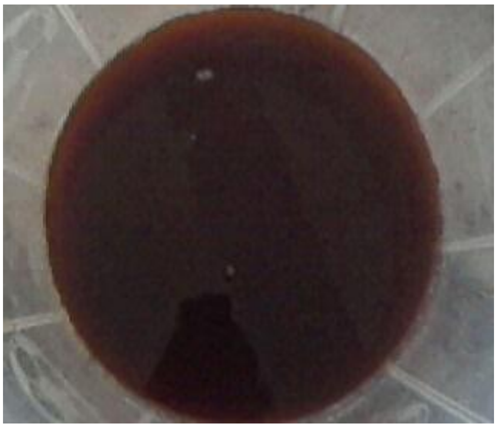

Plate I. Locally made EM-A

Plate II. pH test for locally made EM-A

- **Concrete Mix Design**

A concrete of grade $30N/mm^2$at 28 days was designed using the Department of Environment (DoE) Method, and the proportion of ingredients is as shown in the table 3.1.

Table I. Summary of Concrete Mix Design

Summary of Concrete Mix Design	**Materials**			
	Cement *(kg)*	Water *(kg)*	Coarse aggregate *(kg)*	Fine aggregate *(kg)*
$1m^3$	360	240	1125	750
$0.012m^3$ (12 no. cubes)	4.32	2.88	13.50	9.00

Source: Laboratory work (2014)

- **Preparation of Test Cubes**

To achieve the objective of the study, 48 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 (EM-A) was added in 3%, 5%, 10% and 15% as partial replacement to the mixing water required, the choice of the percentage replacements was due to the fact that 5% and 10% were identified as an optimum dosages in the researches carried out by Andrew, T. 2012 and Jamaludin et al, 2012 respectively. The compressive strength test was carried out at 7, 14, 28 and 56 days according to BS 1881: Part 116: 1983, Method for Determination of Compressive Strength of Concrete Cube.

C. RESULTS AND DISCUSSION

The compressive strength test was conducted to compare the strength between the control and the locally made EM-A concrete cubes. The percentage replacement of the locally made EM-A used were 3%, 5%, 10% and 15%, and a control specimen of 0% locally made EM-A was produced for the purpose of comparism. The water cement ratio used all through the production process was 0.57.

To avoid spalling of hardened concrete during demoulding, the cubes were allowed to harden for 48 hours before demoulding, because it was observed that the cubes containing the locally made EM-A were still wet even after 24 hours. All the cubes were cured using wet curing method and were tested for compression strength at 7, 14, 28 and 56 days respectively.

- **Compressive Strength at 7 Days**

At 7 days, the control specimen was recorded as 22.3 N/mm^2. The specimens added with 3%, 5%, 10% and 15% were recorded 23.7N/mm^2, 19.7N/mm^2, 20.3N/mm^2 and 16.2N/mm^{2}respectively. The specimen with 3% replacement shows an increment in compressive strength over the control specimen with 6.28%. All the remaining specimens have low compressive strength compare to the control specimen.

- **Compressive Strength at 14 Days**

At 14 days, the control specimen was recorded as 24.7 N/mm^2. The specimens added with 3%, 5%, 10% and 15% were recorded 26.4N/mm^2, 22.5N/mm^2, 20.4N/mm^2 and 17.1N/mm^{2}respectively. The specimen with 3% replacement shows an increment in compressive strength over the control specimen with 6.88%. All the remaining specimens have low compressive strength compare to the control specimen.

- **Compressive Strength at 28 Days**

The control specimen at 28 days maturity age was recorded as 25.1 N/mm^2 which was 83.67% of the design strength. The specimens added with 3%, 5%, 10% and 15% were recorded 28.5N/mm^2, 24.5N/mm^2, 24.0N/mm^2 and 20.3N/mm^{2}respectively. The specimen with 3% replacement shows an increment in compressive strength over the control specimen with 13.55% and also the compressive strength was 95% of the design strength. All the remaining specimens have low compressive strength compare to the control specimen.

- **Compressive Strength at 56 Days**

At 56 days the control specimen was recorded as 31.6 N/mm^2. The specimens added with 3%, 5%, 10% and 15% were recorded 34.3 N/mm^2, 6.2N/mm^2, 25.1N/mm^2 and 2.6N/mm^{2}respectively. The specimen with 3% replacement shows an increment in compressive strength over the control specimen with 8.54%. All the remaining specimens have low compressive strength compare to the control specimen. Concrete with 3% locally made EM-A shows an enhanced compressive strength compared to the control and all other specimens at all ages of tests.

Table II. Average Compressive Strength of Concrete at all Ages of Tests

Locally Made EM-A (%)	**Average Compressive Strength (N/mm^2)**			
	7 Days	***14 Days***	***28 Days***	***56 Days***
0	22.3	24.7	25.1	31.6
3	23.7	26.4	28.5	34.3
5	19.7	22.5	25.5	26.2
10	20.3	20.4	24.0	25.1
15	16.2	17.1	20.3	22.6

Source: Laboratory Work (2014)

The increase in the compressive strength 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.

D. CONCLUSION

i. The locally made EM-A can be used as an admixture in concrete production.
ii. The finding of the study showed that the 3% locally made EM-A content specimens possessed a higher compressive strength than the control specimens by 6.28%, 6.88%, 13.55% and 8.54% at 7, 14, 28 and 56 days respectively.

iii. Moreover, it was found out that all the specimens containing 5, 10 and 15% of locally made EM-A possessed a lower compressive strength compared to the control.

iv. Therefore, this concluded that the optimum and economical dosage of the locally made EM-A in concrete should not exceed 3%.

E. RECOMMENDATIONS FOR FURTHER STUDIES

i. Further research should be carried out to check 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 locally made EM-A on strength of concrete.

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

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