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EFFECT OF WATER TEMPERATURES ON THE COMPRESSIVE STRENGTH, SLUMP AND SETTING TIME OF CONCRETE

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ABSTRACT- This research conducted in Eastern Nigeria was aimed at determining the effects of mixing-water temperature on the compressive strength, workability and setting time of concrete. The river sand used was from River Otamiri and granite stones from Abakaliki were used as the coarse aggregates. These materials were prepared based on BS 812: 1987, BS410:1986 and BS 1881:1983. The temperatures of the water used were variously: – 5^0C, 10^0 C, 15^0C, 28^0C, 35^0C, 45^0C, 50^0C, 60^0C, 70^0C, 75^0C, 90^0C and 100^0C. The mix ratio of 1:2:4 with water –cement ratio of 0.58 by weight of concrete was used. It was found that the compressive strengths were increasing as the age increased. This increase reached a peak of 33.65Mpa at 50^0C after which the strength declined gradually to as low as 1.97Mpa at a water temperature of 100^0C. In terms of workability, the workability of the concrete increased as the temperature of the mixing-water increased, getting to a high of 175mm slump at 100^0C and became constant for temperatures between 28^0C – 50^0C. For setting time, the setting time of the paste increased with the rise in temperature of the mixing water. The study has revealed that water temperature has a significant influence on the strength, workability and setting time of concrete. Also, it was shown that the optimal temperature to achieve a high strength at 28 days was 50^0C.

Keywords: compressive strength, setting time, workability, aggregates, mixing water, temperature,slump.

1.0 INTRODUCTION

Concrete is defined as a material used in building construction, consisting of a hard, chemically inert particulate substance known as aggregate (usually made from different types of sand and gravels), that is bonded together by cement and water [1][2]. The first concrete was made by a British engineer, John Smeaton by adding pebbles as a coarse aggregate and mixing powdered brick into the cement. Many factors such as aggregate properties, weather conditions, and water purity level and water temperature affect the strength development of concrete [3][4]. To a large extent, the durability of concrete depends on the type of aggregate used. Aggregates can be either fine or coarse [5][6]. Water being an essential component in concrete mix has a direct influence on the strength, workability, durability and performance of concrete. A mechanical property of aggregates is water absorption [7] [8].

2. MATERIALS AND METHOD

2.1 MATERIALS

The coarse aggregate used was granite of 19mm size. It was sourced from Abakaliki, Eastern Nigeria. The fine aggregate was fine river sand from Otamiri River, also in Eastern Nigeria. The cement used was ordinary Portland cement.

2.2 METHODS

2.2.1 PREPARATIONS, CURING AND TESTING OF CONCRETE CUBE SAMPLES

The concrete mix ratio used was 1:2:4 with a water-cement ratio of 0.58. The water used in preparing the experimental samples satisfied the conditions prescribed in BS 3148 [9]. The water used in the experiment was either heated with a boiling ring or refrigerated to the required temperature. The required concrete specimens were made in threes in accordance with the method specified in BS 1881: 108 [10]. These specimens were cured for 3, 7, 14 and 28 days in accordance with BS 1881: Part 111 [11]. The testing of the cubes was done in accordance with BS 1881: Part 116 [12] using the compressive testing machine.

2.2.2 SLUMP TEST OF THE FRESH CONCRETE

The slump apparatus was a mould of 1.18mm thick galvanized metal in the form of frustrum of a cone with the base 200mm in diameter. The top was 100mm in diameter and the height 300mm. The taping end was a hemisphere 16mm in diameter.

2.2.3 SETTING TIME OF CEMENT PASTE

The setting time of the concrete was conducted using Vicat apparatus. The cement used for the test was mixed with water of 5, 10, 15, 28, 35, 50, 60, 70, 90 and 100^0C. The paste was then placed under a penetrometer and a stop watch was used to time the penetration of the pin.

3. RESULTS AND DISCUSSION

3.1 COMPRESSIVE STRENGTH TESTS

Figure 1 shows the graph of the compressive strength in Mpa against temperature (Celsius) from Day 1 to Day 28. At the control temperature (28.7 ^{0}C), the compressive strength ranged from 16.37 Mpa to 29.45 Mpa. At 5 degree Celsius, the compressive strength ranged from 11.47 Mpa at Day 1 to 26.65 Mpa at Day 28. At 10 degree Celsius, the compressive strength ranged from 14.07 Mpa at Day 1 to 28.12 Mpa at Day 28. At 15 degree Celsius, the compressive strength ranged from 14.66 Mpa at Day 1 to 28.22 Mpa at Day 28. At 35 degree Celsius, the compressive strength ranged from 7.75 Mpa at Day 1 to 30.38 Mpa at Day 28. At 45 degree Celsius, the compressive strength ranged from 10.08 Mpa at Day 1 to 34.19 Mpa at Day 28. At 50 degree Celsius, the compressive strength ranged from 8.41 Mpa at Day 1 to 33.90 Mpa at Day 28. At 60 degree Celsius, the compressive strength ranged from 5.58 Mpa at Day 1 to

22.78 Mpa at Day 28. At 70 degree Celsius, the compressive strength ranged from 5.15 Mpa at Day 1 to 20.62 Mpa at Day 28. At 75 degree Celsius, the compressive strength ranged from 4.13 Mpa at Day 1 to 18.57 Mpa at Day 28. At 90 degree Celsius, the compressive strength ranged from 3.09 Mpa at Day 1 to 10.64 Mpa at Day 28. At 100 degree Celsius, the compressive strength ranged from 2.05 Mpa at Day 1 to 8.20 Mpa at Day 28.

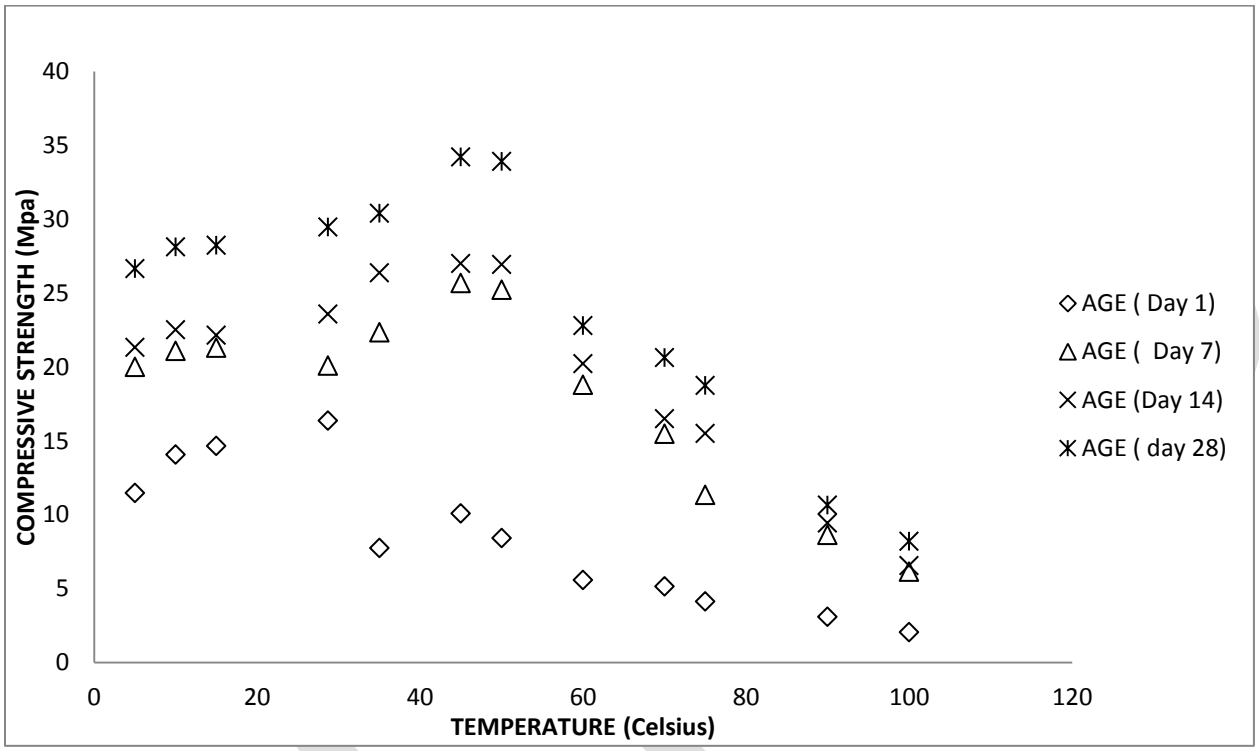

Figure 1 Graph of Compressive strength (Mpa) versus concrete mix – water temperatures (Degree Celsius)

3.2 SLUMP TESTS

Figure 2 shows the graph of slump (mm) at various water temperatures. The slump increased from 5mm at 5^0C to 175mm at 100^0C. In effect, the slump increased progressively as the water temperature increased.

3.3 SETTING TIME

Figure 3 shows the initial setting and the final setting time of cement paste at various water temperatures. The setting time of the cement paste increased as the water temperature increased.

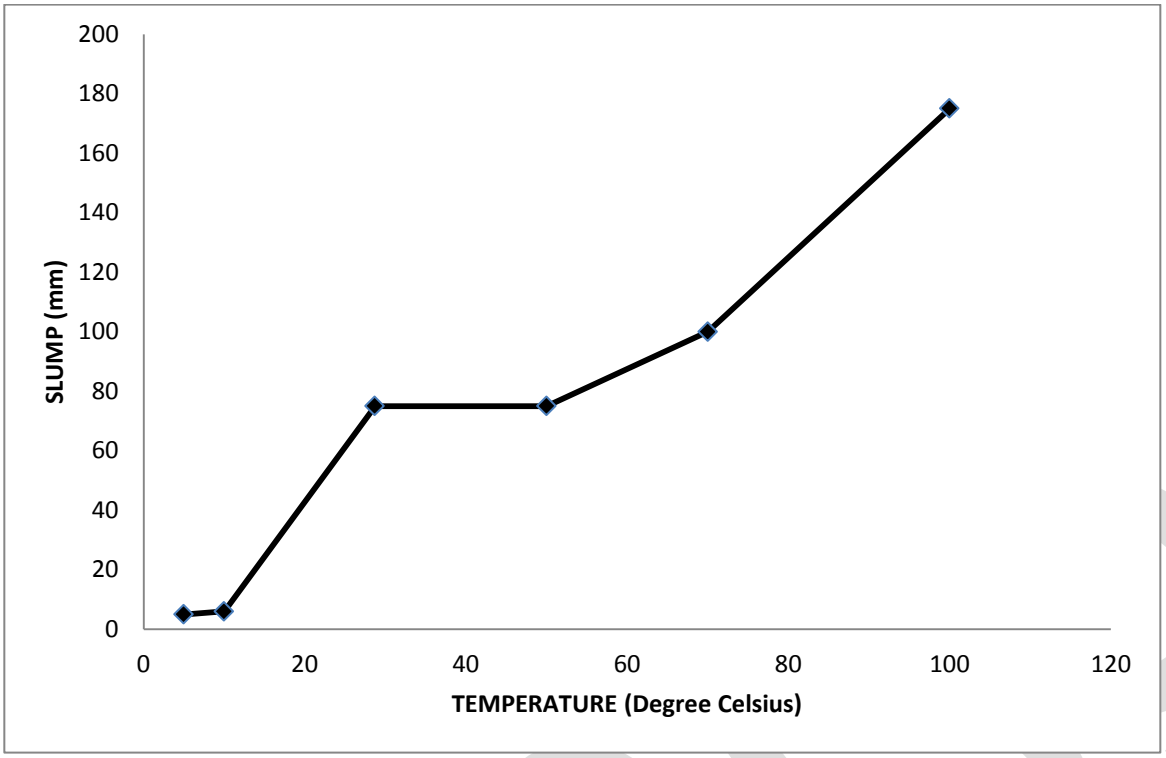

Figure 2 Graph of Slump (mm) versus concrete mix – water temperatures (Degree Celsius)

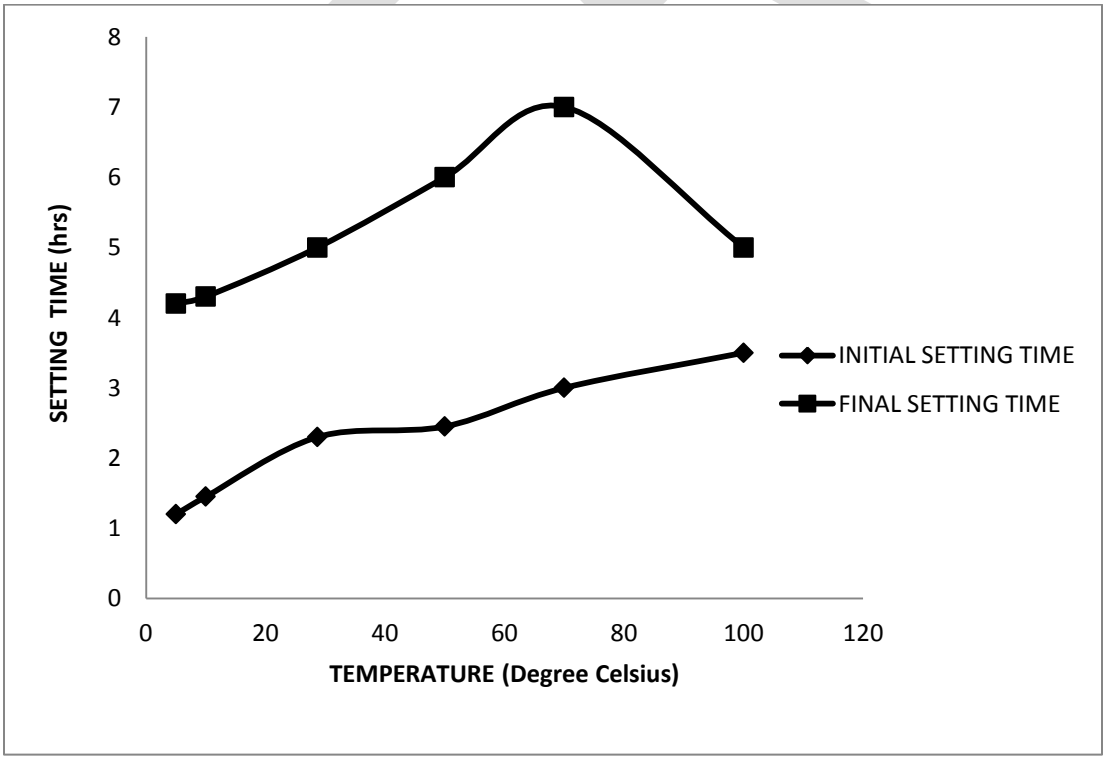

Figure3 Graph of Setting time (hrs) versus Water temperature (Degree Celsius)

4. CONCLUSIONS AND RECOMMENDATION

From the studies, the effect of water temperature, the effect of water temperature on the compressive strength and setting time of concrete was significant. It was found that the compressive strength increased with increase in mixing water temperature. Also, it was observed that the compressive strength for each age was a maximum at 50^0C. At above 50^0C water temperature, the compressive strength started declining. The maximum compressive strength was 33.65 Mpa at the age of 28 days. The workability of the concrete increased as the temperature of the mixing water increased getting to a high of 175mm slump at 100^0C. The setting time of concrete increased with rise in the temperature of the mixing water. This showed that water temperature had a significant influence on the strength, workability and setting time of concrete.

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