International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-9, September 2014

Influence of Air Temperature on Mechanical Properties of Concrete

Dr Mbereyaho Leopold, Mr Harerimana Charles, Mr Kagambira Eric

***Abstract*— The concrete preparation works and its curing takes place under variable air temperatures. This variation depending on the weather/climate conditions is very sensitive for the South- Saharan region, especially in areas between tropics with climate varying from warm to hot. The 28-day concrete strength considered as the basic strength in design of reinforced concrete structures is calculated from tests results of samples prepared under above weather conditions under which the concreting is done.**

This study on "Influence of air temperature on mechanical properties of concrete" was conducted with objective of investigating on the effect of temperature variation on mechanical properties of concrete while changing the proportion of its components. The compressive strength, tensile strength and flexural strength were analyzed for concrete samples prepared from three different mix ratios (1:2:4; 1:1.5:3 and 1:1:2), and placed under three different temperatures (9, 20 and 36 ^{0}C) at their early stage of curing during 24 hours.

The results from testing after 28days proved that bellow the normal temperature of curing condition (around 20^{0}C), the mechanical properties of concrete slightly decrease, while when same samples are placed above the normal temperature, these properties considerably decrease.

Therefore special measures should be taken when the concrete works are to be conducted under varying air temperature in order to avoid the negative impact.

***Index Terms*— Concrete, air temperature, mechanical properties, concrete components, concrete mix ratio, Water and Cement Ratio**

I. INTRODUCTION

Today, concrete structures are dominating in the building construction industry, not only in Rwanda but also in the great part of the world. Among other many advantages of concrete structures, the most important merit resides in its mechanical properties as a building material [9]

Concrete is a composite material composed of water, coarse granular material (the fine and coarse aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together [2] and [10].

Concrete has a great variety of applications because it meets not only structural demands but also lends itself readily to architectural treatment. In buildings, concrete is used for footings, columns, beams, girders, wall, slabs, and roof units; in short, all important building elements. Other important concrete applications are in road pavements, airport runways, bridges, dams, irrigation canals, water-diversion structures, sewage-treatment plants, and water-distribution pipelines. A great deal of concrete is used in manufacturing masonry units, such as concrete bricks and blocs [5].

As far as the temperature effect concerns, there are two positions to pay attention.

On one hand, the normal procedure adopted for concrete in fair weather will not be valid for concreting when the temperature is lower or below the freezing point. The production of concrete in cold weather introduces special and peculiar problems, such as delay in setting and hardening, damage to concrete in plastic condition when exposed to below freezing point owing to the formation of ice lenses. Therefore it is essential to maintain the temperature of the concrete positively above 0^{0}C, possibly at much higher temperature.

On the other hand, normal methods of mixing, transporting and placing of concrete will not be exactly applicable to extreme weather conditions. Special problems are faced in making, placing and compacting concrete in hot weather and in cold weather.

Even if it is difficult to define what hot weather condition is, just for convenience, it is regarded that the concrete placed at an atmospheric temperature above 40^{0}C is considered as hot weather concreting [4].

Many authors from all sides of the world have worked on effects of change of temperature on different mechanical properties with consideration of different factors, such as admixtures, water cement ratios, concrete age, etc. [1], [7],[8], etc. It was established that the temperature change may cause negative as well as positive impact.

II. METHODOLOGY FOR THE STUDY

Under different selected temperature conditions, this study was focused on three important mechanical properties of concrete which are Compressive strength, tensile strength and flexural strength. Temperature changes were selected based on Rwandan Conditions, where the minimum temperature (with a high probability) was 9^{0}C and the maximum of 36^{0}C. 20^{0}C is considered as a normal curing temperature for concrete. Concrete was tasted at 28days age.

The laboratory testing methods of concrete are in accordance with ASTM International.

The study started with checking on the variation of temperatures in Rwanda, what established considered temperatures above mentioned.

Manuscript received September 23, 2014.

Dr Mbereyaho Leopold, University of Rwanda, College of Science and Technology (CST), Postal address: BP 3900 Kigali

Mr Harerimana Charles, Graduates, College of Science and Technology (Former Institute of Science and Technology - KIST), Postal address: BP 3900 Kigali

Mr Kagambira Eric, Graduates, College of Science and Technology (Former Institute of Science and Technology - KIST), Postal address: BP 3900 Kigali

It was also important to visit different construction companies or industries in order to establish the most applied concrete mixture ratios on the country sites. It was found that the mix ratios of 1:2:4; 1:1.5:3 and 1:1:2 were the most used.
With these mix ratios, a fresh concrete was prepared and after checking its workability 81 concrete samples (27 cubes, 27 beams and 27 cylinders) were prepared for compression, tensile and flexural tests, conducted after 28 days, following all rules and regulations.

III. TESTING FOR CONCRETE MECHANICAL PROPERTIES

The first simple test was to check the workability using the slump test. Next tests consist in determination of strength characteristics. For that, standard samples as per regulations were prepared respectively to the types of strengths to be studied. The figure below presents photos of these samples (cubes, rectangular beams, and cylinders).

Figure 1. Different samples used for testing

A. PREPARATION OF SAMPLES AND TESTING FOR COMPRESSION STRENGTH

For each of three selected mix ratios, 27 standard cubes of 15x15x15 cm were used. The crushing test of the cubes was conducted 28 days after the curing.

Figure 2. Compression Test

B. PREPARATION OF SAMPLES AND TESTING FOR TENSILE STRENGTH

The sizes of used cylinders were 30cm length, and 15cm diameter. The cylinder lays on its side, as shown in Figure4. The machine pushes down on the free side of the cylinder. The cylinder will split in two halves.

Figure 3 Splitting test

C. *DETERMINATION OF FLEXURAL STRENGTH*

For this test, the concrete sample was in the shape of a beam, with 10cm x 10cm section and 40 cm long). The beam sits horizontally in the loading machine. It is loaded at a point as shown below until it cracks.

Figure 4.Flexural test

IV. RESULTS AND DISCUSSION

The results from above mentioned tests are presented bellow. Let first adopt the following designations:
A: Mixture 1:2:4
B: Mixture 1:1.5:3
C: Mixture 1:1:2

A. *COMPRESSIVE STRENGTH VARIATION*

Then the figure 5 presents the variation of compressive strength with regards to the 3 selected mix ratios.

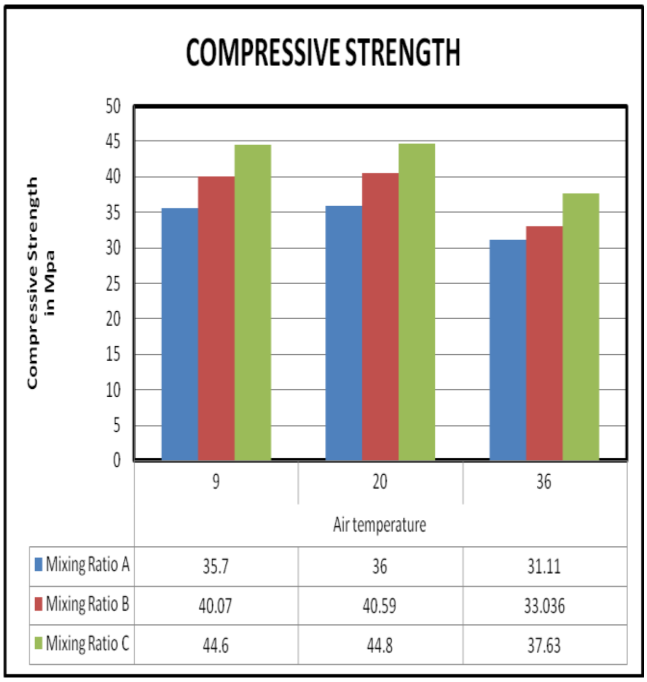

Figure 5. Compression tests results for all three mixing ratios

B. *TENSILE STRENGTH VARIATION*

Then the figure 6 presents the variation of tensile strength with regards to the 3 selected mix ratios.

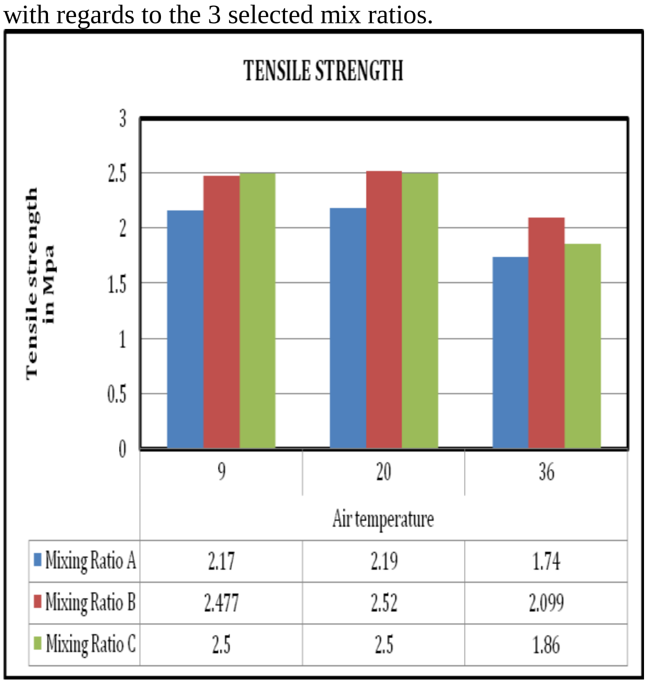

Figure 6. Tensile test results for all three mixing ratios

C. FLEXURAL STRENGTH VARIATION

Then the figure 7 presents the variation of flexural strength with regards to the 3 selected mix ratios.

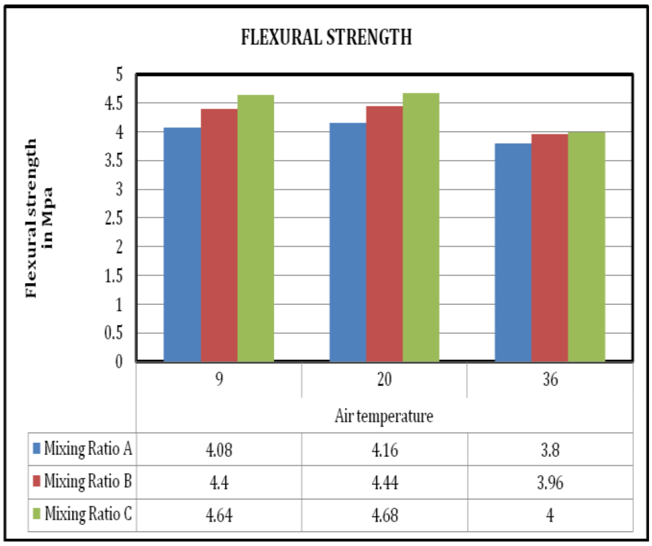

Figure 7. Flexural test results for both three mixing ratios

V. CONCLUSION

It was confirmed that the mix ratio of 1:1:2 offers the highest concrete strength. This goes to prove the quality of concrete components used in this research.

It was also established that when the air temperature decreases to 9^0C, concrete strength decreases but it is around the required strength at curing condition of 20^0C,while when it is increased to 36^0C the concrete strength decreases considerably.

From the above, it is concluded that the effect of air temperature on mechanical properties of concrete is not to be neglected when concreting especially during concrete placement and setting. The special measures should be taken when the concrete works are to be conducted under variable air temperature in order to avoid the negative impact, such as delaying the setting due to low air temperature and decreasing of long term strength due to hot weather conditions.

This research on the effect of air temperature on mechanical properties for different proportion of concrete components has focused on its strength, such properties as shrinkage, creep, water absorption and elasticity are not of the least importance and should be checked for a complete understanding of the above effect.

Finally, the study considered the testing at the sole concrete age of 20 days. The same study with consideration of different ages of concrete (7, 14 and 21 days), would establish the consistence.

REFERENCES

[1] AHMAD,A.H. (Professor) Abdulkareem,O.M. Civil Engineering Dept. University of Mosul Effect of high temperature on mechanical properties of concrete containing admixtures. Al-Rafidain Engineering Vol.18 No.4 August 2010.

[2] Eng. A.Al Kourd Eng. Adel Hammad. CEMENT and CONCRETE TECHNOLOGY. 2009/2010

[3] Fort Leonard Wood, MO 65473 (September 1992). Sub-course EN 5466, Edition A; Us army engineer center and school Concrete Engineering. September 1992.

[4] M.S. Shetty, S.chand & company ltd. Ram Nagar. Concrete Technology, Theory and practice. NEW DELHI- 110 055, 2005

[5] Search Labs by ASTM Standards ASTM Free Online Lab Directory. Test Lab Directory ASTM www.astm.org/labs

[6] Tarun R. Naik, and Rudolph N. Kraus. Temperature Effects on High-Performance Concrete. 6th International Symposium on "Utilization of High Strength/High Performance Concrete. Leipzig, Germany. June 16 – June 20, 2002.

[7] Twubahimana Joseph Désiré and Mbereyaho Léopold. Impact of sudden temperature change of fresh concrete on its flexural strength. International Research Journal on Engineering Vol. 2(2), pp. 028-035, February, 2014.

[8] Usman Ghani, Faisal Shabbir, Kamran Muzaffar Khan. EFFECT OF TEMPERATURE ON DIFFERENT PROPERTIES OF CONCRETE

[9] www.kigalicity.gov.rw. THE KIGALI HOUSING MARKET.

[10] Zongjin Li; Advanced concrete technology; 2011.