Studying of Floating Concrete Report

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Table of Contents

1. Introduction

Concrete is created by the mixing of primary raw materials of varying proportions. The cement and the aggregates mainly constitute the cement mix; cement is a basic ingredient of concrete. Sand, natural gravel and crushed stove are used mainly as aggregates. Combining water to the cement forms a cement paste that glues the aggregates together. Sometimes, the mixture contains admixtures, fibers and reinforcement. Concrete can withstand compression but liable to break under tension due to its low tensile strength. But it can be improved by adding other materials such as steel. Civil engineers follow ASTM standards to test concrete to determine, evaluate its various properties including its strength and to ensure its safety.

During the wet state of concrete, it has relatively low compressive strength. Concrete compressive strength yet to occur when the concrete is progressing form its viscous state to hardening. Theoretically, concrete reaches its relative maximum compressive strength after 28 days from the time of its casting. The density of concrete is a ratio of its mass over its volume. Lightweight aggregates such as perlite, can affect the compressive strength of concrete but lead to a lower dense concrete

The objective of this experiment is to explore the optimal design of lightweight concrete by considering compressive strength and density to achieve a greater value. The equations below were used for the design. Eq. (1) is the definition of the density.

$$\rho = \frac{m}{V} \tag{1}$$

where $\rho =$ density of concrete specimen (kg/m^3), $m =$ mass of the concrete (kg) and V = volume of the concrete (m^3). The performance criterion, which is used to evaluate for the performance of the floating concrete is given in Eq. (2)

$$p = \frac{f_c^{'}}{\rho} \quad (2)$$

where $p =$ is the performance criterion, $f_c^{'} =$ compressive strength at 28 days (MPa) and $\rho =$ density of concrete specimen (kg/m^3).

2. Approach

The purpose of this topic is to compare the compressive strength from different portions of the mixture ratio. To determine the best ratio that gives the lowest density and provides the greatest 28 days compressive strength and compare the compressive strength of the concrete due to the change of the water to cement ratio.

The materials that were used for this experiment were Quikrete type I/II Portland Cement, Ottawa sand for fine aggregate, and Miracle-Gro Perlite for course aggregate. The ACI design code does not specific the procedure of casting the light weight concrete with using perlite. This experiment did not follow the ACI design code.

The experiment result was evaluated by three different portions of mixture. With different water to cement ratio, cement to fine aggregate ratio and cement to course aggregate ratio. The portion ratio was measured by the weight of the material. The density Portland cement is 1350 kg/m^3, the density of Ottawa sand is 1667 kg/m^3 and the density of perlite is 127 kg/m^3. The design was based on a total volume of 1.311×10^{-4} m^3. The quantity of each material that was used for the casting, was calculated by the total volume multiplies the density. The first trial for this experiment was to cast a 0.4 water to cement ratio concrete cube with 1 cement to fine aggregate ratio, and 6.67 cement to course aggregate ratio. The second trial for this experiment was to cast a 0.45 water to cement ratio concrete cube with 1 cement to fine aggregate ratio, and 4 cement to course aggregate ratio. The third trial for this experiment was to cast a 0.5 water to cement ratio

(a) (b) (c)

Figure 1. (a) course aggregate (perlite)[1], (b) cement[2], (c) fine aggregate[3]

concrete cube with 1 cement to fine aggregate ratio, and 2 cement to course aggregate ratio. The sample materials (cement, sand and course aggregate) that were used for casting the specimens were illustrated in figure 1. The water absorption of the perlite is 0.27 kg of water for every 1.0 kg of perlite. The actual water to cement ratio is list below table.

Table 1. Mixture Portion of individual trial.

Group 1	**Group 2**	**Group 3**
w/c=0.28	w/c=0.35	w/c=0.31
Water=0.26 kg	Water=0.23 kg	Water=0.18 kg
Cement=0.45 kg	Cement=0.45 kg	Cement=0.45 kg
Sand=0.45 kg	Sand=0.45 kg	Sand=0.45 kg
Aggregate=0.23 kg	Aggregate=0.11 kg	Aggregate=0.07 kg

The experimental work was performed in the concrete laboratory of the department of Civil and Environmental Engineering at University of Massachusetts Lowell. The concrete samples were casted and the tools used for the casting are as follow:

- ASTM standard metal tray
- Mixing steel rod
- 2”x2” cube mold

The procedure was to measure and prepare the portion of each materials precisely. Mixing all the material in the mixing tray completely and the water was added slowly and gradually. After the mixing was completed, the concrete was then transferred to the cube mold, to have a better performance concrete. The concrete paste was filled to 1/3 of the mold and the rod was used to press and stir the concrete paste to make the concrete evenly distributed. The concrete was filled to 2/3 and repeat the procedure, then it was filled completely to the mold and repeat the same procedure. The excessive concrete paste was removed from the mold.

(a) (b)

Figure 2. (a) casting the floating concrete, (b) compact the floating concrete

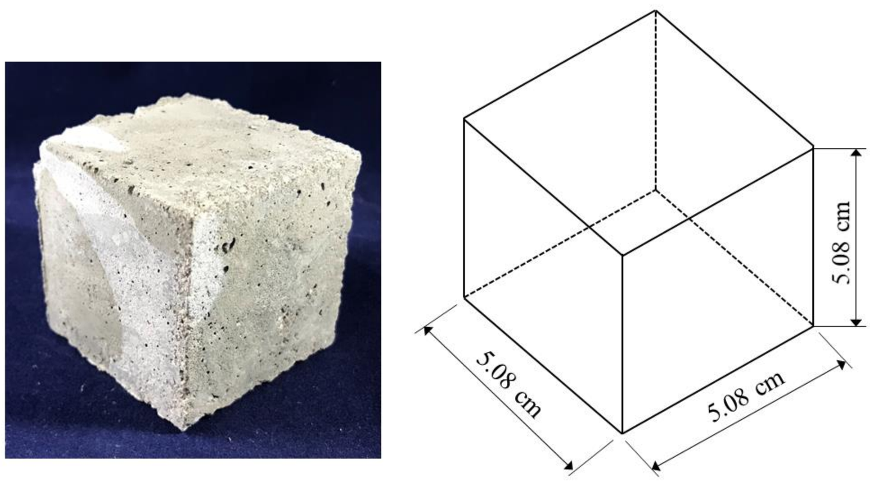
After the concrete was completely transferred and filled the cube mold, a clear flat plastic wrap was covered the top surface of the concrete mold, to avoid the excessive water lost due to the atmosphere and humidity change as well as to minimize the shrinkage of the concrete. This was done to minimize the residual stress due to hydration process. After the concrete paste was filled the cube mode, and cover by the plastic wrap entirely, the cube mold was stored at the constant room temperature and constant humidity place for complete 24 hours, the concrete specimen was removed from the mold after 24 hours, each specimen trials were labeled with actual casted date, and with its exclusive water to cement ratio, cement to fine aggregate ratio and cement to course aggregate ratio.

At the curing stage of the concrete specimen, the specimens were stored in the water tank for 20 days with normal room temperature after they were removed from the molds. During the whole curing period, the temperature was controlled approximately constantly throughout the entire 20 days and approximately at 68 Fahrenheit.

After the 20 days of curing, to get the 28 days of the compressive strength the concrete specimens were transferred to a dry with room temperature place for addition 7 days. The 28 days of concrete compressive strength will approximately reach to 85% of the full

(a) (b)

Figure 3. (a) floating concrete before cracking, (b) floating concrete after cracking



(a) (b)

Figure 4. (a) float concrete specimen, (b) dimension of the float concrete specimen

compressive strength. The specimen was removed from the water to help the specimen dry as soon as possible. The compressive strength test was tested at the Laboratory at the University of Massachusetts Lowell. After 28 days of casted of the concrete specimen, the specimens were test at the hydraulic machine (Instron model 1332) the concrete crushing test was tested 2 of the 3 specimens of each trial. Figure 2 illustrates the floating concrete before and after cracking. The other specimen was used for weight measurement, volume measurement, and for identification, which is shown in figure 3.

3. Result and Analysis

The results of the compressive test of the specimens were summarized below. The highest compressive strength result was given by the third trial with specimens (3-1, 3-2, 3-3) which has actual water to cement ratio of 0.31. Based on this information, the density of these three concrete specimens are 1.922×10^3 kg/m^3, 1.929×10^3 kg/m^3 and 1.967×10^3 kg/m^3. For testing the compressive strength of the concrete, only No. 2 and No.3 specimens were used for trial 3. The compressive stress and strain curve is given in figure 5. The overall shape of the two curves of the trial 3 follow the same trend. At low loading level, the concrete can be pressed. However, when the strain increases to a threshold (>0.01 for 3 and >0.02 for No.3), there is a linear relationship between the compressive stress and compressive strain. By doing the curve fitting, the Young's modulus of these two specimens (No. 2 and No. 3) can be addressed, which is E_2=425 GPa and E_3=900 GPa, respectively. The performance criterion for evaluating the floating concrete is give in table 2. As shown before, the performance criterion is defined as the ratio between the compressive strength and the density. For our testing results, the performance criterion for the two specimens are 15.0 and 13.8, respectively. The result revealed that the compressive strength can be affected by the water to cement ratio and cement to course aggregate ratio. The amount of perlite used in third trial was the least in casting the concrete while the first trial used the highest amount of perlite for the concrete casting. The amount of perlite used for the three trials effected the total weight of the specimens, as well as the porosity. Perlite has a significant water absorption ratio, meaning, after the concrete was dried, the original size of perlite after absorbing the water will shrink and the concrete becomes very porous. The actual water to cement ratio will be different from the design amount. The increase in perlite used for concrete casting, will increase the porosity of the concrete and will decrease the compressive strength of the concrete due to the porosity as well as perlite being a fragmentary material. Figure 6 shows the microstructure of the 3rd trial specimen. The compressive test result of the third trial has the greatest strength of the three trials because the 3rd trial design has the lowest cement to course aggregate ratio, in which a low amount of perlite was used as well as a low water to cement ratio.

Table 2. Mass, volume and density of float concrete specimens

	Mass (kg)	Volume (m^3)	Density (kg/m^3)
No. 1	0.252	1.311×10^{-4}	1.922×10^{3}
No. 2	0.253	1.311×10^{-4}	1.929×10^{3}
No. 3	0.258	1.311×10^{-4}	1.967×10^{3}

Table 3. Performance criterion of float concrete specimens

	Compressive Strength (kPa)	Density (kg/m3)	Performance criterion	Average of Performance criterion
No. 2	2.892×10^{4}	1.929×10^{3}	15.0	14.4
No. 3	2.717×10^{3}	1.967×10^{3}	13.8	

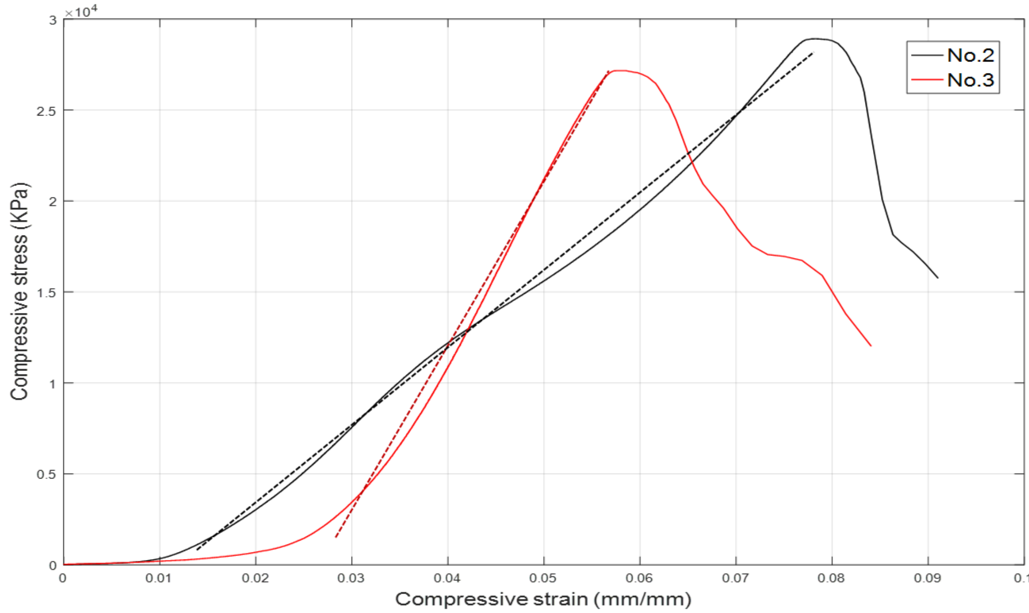


Figure 5. Compressive strain and stress curve for No. 2 and No.3 specimens

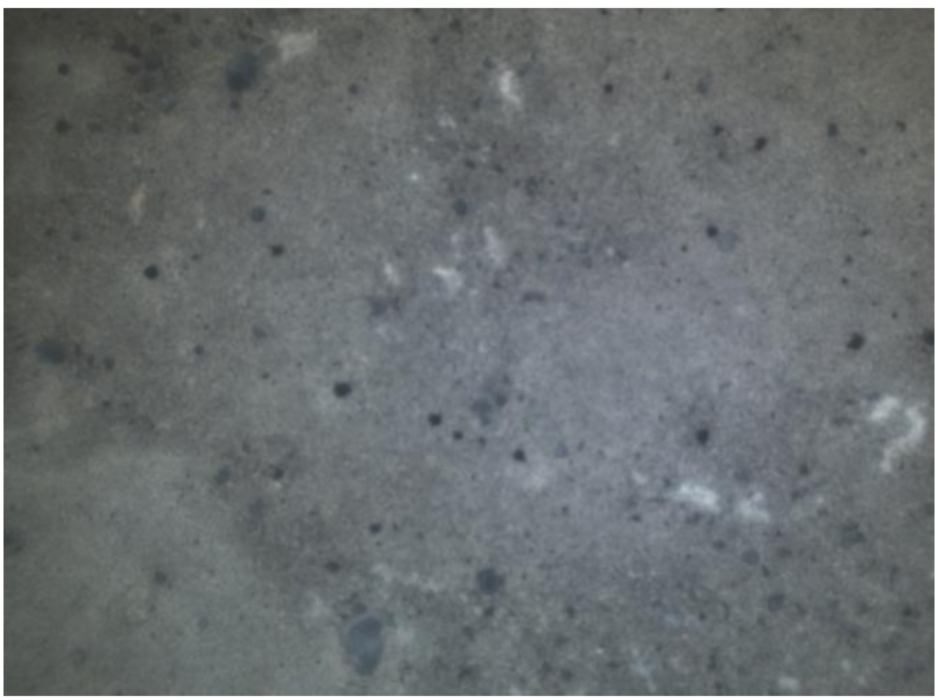


Figure 6. Specimen No. 1 Microstructure

4. Discussion

One key issue that occurred, was failure to test crush the concrete specimens on the 28th day. Mixing and placement of the concrete was done on the 27th, 28th and 29th of October,

2017. The respective 28 days were the 24th, 25th and 26th of November. Unfortunately, the Laboratory in the Civil Engineering Department of the University of Massachusetts Lowell is not available on the weekends, in which the 28 compressive days fell on. Instead of testing on day 28, the concrete specimens were tested on day 29, 30, and 31.

A second issue that arose was that the water to cement ratios presented were not completely accurate at the beginning of the casting process. Due to the perlite absorbing some of the water, miniscule amounts of water were added after to ensure that the mixed concrete was intact and ready to be casted.

A final issue that occurred was that the concrete specimens were removed from curing at day 20, instead of day 28. The specimens were removed at day 20 to allow for some air drying before the compression test.

5. Conclusion

The purpose of the experiment was to mix and cast concrete specimens that would achieve a high enough performance criterion value that was based on compressive strength of the specimen as well as the specimen density. With each specimen containing a different w/c ratio, aggregate to cement ratio as well as sand to cement ratio, a multitude of different results were generated and analyzed. Specimen No. 2 as well as Specimen No. 3 were the specimens that permitted the highest value for the performance criterion, with values of 15.0 and 13.8 respectively with an average value of 14.4. Overall, the experiment succeeded in showing how concrete reaches its maximum potential in compressive strength at 28 days after being casted as well as demonstrating how different ratios (water to cement, aggregate to cement and sand to cement) affect the density as well as final compressive strength.

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