Lake Water Effect on the Performance of Concrete

A A Shamilah\textsuperscript{1,*} and A A Norfathin\textsuperscript{2}

\textsuperscript{1,2}Faculty of Civil Engineering Technology, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia.

\textsuperscript{*}E-mail: shamilah@unimap.edu.my

Abstract. This study was related to the application of lake water in the production of concrete samples as partial replacement to freshwater. The effect of the applications in terms of concrete properties were determined and compared with normal concrete samples that were cast with fresh water. The lake water was collected at Tasik Timah Tasoh, Perlis. In this study, the percentage of water replacement were 50\%, 80\% and 100\%. A standard mix ratio of concrete was used. The main objective of this study was to investigate the compressive strength of concrete cube casting using lake water replacement. The test conducted in this laboratory works were compression, density, water absorption and Ultrasonic Pulse Velocity. Among the 3 different percentage of lake water replacement used in this study, it found that 100\% amount of lake water indicates higher compressive strength as compared with the control sample. This indicates the good agreement between lake water and cement to be combined for concrete casting.

1. Introduction

The availability of water in adequate quantity and quality are an essential condition to approach sustainable development, whereas its shortage is the core constraint of water resources development and utilization. Malaysia as a tropical climate country has enormously received 3,000 mm average of rainfall, with an estimated 900 billion meter cube of water supply runoff dispersed into the river system. However, due to the increase in population, higher demand from industry and domestic/agriculture user, delay of the treatment plant and most importantly lack of maintenance creates water crisis in urban areas. As mentioned before, the high demand usage of fresh water in the construction industry may lead to water shortage. There are various efforts being done to find a suitable water that can be used to replace fresh water in concrete mixing. At various water has been studied to be used of concrete casting such as salt water, river water, wastewater, lake water and others. However, the performance investigation of concrete casting using lake water is still questionable. Lake water seems to be effective for a replacement of potable water in concrete mixing to preserve the fresh water usage in daily life.

The workability of concrete is significantly affected by the water amount used because it is a major constituent of cement to hydrate efficiently [1]. The effect of tap water, bore well water, well water, mineral water and wastewater usage in the concrete casting have been investigated [2]. The result indicates that the concrete sample casting using mineral water gives the 13.5\% stronger than the control sample. Meanwhile, wastewater shows the lowest concrete strength among other samples. The effect of using primary treated wastewater (PTWW) in concrete mixing have been investigated [3]. The result indicates significant increase in load capacity when compared to the compressive strength of primary treated waste water with portable water. The compressive strength of the primary treated waste water is 10.68\% higher in case of concrete cube confined.
2. Materials and Methods
A total of 72 cubes has been cast in this study. Meanwhile, 18 cubes were cast using 100% of fresh water and acted as the control sample. Meanwhile, the other 54 cubes were cast with 50%, 80% and 100% of the lake water content. Each cube with different percentage of diluted lake water were divided into 4 groups with 18 samples of cube sample for 7, 14 and 28 days of curing for each day. All the test results that obtained from each specimen for each condition will be compared with the control samples. The concrete grade used in this study is 25 N/mm². The lake water was collected at Tasik Timah Tasoh, Perlis. The main catchment came from Sungai Timah and Sungai Tasoh.

3. Testing of concrete cube

3.1. pH test
The pH test is done on the lake water sample as soon as the water is collected from Tasik Timah Tasoh, Perlis. This is because the pH value of the water sample has the tendency to change when exposed to the atmosphere, as it can absorb carbon dioxide and form carbonic acid which will lower the pH level. The casting of concrete was conducted immediately, so that the water properties does not change when exposed to atmosphere for too long and can affect the concrete strength. The pH tests were done for both fresh and lake water samples as depicted in Figure 1.

3.2. Density test
Density test is a test that conducted to determine the density of the freshly mixed concrete. The denser of concrete, the higher the strength of concrete. This is because of the lack number of voids and air pores exist during the hydration period. In the meantime, through this test, the unit weight, yield or relative yield and cement content can be obtained. Thus, by using this data information, the air content in concrete mixture can be determined during verification of concrete volume. The density test is tested on cube where its weight is taken before and after curing. The weight usually increased after curing process. Figure 2 shows the cube is weighted before and after curing process.
3.3. Ultrasonic pulse velocity test

Ultrasonic Pulse Velocity Test is an in-situ, non-destructive test to measure or assess variations in the apparent strength of concrete. The strength and quality of concrete were measured by the velocity of the ultrasonic pulse that passed through the concrete structure. The velocity that passes through the concrete depends on the density and elasticity of the materials. This test was conducted to detect the presence of honeycomb, air void, cracking and decay.

This test was done by placing the two transducers that have a cylindrical metal head on the surface of the concrete cube. Before placing it on the concrete surface a gel must be applied on the surface of the transducer. Other than that, it is also must be placed on a flat surface of the concrete, to avoid the disturbance of the ultrasonic pulse submission through the concrete which can affect the reading of this test as shown in Figure 3.

3.4. Compression test

Compressive strength is a capacity of a material to withstand load. The compressive strength of concrete usually depends on the mixing of a specified proportion of the ingredients such as the ratio of cement, ratio of fine and coarse aggregates and the ratio of water. In this study the design mix of 1:2:4 is used and the compression test has been conducted on cube sample after 7, 14 and 28 days of curing test in order to ensure the targeted concrete grade can be achieved as indicated in Figure 4. The concrete cube must be placed centrally aligned on the base plate of the compression testing machine, so that the load will not be transferred to the wrong cube. This may affect the result of the compressive strength of cube. The results were recorded until the load applied by the machine to the cube fails.
3.5. Water Absorption Test

The water absorption is conducted for all the cube samples with different curing days. The concrete cube was removed from the curing tank and wiped with a damp cloth to remove the surface water. The cube was then transferred into an oven with 150°C for 24 hour period. After 24 hours, the cube was removed from the oven and the weight was taken. Then, the cube was immediately immersed in water for 30 minutes. After 30 minutes passed, the cube was taken out and cleaned with a dry cloth until the cube surface was all dried up. The weight of the cube was once again weighted using an electronic weight scale.

4. Empirical results and discussions

4.1. pH test

The pH test was conducted on both lake water sample and tap water as a control sample for this study to determine the suitability of the water for concrete and to measure the acidity or alkalinity of water-soluble substances of water samples. The permeability of concrete mixer can be increased by increasing the pore structure to allow the substances penetration [4]. Table 1 indicates the pH result of samples.

| Water sample | pH Value |
|--------------|----------|
| Tap Water    | 7.08     |
| Lake Water   | 7.03     |
| River Water  | 6.75     |
| Salt Water   | 8.36     |

The tap water has the reading of 7.08, which was still considered as neutral. Meanwhile, the lake water has the reading of 7.03 that also consider as neutral value. The pH value of river water was 6.750 according to [3] and value of salt water is 8.364 according to [4]. The river water pH value usually falls between 6.5 and 8.5 with 7.0 being neutral. The optimum pH value of river water was around 7.4. The river water’s acidity can be increased by acid rain. In other hand, the lake water was suitable to be used in concrete casting to replace the usage of fresh water. Furthermore, the concrete cast with lake water sample has been undergoing physical test such as compression test, water absorption test and ultrasonic pulse velocity test.
4.2. Concrete properties test

Density test. Based on the overall results for all samples, the density of the samples increased after its perspective curing days increase. Normally, if the moisture present, the concrete will continue to hydrate and gaining strength. The weight of concrete normally has the density around 2200 kg/m$^3$ to 2600 kg/m$^3$ [5]. The sample of lake water sample concrete mix density test result mostly lies within the range of 2370 kg/m$^3$ to 2470 kg/m$^3$, which fulfilled the standard range for normal concrete density. Figure 5 shows the density test result for all concrete samples used in this study.

![Figure 5. Comparison of density for all concrete samples used in this study](image)

Compression Test. Based on Figure 6, the compressive strength results for all samples increased, according to the increment of the curing period. The 80% Lake Water Dilute and the 100% Lake Water Dilute was recorded to be the highest compressive strength between all the samples 80% Lake Water Dilute recorded to be the highest on the compressive strength result on the 7th day that is 30.57 N/mm$^2$ and 14th day of curing that is 31.11 N/mm$^2$ before the 100% Lake Water Dilute compressive strength recorded to be increasing on the 28th day of curing with the value of 37.14 N/mm$^2$.

![Figure 6. Comparison of compression for all samples used in this study](image)

Ultrasonic Velocity Test. Ultrasonic Pulse Velocity Test (UPV) is an in-situ, non-destructive test to measure or assessing variations in the apparent strength of concrete. The strength and quality of concrete were measured by the velocity of the ultrasonic pulse that passed through the concrete structure. This
test was conducted to detect the presence of honeycomb, air void, cracking and decay. In this study, the test is conducted and tested for all samples, 50%, 80%, and 100% lake water dilute for each different curing days of 7th, 14th and 28th day. Figure 7 shows the UPV test result on all the samples recorded.

Based on the plotted graph, ultrasonic pulse velocity increased as the curing period increased. The effect of curing time can be explained by the fact that, there is an inverse relationship between the volume of pores and ultrasonic pulse velocity. An increase of capillary voids and micro cracks leads to higher resistance of concrete to transfer ultrasound waves as found in the study conducted by [6]and [7]. However, the recorded data that of 50%, 80% and 100% Lake Water dilute seems to have lower value than control sample. This is due to the reaction of the composite material content in lake water between the concrete.

![Figure 7. Comparison of UPV results for all samples in this study](image)

**Water Absorption Test.** The water absorption test is a method to determine the rate of absorption of water by the concrete cubes. The estimation of the total (reachable) pore volume of the concrete has been investigated by [8]. Having low permeability indicates a good quality of concrete. It also can resist ingress of water and does not expose to freezing and thawing. Water absorption is carried out based on [9]. The result obtained in Figure 8 indicated that all the concrete samples have the percentage of water absorption less than 10%, which are considered as good quality concrete.

![Figure 8. Comparison of water absorption for all concrete samples](image)
5. Conclusion

Based on the result obtained from compression test, 100% lake water dilute recorded to have the highest compressive strength compared to control sample obtained on the 28th day of curing. Therefore, the 100% lake water dilute appear to be the suitable volume replacement to be used in concrete casting to obtain much better strength as compared with control samples which were cast using tap water.

The usage of lake water in concrete casting as a tap water replacement can mitigate the use of fresh water in the construction industry to sustain the environmental sources. The conserving fresh water can be reserved to be used in daily life and for other purposes such as drinking, washing, hygiene and cooking. Moreover, conservation of water will contribute to reduce energy used and solve the shortage of fresh water problems. Therefore, the sustainability can be contributing to the society and the environment. In conclusion, it is significant to consider the sustainability aspect in this study as the environment is conserved by conserving the use of fresh water. Thus, the recommended percentage of Lake Water Dilute to be used as a replacement for concrete cube sample is 100%.

References

[1] Hama S M, Mawlood I A and Hilal N N 2019 *Iraqi J. of Civ. Eng.* 013-001
[2] Ghrair A M, Al-mashaqbeh O A, Sarireh M K, Al-kouz, N, Farfoura M, & Megdal S B 2016 9(4), 1519–1525.
[3] Shrilatha A, Rohtih M, Puneeth H C, Naveen K 2017 J. 4 2/9-13
[4] Schutter G D and Audenaert K 2004 *Materials and Structures* 37(9):591-596
[5] Abo-Qudais S A 2005 *Const. and Buil. Mat.* 19 257-263
[6] Lin Y, Kuo S-F, Hsiao C, and Lia C-P 2007 *ACI Mat. J.* 14 344-380.
[7] DeSchutter G. & Audenaert K 2004 *Mat. and Struc.* 37(9), 591-596
[8] ASTM D570-13 2013, *ASTM Inter.*, West Conshohocken
[9] Thavamalar 2009 *Treat. Wast. Wat. and Environ. J.* 20 219-221
[10] Al-Ghusain I & Terro M J 2003 *Kuwait J. Sci. Eng.* 30(1)
[11] Rakesh A, & Dubey S K 2014 *Inter. J. on Emerg. Tech.* 5(2): 40-50(2014)