Journal of Engineering Research and Reports

Volume 26, Issue 1, Page 10-17, 2024; Article no.JERR.111038
ISSN: 2582-2926

The Effect of Soaking K-300 Concrete Using Seawater on Concrete Quality

Musrifah [a++*], Viva Oktaviani [a++] and Tukimun [a++]

[a] *Civil Engineering Study Program, Faculty of Engineering, University of 17 Agustus 1945 Samarinda, Indonesia.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2024/v26i11059

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/111038

Original Research Article

Received: 01/11/2023
Accepted: 05/01/2024
Published: 09/01/2024

ABSTRACT

Concrete is a mixture of cement, fine aggregate, coarse aggregate, and water with or without additional ingredients to form a solid mass, its use is very common in building structures, but the final quality of the strength of the concrete depends on many factors, including the implementation of its manufacture. and immersion. The research aimed to determine changes in the quality of k-300 concrete and the maximum strength of concrete immersed in salt water. The research was carried out in the Laboratory of the Faculty of Engineering, University of 17 August 1945 Samarinda for 2 months. The stages of research activities are starting, literature study, preparation of materials and tools, testing concrete building materials in the laboratory, designing concrete mixes, making test objects/samples, evaluation, testing concrete compressive strength, conclusions, and reporting. Tests carried out in the laboratory include: (1) checking wear/abrasion of coarse aggregate using the Los Angeles method; (2) examination of coarse aggregate and fine aggregate sieve analysis; (3) examination of specific gravity and SSD absorption of coarse aggregate and fine aggregate; (4) checking water content; (5) checking mud and clay levels; (6) checking the bulk density of coarse aggregate, fine aggregate and mixed aggregate; (7) inspection of concrete slump experiments; (8) soaking concrete using seawater and freshwater; and (9) checking concrete compression strength.

[++] *Lecturer;*
**Corresponding author: Email: Musrifah.tohir76@gmail.com;*

The research results show that: (1) The compressive strength of K-300 concrete soaked in seawater, namely 304,915 f'c, is lower than that soaked in fresh water, namely 308,580 f'c; and (2) differences in concrete compressive strength occur at old concrete ages (21 days and 28 days) but at young concrete ages (3, 7 and 14 days) there are no differences in compressive strength.

Keywords: Compressive strength; K-300 concrete; immersion in seawater.

1. INTRODUCTION

Concrete is the result of mixing cement, water, fine aggregate, and coarse aggregate. Size variations in a mixture must have good gradation by the sieve analysis standards of the American Society of Testing Materials or ASTM [1]. Concrete is a type of artificial building material used for construction and this material is obtained by mixing cement, fine aggregate, coarse aggregate, and water, in certain proportions. After being formed and cast or molded, this mixture of materials will harden at a certain time, which functions to support the structural load [2].

Concrete is very important for a building, especially in buildings that are not too high and in buildings that are continuously submerged in water. All of this concrete has advantages, namely high compressive strength, economical, heat resistance, and so on. Also, the manufacturing process is easier and the materials for making concrete are easy to obtain.

When compared with other building materials, concrete is still considered to have many advantages, such as (a) the cost of making it is relatively cheap, (b) the materials used to make concrete are easy to obtain, (c) it requires relatively low maintenance costs, (d) it can be used in various weather conditions, and (e) can be made at the workplace (in situ) according to the desired shape [3].

In reality, concrete buildings are not always located on land that is free from the influence of the sea. Indonesia, as the largest archipelagic country in the world, has many concrete buildings that are always submerged or exposed to the influence of seawater. When compared with ordinary concrete, the actual use of concrete materials that are exposed to the influence of seawater has different material requirements. Concrete that is influenced/in contact with seawater is required to use Type V cement, which is specifically for making concrete that is affected by seawater [4].

However, making concrete that suits what we want, is not necessarily achieved by simply mixing Portland cement or other types of cement, fine aggregate, coarse aggregate, and water. However, care is needed in making concrete. An example is that certain buildings are continuously submerged in salt water, for example at ports on the seafront. This problem could result in a reduction in the increase in strength of the quality of the concrete that has been built.

The research aimed to determine changes in the quality of K-300 concrete and the maximum strength of concrete immersed in seawater.

2. METHODOLOGY

2.1 Location and Time

The research was carried out in the Laboratory of the Faculty of Engineering, University of 17 August 1945 Samarinda for 2 months

2.2 Materials and Tools

The materials used are Ex Palu coarse aggregate, Ex Palu fine aggregate, cement, plain water, salt water, and concrete. The equipment used is tools for testing aggregate samples and concrete in the laboratory.

2.3 Research Stages

The stages of research activities are starting, literature study, preparation of materials and tools, testing concrete building materials in the laboratory, designing concrete mixes, making test objects/samples, evaluation, testing concrete compressive strength, conclusions, and reporting.

2.4 Testing in the Laboratory

Making concrete test specimens is carried out using a mixed plan based on the provisions of SNI 03-2834-2000. The test objects are in the form of concrete cubes with a size of 15 cm on each side. There are 30 test objects for testing using seawater and 30 test objects for testing using fresh water.

Tests carried out in the laboratory include: (1) checking wear/abrasion of coarse aggregate using the Los Angeles method; (2) examination of coarse aggregate and fine aggregate sieve analysis; (3) examination of specific gravity and SSD absorption of coarse aggregate and fine aggregate; (4) checking water content; (5) checking mud and clay levels; (6) checking the bulk density of coarse aggregate, fine aggregate and mixed aggregate; (7) inspection of concrete slump experiments; (8) soaking concrete using seawater and freshwater; and (9) checking concrete compression strength.

2.5 Concrete Soaking Activities Using Sea Water and Fresh Water

The stages of this activity are: (1) mix all the materials with a certain planned composition until evenly distributed and put them into the prepared cube mold measuring 15 x 15 x 15 cm, the amount of concrete made is 60 pieces; (2) let it sit for one day then remove it from the mold and mark it according to the age of the concrete being made; (3) after that soak it using seawater and freshwater; and (4) After soaking, remove the cube blocks one day before testing.

2.6 Concrete Compressive Strength Check

This examination aims to determine the compressive strength of cube-shaped concrete that is made and cured (cured) in the laboratory. The compressive strength of concrete is the unit area that causes the concrete to crumble. The maximum compressive stress is calculated using the formula σ = P/A where, P = the maximum compressive load that the test object can withstand, and A = cross-sectional area of the concrete cylinder [5].

3. RESULTS AND DISCUSSION

3.1 Ex Palu Coarse Aggregate Inspection

The results of laboratory tests on Ex Palu coarse aggregate are presented in Table 1.

3.2 Ex Palu Fine Aggregate Inspection

The results of laboratory tests on Ex Palu fine aggregate are presented in Table 2.

The test results on the Ex Palu coarse aggregate and fine aggregate based on the SK SNI S-04-1989-F standard are eligible as an aggregate mixture [6,7].

3.3 Aggregate Mixture Design

Inspection and calculations to determine the composition or proportion of the mixture of each aggregate consisting of coarse aggregate and fine aggregate. The implementation is carried out after each aggregate has known the percentage of passes which can be calculated using the formula below:

$$y = y_{p1} * \frac{x}{100} + y_{p2} * \frac{100 - x}{100}$$

Information:

y = Specifications in terms of sieve No.4
y_{p1} = Amount of coarse aggregate that passes through sieve No.4
y_{p2} = Amount of fine aggregate passing through sieve No.

The mixture of Ex.Palu Coarse Aggregate and Ex.Palu Fine Aggregate.

y = 39 %
y_{p1} = 3.571 % (amount of % passing the coarse aggregate filter)
y_{p2} = 91.061 % (amount of % passing through the fine aggregate sieve)

The mixture calculation for fine aggregate Ex. Palu is as follows:

39 = 91,061 * x /100 3,571 * 100 – x /100
39 = 0,91061 x + 3,571 - 0,03571 x
0,8749 x = 39 – 3,571
0,8749 x = 35,429
x = 35,429 / 0,8749
x = 40,4 ~ 40 %

The mixture calculation for Ex. Palu Coarse aggregate is as follows:

39 = 3,571 * x / 100 91,061 * 100 – x / 100
39= 0,03571 x + 91,061 - 0,91061 x
- 0,8749 x = 39 – 91,061
- 0,8749 x = - 52,061
x = - 52,061 / - 0,8749
x = 59.5 ~ 60 %

Table 1. The results of laboratory tests on ex palu coarse aggregate

No	Item Inspection/Test	Results	Information
1	Aggregate Wear	**21,74%**	Meets the Requirements as an Aggregate Mixture SNI Decree S-04-1989-F
2	Water content Inspection/test Average	1. 0,717% 2. 0,341% 3. 0,348% **0,469%**	
3	Mud/clay content Inspection/test Average	1. 2,151% 2. 2,389% 3. 2,091% **2,210%**	
4	Specific Gravity and Absorption Inspection/test Average	1. 2,735 dan 0,946% 2. 2,743 dan 1,053% 3. 2,728 dan 1,263% **2,735 g cm^{-3} dan 1,087%**	
5	Aggregate Content Weight Inspection/test Average	1. 1,632 g cm^{-3} 2. 1,659 g cm^{3} 3. 1,691 g cm^{-3} **1,661 g cm^{-3}**	

Source: Processed Primary Data

Table 2. The results of laboratory tests on ex palu fine aggregate

No	Item Inspection/Test	Results	Information
1	Water content Inspection/test Average	1. 4,785% 2. 5,093% 3. 4,681% **4,853%**	Meets the Requirements as an Aggregate Mixture SNI Decree S-04-1989-F
2	Mud/clay content Inspection/test Average	1. 2,561% 2. 5,400% 3. 6,568% **4,828%**	
3	Specific Gravity and Absorption Inspection/test Average	1. 2,700 dan 3,448% 2. 2,713 dan 2,477% 3. 2,763 dan 2,839% **2,725 g cm^{-3} dan 2,921%**	
4	Aggregate Content Weight Inspection/test Average	1. 1,581 g cm^{-3} 2. 1,656 g cm^{3} 3. 1,673 g cm^{-3} **1,637 g cm^{-3}**	

Source: Processed Primary Data

3.4 Concrete Mix Design Analysis

The mixture carried out with the composition of each aggregate obtained the following results:

3.4.1 Design of K 300 Concrete which is soaked using seawater

The K-300 concrete mix design with a composition of 60% for coarse aggregate Ex. Palu and 40% for fine aggregate Ex. Palu was obtained after correction for each M^3.

a. cement = 464,744 Kg
b. Water = 235 Liters
c. Fine aggregate = 670 Kg
d. Coarse aggregate = 980 Kg

Estimated concrete compression test results at 28 days for Ex. Palu coarse aggregate and Ex. Palu fine aggregate after immersion using seawater/salt water.

a. F'cr = 351.217 Kg cm^{-2}
b. S = 46.302 Kg cm^{-2}

c. n = 30 k = 1.00
d. F'c = 304.915 Kg cm^{-2}

3.4.2 Design of K 300 Concrete which is soaked using freshwater

The K-300 concrete mix design with a composition of 60% for coarse aggregate Ex.Palu and 40% for fine aggregate Ex.Palu was obtained after correction for each M^3.

a. cement = 464,744 Kg
b. Water = 235 Liters
c. Fine aggregate = 670 Kg
d. Coarse aggregate = 980 Kg

Estimated concrete compression test results at 28 days for coarse aggregate Ex.Palu and fine aggregate Ex. Palu.

a. F'cr = 357.249 Kg cm^{-2}
b. S = 48.669 Kg cm^{-2}
c. n = 30 k = 1.00
d. F'c = 308,580 Kg cm^{-2}

3.4.3 Calculation of compressive strength of 28-day concrete

Concrete compressive strength is the magnitude of the load per unit area that causes the concrete specimen to crumble when loaded with a certain compressive force, which is produced by a pressing machine (SNI 03-1974-1990) [8].

$$\text{Compressive strength (kg cm}^{-2}) = \frac{K \times 1000}{\Delta \times 1}$$

Information:

K = Calibration of machine manometer reading for compressive strength
1000 = Constant
Δ = Area of the cube
1 = Comparison of the compressive strength of the cube shape

$$\text{28 day compressive strength (Kg cm}^{-2}) = \frac{(70.660 \times 1000)}{(225 \times 1)}$$
$= 314.044$ kg cm^{-2}

3.4.4 Calculation of compressive strength of concrete estimated 28 days

Concrete Compressive strength estimated at 28 days (kg cm^{-2})
= ((K x 1000) / Δ)) / Day

Information:

K = Calibration of machine manometer reading for compressive strength
1000 = Constant
Δ = Area of the cube
Days = Concrete age (concrete age correction)

Compressive strength estimated at 28 days (kg cm^{-2})
= ((70,660 x 1000 / 225)) / 1.00
= 314.044 kg cm^{-2}

3.4.5 Calculation of compressive strength (F'cr) standard deviation (S) and (F'c)

$$f'cr = \frac{(\tau b1 + \tau b2 + \tau b3 + \ldots \tau b30)}{N}$$

Information:

f'cr = Average compressive strength to be achieved
τ b = Compressive strength of concrete obtained by test results examination of each test object in kg/cm
N = Total number of test objects (30 test objects)

f'cr = 10,536.497 / 30 = 351.217 kg cm^{-2}

$$S = \sqrt{(\tau b^1 - f'cr)^2 + (\tau b^2 - f'cr)^2 + (\tau b^3 - f'cr)^2 + \ldots (\tau b^{30} - f'cr)^2 / N - 1}$$

S = 46,302 kg cm^{-2}

$$f'c = f'cr - (S \times k)$$

Information:

f'c = Design compressive strength
f'cr = Average compressive strength to be achieved
S = Standard deviation
k = Correction for the number of test objects to 30

f'c = 351,217 – (46,302 *x* 1,00) = 304,915 kg cm^{-2}

The results of the compressive strength test of concrete soaked in seawater and fresh water on 30 K300 concrete samples are presented in Fig. 1.

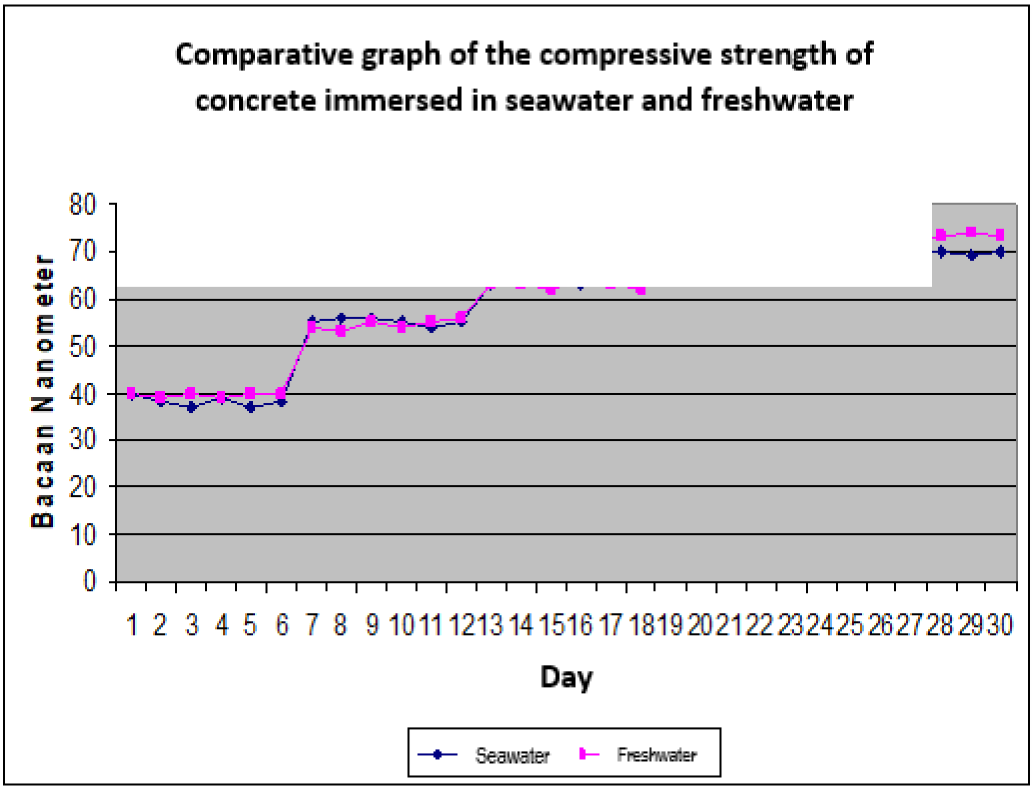

Fig. 1. Comparison of compressive strength results for concrete soaked in seawater and freshwater

Based on the test results of immersing K300 concrete in fresh water and seawater, shows that concrete soaked in seawater produces lower concrete compressive strength than concrete soaked in fresh water. This situation is caused by the first time it was soaked in seawater, the seawater automatically began to seep into the pores of the concrete, and that's when the concrete begins to be attacked by sulfates. According to Emmanuel et al. [9] concrete begins to be attacked by sulfate salts, characterized by an increase in compressive strength. This could happen because generally, the attack comes from Calcium chloroaluminate (Friedls' salt) which can expand. When it enters the pores of the concrete, Friedl's salt is still in its initial floating state, so the cavities in the concrete will be forced to become denser. As a result, if a compression test is carried out, the strength will increase; However, if it is soaked longer, the Friedls salt will continue to expand, until it presses excessively on the cavities in the concrete. As a result, the cavities in the concrete experience greater pressure, so that if a compression test is carried out the compressive strength will decrease. Utami et al. [10] explained that the properties of Friedel salt include, it enters, penetrates, fills the pores of the mortar, and expands over time. As a result, internal stress occurs in the body of the mortar due to the floating of Friedel salt in the pores of the mortar/concrete, so the strength of the mortar/concrete decreases over time. Then explained by Islam and Md [11] that chloride ions as a cause that is detrimental to the strength of concrete, can attack in various forms, but generally the attack comes from the result of a chemical reaction that is expansive (expands) from a type of salt, called Friedl's salt (Calcium Chloroaluminate). This salt can expand from low to medium levels. Friedl's salt is formed from the seepage of Calcium Chloride solution which enters the concrete as a result of increasing the water absorption capacity of the concrete. $MgCl_2$ from cement hydrate forms Calcium Chloride which will dissolve and then seep into the concrete as the beginning of the deterioration of the material to become softer. Mehta et al. [12] explains that the appearance of expanded ettringite (Calcium Aluminate Sulfate) is usually considered to be a sulfate attack. Ettringite and gypsum, both occupy 20% of the crystal volume of the concrete pores, so these crystals will cause stress in the concrete, which then results in cracks appearing on the surface of the concrete, and is known as a soft sulfate attack, usually the cracks originate from the formation of ettringite cracking.

The results of this research are in line with the results of the research reported by Wedhanto [5] that concrete made from the type of cement sold in building materials shops in Malang City if soaked in sea water for 7 days will increase the compressive strength quickly, but if soaked continuously for 28 days, the compressive strength will decrease. The results of research [2] reported that normal K-175 concrete treated using seawater experienced a decrease in compressive strength of 1.18% at 3 days of age, 1.05% at 7 days of age, 1.24% at 14 days of age, 1 .1% at 28 days of age. For concrete that uses seawater as a concrete mixture, the compressive strength of the concrete decreases compared to normal by 8.1% at 3 days of age and 7.24% at 7 days of age. The results of research [13] that the compressive strength of cylindrical concrete using fresh water and seawater shows that the compressive strength of concrete with fresh water is greater than that of seawater where the compressive strength of fresh water is 28.25, 31.14, 32.55 Mpa, whereas in seawater 26.89, 31.14, 31.99 Mpa. Wibowo [2] reported that normal K-175 concrete treated using seawater experienced a decrease in compressive strength of 1.18% at 3 days of age, 1.05% at 7 days of age, 1.24% at 14 days of age, and 1.1 % at 28 days of age. For concrete that uses seawater as a concrete mixture, the compressive strength of concrete decreases compared to normal concrete by 8.1% at 3 days of age and 7.24% at 7 days of age. The results of other research were reported by Nurtanto et al. [14]. In this study, different treatments were applied for the treatment process, namely using seawater and fresh water. In seawater, concrete is produced that has a greater compressive strength, namely 53.14 MPa and 54.89 MPa, while concrete in freshwater treatment produces compressive strengths of 51.55 MPa and 51.86 MPa. Furthermore, it was reported by Akbar et al. [15] that in comparing compressive strength tests of seawater concrete with fresh water, the compressive strength of concrete soaked in seawater was higher than that of concrete soaked in freshwater because it was predicted that there would be Friedel salt crystallization which occurred due to the reaction of cement with water. sea, so that Friedel's salt can fill the pores of the concrete so that the concrete becomes denser.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the results of the research and discussion, conclusions are drawn, namely as follows:

a. The compressive strength of K-300 concrete immersed in seawater (304,915 f'c) is lower than that immersed in freshwater (308,580 f'c).
b. Differences in the compressive strength of concrete occurred at the age of old concrete (21 days and 28 days) but at the age of young concrete (3, 7, and 14 days) there was no difference in the compressive strength of concrete.

4.2 Suggestion

a. It is necessary to carry out similar research by adding a larger number of samples so that the data obtained is more accurate on the differences in pressure strength that occur.
b. It is necessary to increase the soaking age of concrete to 180 days or more and try to carry out research using local aggregates (Ex Mahakam)

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rahmat, Irna Hendriyani, and Anwar MS. Compressive strength analysis of concrete using reduced water and accelerated admixture. Technical Information Journal. 2016;17(2):205-218.
2. Wibowo. The effect of sea flow on the compressive strength of K-175 quality concrete; 2013. Available:https://media.neliti.com/media/publications/262506-Influence-air-laut-terhadap-kuat-tekan-be-b610f146.pdf
3. Tomasz Gorzelańczyk, Jerzy Hoła, Łukasz Sadowski, Krzysztof Schabowicz. Evaluation of concrete homogeneity in massive structural element of hydroelectric power plant by means of non destructive impulse response method. Czech Society

for Nondestructive Testing NDE for Safety / DEFEKTOSKOPIE. Seč u Chrudimi – Czech Republic. 2012;71- 76.
4. Neville AM, Brooks JJ. Concrete technology. Longman Scientific & Technical. Longman Group UK Limited; 1987.
5. Wedhanto S. The effect of sea water on the compressive strength of concrete made from various brands of cement in Malang City. Building Journal. 2017;22 (2):21-30.
6. National Standardization Agency. SNI Decree S-04-1989-F. Building material specifications Part A (Non-metallic building materials). Bandung; 1989.
7. Mulyono T. Concrete technology. Andi Offset, Yogyakarta; 2005.
8. National Standardization Agency. SNI 03-1974-1990. Compressive strength test method. Jakarta; 1990.
9. Emmanuel AO, Oladipor FA, Olabode O. Investigation of Salinity Effect on Compressive Strength of Reinforced Concrete. Journal of Sustainable Development. Published by Canadian Center of Science and Education. 2012;5 (6):74-82.
10. Utami GP, Wedhanto S, Karyadi. The effect of mixing water type and soaking on the compressive strength behavior of sand-cement mixed mortar. Proceedings of the National Civil Engineering Seminar. Surakarta. 2016; 415-424.
11. Islam Moinul, Md et al. Strength behavior of concrete using slag with cement in sea water environment. Journal of Civil Engineering (IEB). Department of Civil Engineering, Chittagong University of Engineering and Technology, Chittagong-4349, Bangladesh. 2010;38(2):129-140.
12. Mehta PK. Durability, chapter-5, concrete structures, properties and materials, printice-hall, eaglewood cliffs, New Jersey; 1986.
13. Wahyudi J. The effect of salt water on the compressive strength of concrete with fine beach sand aggregate in seawall construction methods. Thesis, Water Civil Engineering Department, Faculty of Engineering, Muhammadiyah University of Makassar; 2018.
14. Nurtanto D, Rahayu AA, Wahyuningtyas WT. The effect of sea water and fresh water treatment on the compressive strength of self-compacting geopolymer concrete. Engineering Journal. 2021;14(1): 114-120. DOI:https://doi.org/10.21107/engineering.v14i1.8375
15. Akbar MF, Kodariah GS, Sudarsono I, Utomo EW. The Effect of Seawater Immersion on the Compressive Strength of Self-Compacting Concrete (SCC) with the Addition of Fly Ash and Visconcrete. Hexatech Engineering Scientific Journal. 2023;2(1):1-12. Available:https://jurnal.arkainstitute.co.id/index.php/hexatech/index

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/111038