Program Schedule

The 6th EPI International Conference on Science and Engineering (EICSE) 2022

AGENDA: Tuesday (October 25th) Time (GMT+8)			
08.00-08.30		Registration and Preparation	
08.30-08.50		Opening and National Anthem	
08.50–08.55	Chairman Report	Fadhil Clausthaldi S.T., B.Eng., M.Sc	
08.55-09.10	Dean's Welcome Speech	Prof. Dr. Eng. Ir. Muhammad Isran Ramli, S.T., M.T, IPM	
09.10-09.25	Rector's Opening Speech	Prof. Dr. Ir. Jamaluddin Jompa, M.Sc.	
09.25-09.55	Keynote Speaker	Ir. H. Mohammad Ramdhan Pomanto (Mayor of Makassar)	
09.55-10.00		Photo Session	
10.00-10.20	Invited Speaker 1	Dr. Wesam Al Madhoun (Dean of Graduate Studies and Research, Gaza University)	
10.20-10.30		Q&A	
10.30-10.50	Invited Speaker 2	Prof. Ts. Dr. Che Mohd Ruzaidi Bin Ghazali (Dean of Fakulti Teknologi Kejuruteraan Kelautan dan Informatik Universiti Malaysia Terengganu)	
10.50-11.00		Q&A	*Moderator*
11.00-11.20	Invited Speaker 3	Prof. Keiko Okawa (Digital Communication and Educational Environment Keio University)	
11.20-11.30		Q&A	
11.30-11.50	Invited Speaker 4	Prof. Dr.-Ing. Ir. Faizal Arya Samman (Professor in The Field of Electronics and Digital Systems, Universitas Hasanuddin)	
11.50-12.00		Q&A	
LUNCH AND BREAK (12.00-13.00)			
PARALLEL SESSION (13.00–17.00)			

The 6th EPI International Conference on Science and Engineering (EICSE2022)

"Strengthening IUG-Based Research and Digital Innovations for Supporting the Sustainability and Development Goals"

ROOM 5 – EICSE 2022

Date : October 25th, 2022 **Meeting ID : 875 5640 3433**

Location : Zoom meeting (online) **Passcode : EICSE**

No.	Time	Paper ID	Title	Author(s)
1	**13.00 - 13.15**	ID 046	Effect of Sulfate Environment on Concrete Characteristics	Fakhruddin
2	**13.15 - 13.30**	ID 054	Remote Body Temperature Monitoring System (Wireless) On Passenger Ship	M. Rahmad Nur Syam
3	**13.30 - 13.45**	ID 055	Design of Solar and Wind Energy based Hybrid Power Plant	Yusran
4	**13.45 - 14.00**	ID 057	Determine the Potential Location as Tourist Destination Development Priority in Makassar City Using Geographic Information System (GIS)	Arifuddin Akil
5	**14.00 - 14.15**	ID 062	Land Use Change Characteristic in Makassar Suburb	Isfa Sastrawati
6	**14.15 - 14.30**	ID 071	Marine Transportation System in the Islands Area in Makassar	Mafrizal
7	**14.30 - 14.45**	ID 072	Direction For Implementation Strategy Based on Evaluation of the Cities Without Slum Program in Lette Village Makassar	Mimi Arifin
8	**14.45 - 15.00**	ID 073	Self-Correction System on Mobile Robot Navigation Mechanism	Muh Anshar
15.00 - 15.30			Break Session	

No.	Time	Paper ID	Title	Author(s)
9	**15.30 - 15.45**	ID 066	Effect of blade thickness variation on bowl-shaped water wheel power	Gerard Antonini Duma
10	**15.45 - 16.00**	ID 079	Optimization Of The Function Of Public Open Space In The Area Of The Simpang Lima Gorontalo Round	Faridah
11	**16.00 - 16.15**	ID 080	The Function Of Green Open Space At The Keren Mo'odu Park Gorontalo City	Suleman Rauf
12	**16.15 - 16.30**	ID 005	Analysis of Design Temperature And Humidity in Makassar	Erwin Eka Putra
13	**16.30 - 16.45**	ID 068	Effect of Thickness of Sound Absorption of Chicken Feather Composite	Karyoso Ramadhan

Effect of Sulfate Environment on Concrete Characteristics

Fakhruddin[1, a)], Rita Irmawaty[1, b)], Herman Parung [1, c)] and Rudy Djamaluddin[1, d)]

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Abstract. Concrete is a composite material that is commonly used in various types of construction work. Concrete material is expected to be able to survive in a certain environment, without experiencing damage during its service life. Decrease in the quality of concrete can be caused by environmental factors such as the influence of weather, drastic temperature changes, abrasion, electrolytic action, attack by liquids or natural gases and industrial fumes. Meanwhile, the use of concrete in an aggressive environment greatly affects the durability and compressive strength of concrete. This study aims to evaluate the characteristics of concrete using PCC cement in a sulfuric acid environment. The test variable was concrete strength of concrete of 20 MPa (N20) and 30 MPa (N30). The specimens of a 5x5x5 cm cube were immersed in a sulfuric acid solution with a concentration of 2% and 5%. Then, the weight loss, compressive strength and abrasion resistance were tested. The results showed that N20 concrete soaked in sulfuric acid solution decreased compressive strength by 99.065% after soaking for 91 days, all specimens lost weight and increased abrasion rate. From visual observation, N30 concrete experienced greater degradation than N20 when immersed in sulfuric acid solution with the same concentration. Therefore, an analysis of the chemical composition of PCC cement with XRD was carried out, the results showed that the C_3A (Tricalcium Aluminate) content was 52.6%. The greater the C_3A content of cement can increase the growth of ettringite in concrete, causing greater damage.

INTRODUCTION

Concrete is a composite material (mixture) of several materials, the main ingredients of which consist of a mixture of cement, fine aggregate, coarse aggregate, water and or without other additives in a certain ratio. Because concrete is a composite, the quality of concrete is highly dependent on the quality of each forming material [1].

The durability of concrete is the resistance of the concrete structure in the face of conditions where the concrete is designed without deterioration during the service life of the structure. The decrease in the durability of concrete can be caused by internal factors such as alkali-aggregate reaction, volume changes due to differences in the thermal properties of the aggregate to paste, and permeability. External factors such as physical, chemical, and mechanical influences are factors that affect the durability of concrete [2].

The resistance of concrete in an acidic environment is influenced by the pore characteristics of the concrete, the ability of the cement matrix to neutralize acids and the reaction products (products) of corrosion due to acid, the type and composition of the cement, the pH value, the type of aggregate and the use of additives in the cement mixture [3]. The hydration product $Ca(OH)_2$ of concrete is more susceptible to acid because it is alkaline, thus increasing the use of cement.

Concrete that has been exposed to the sulfate environment will experience a decrease in quality and a reduction in the volume of the concrete. The acidic environment damages the concrete by breaking down $Ca(OH)_2$ in the cement paste, destroying the crystalline structure, and leaving residues that are not useful for the strength of the concrete, then causes a decrease in the compressive strength of the concrete so that the service life of the concrete structure can be reduced [4 and 5].

To overcome the continuous disposal of waste material, this study uses Portland Composite Cement (PCC) which contains 6-35% inorganic materials such as fly ash, blast furnace slag, and others. Fly ash is an industrial waste generated in thermal power plants. Several cement factories produce blended cement containing fly ash to reduce CO2

emissions in the cement clinker production process, reduce consumption of raw materials such as limestone and clay, and contribute to creating a clean environment through the use of recycled waste materials such as fly ash. The incorporation of fly ash in blended cement such as PCC provides ecological benefits and saves materials [1, 6]. Currently, PCC type cement is widely traded and easy to obtain.

Based on above explanations, the study aims to investigate the effect of sulfate environment on the properties of concrete with concrete strength of 20 and 30 MPa. The effect was analyzed based on the results of weight loss, compressive strength of concrete and resistance to abrasion after immersion in sulfuric acid solution with concentrations of 2% and 5% until the age of 91 days.

MATERIALS AND METHODS

Material

Experimental studies were carried out to evaluate the weight loss, compressive strength and resistance to abrasion after immersion in 2% and 5% sulfate solutions until the test life. Portland Composite Cement (PCC) which complies with SNI 15-7064-2004 for Indonesian cement production and is available in the market is used as a binder. XRD (X-Ray Diffraction) test was conducted to determine the chemical composition of cement.

Crushed stone with a maximum aggregate size of 20 mm and a coarseness modulus of 6.79, as well as river sand with a fineness modulus of 2.6 meet the standards of SNI 03-1968-1990 for coarse and fine aggregates. The aggregate comes from the Jeneberang river, Bili-bili. Table 1 summarises the physical properties of the aggregate.

TABLE 1. Physical characteristics of aggregates

Characteristics		Crushed Stone	River Sand
Specific gravity	Oven dry density	2.69	2.42
	Surface dry (SSD)	2.71	2.46
Water absorption %		0.45	1.63

Specimens

The test specimens were cylindrical 100x200 mm as a control test object for compressive strength. The compressive strength testing of control specimens was carried out at the age of 7, 14 and 28 days, using a Universal Testing Machine (UTM) with a capacity of 1000 kN. In addition to the cylindrical shape, a cube specimen with dimensions of 50x50x50 mm is also used. The concrete cube is the result of cutting from a concrete block measuring 50 x 100 x 400 mm. Cutting of concrete blocks is done after the concrete has cured 28 days. Table 2 shows the composition of the concrete mixture calculated by the ACI 211.1-91 method. The number of specimens for each type of test is presented in Tables 3 and 4. The specimens were cured in fresh water for 28 days, then followed by immersion in 2% and 5% acid sulfate solutions until the age of the test as shown in Figure 1.

TABLE 2. Mix concrete design (kg/m^3)

Material	N20	N30
Water	172	154
Cement	365	425
Sand	963	710
Crushed Stone	829	1051
Superplasticizer	-	3.4

TABLE 3. Compressive strength test object

Concrete strength	Curing	Number of specimens			Shape and dimension of specimens
		7 Days	14 Days	28 Days	
20 MPa (N20)	Freshwater	3	3	3	Cylinder 100 x 200 mm
30 MPa (N30)		3	3	3	
20 MPa (N20)		-	-	5	Cube 50 x 50 x 50 mm
30 MPa (N30)		-	-	5	

TABLE 4. The test object loses weight

Concrete strength	Curing	Number of specimens	Shape and dimension of specimens
20 MPa (N20)	H_2SO_4 2%	15	Cube 50 x 50 x 50 mm
	H_2SO_4 5%	15	
30 MPa (N30)	H_2SO_4 2%	15	
	H_2SO_4 5%	15	

FIGURE 1. Immersion specimens in 2% and 5% sulfuric acid (H_2SO_4)

Weight loss test

Resistance to sulfuric acid was carried out by immersing a 5x5x5 cm concrete cube (after curing in fresh water for 28 days) into sulfuric acid solution until the age of 91 days. The sulfuric acid solution used had a concentration of 2% and 5% H_2SO_4 in accordance with ASTM C267-01 (Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes). To maintain the acidity of the solution, changes were made every 7 days. Weight loss of concrete after immersion in a solution of sulfuric acid (H_2SO_4) indicates resistance to sulfate. Weight measurements were carried out every 7 days until the age of 91 days using a scale with an accuracy of 0.01 gr.

Compressive strength test

According to SNI 1974-2011, the compressive strength test is the application of an axial load to the concrete test object at a loading rate that is within the specified limit until destruction occurs. The compressive strength of the test object is calculated by the using Equation (1).

$$f'c = \frac{P}{A} \tag{1}$$

where *f'c* is compressive strength of concrete, *P* is axial compressive force and A is cross-sectional area of specimens.

Abrasion resistance test

Abrasion resistance test based on EN 1097-2:2007 specification using 8 concrete cubes with dimensions of 5x5x5 cm rotated together with 8 steel balls with a Los Angeles abrasion machine. The machine is rotated for 1000 revolutions where every 100 revolutions a weighing is carried out on changes in the weight of the test object. To calculate the percentage of weight loss from the concrete from the abrasion test, the Equation (2) is used.

$$\text{Abrasion} = \frac{w_1 - w_0}{w_0} \text{ x } 100\% \tag{2}$$

where w_0 = weight before testing (gr), w_1 =weight after testing (gr)

RESULT AND DISCUSION

PCC Cement chemical composition

The chemical composition of PCC cement was determined through XRD (X-Ray Diffraction) testing. The results of the XRD analysis show that the content of C3A (Tricalcium Aluminate) was 52.6%, as presented in Tand Figure 2 and Table 5. The greater the C_3A content, the growth of etteringite in the concrete increases, causing greater damage.

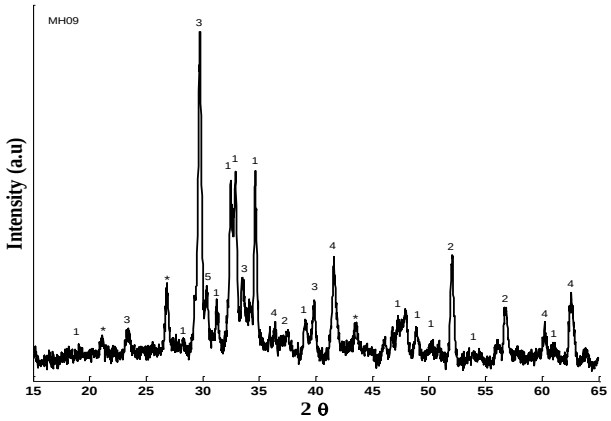

FIGURE 2. XRD Test Results

TABE 5. Chemical composition of cement analyzed by XRD

Composition (%)	Compound Name	Chemical Notation
52.6	*Grossite*	$Ca_3 Al_2 O_6$
28.3	*Corundum*	$Al_2 O_3$
9.6	*Cristobalite*	$O_2 Si$
6.7	*Periclase*	Mg O
2.7	*Maghemite*	$Fe_2 O_3$

Compressive strength

This test uses 18 samples of 10 cm x 20 cm concrete cylinder specimens with a test age of 7, 14, 28 days for N20 and N30 concrete. Table 6 shows the results of the compressive strength of the concrete cylinder according to the target.

TABLE 6. Compressive strength of concrete cylinder

Age (days)	N20 (MPa)	N30 (MPa)
7	12.133	19.735
	12.023	18.665
	14.230	18.472
14	18.330	27.453
	20.170	26.784
	20.028	26.856
28	20.700	29.231
	20.991	29.358
	21.022	29.143

Visual conditions

Visually, the concrete cubes N20 and N30 show a significant change in shape due to sulfuric acid attack. Changes in shape are strongly influenced by the concentration of acidity of the solution. Figures 3 and 4 show the changes in the shape of the N20 specimens immersed in a solution of 2% and 5% sulfuric acid (H_2SO_4) at the age of 0 days (before immersion in sulfuric acid solution), 7,14, 28, 56, and 91 days. Damage occurs less in solutions with lower concentrations. N20 concrete soaked in 2% H_2SO_4 solution can last up to 91 days compared to N20 concrete in 5% H_2SO_4 solution which only lasts up to 42 days.

0 days 7 days 14 days

28 days 56 days 91 days

FIGURE 3. Visual condition of N20 concrete after soaking in 2% sulfuric acid (H_2SO_4)

0 days 7 days 14 days 56 days 77 days

FIGURE 4. Visual condition of N20 concrete after soaking in 5% sulfuric acid (H_2SO_4)

Figures 5 and 6 show the damage to N30 concrete due to attack by sulfuric acid (H_2SO_4) with concentrations of 2% and 5%. The higher the concentration of the solution, the greater the damage that occurs. At a concentration of 2% H_2SO_4 solution, N30 concrete can last up to 77 days, while at a concentration of 5% H2SO4 concrete can only last up to 35 days. The results of visual observations also show a greater level of concrete damage in concrete with more cement content at the same solution concentration.

0 days 7 days 14 days 56 days 77 days

FIGURE 5. Visual condition of N30 concrete after soaking in 2% sulfuric acid (H_2SO_4)

0 days 7 days 14 days 35 days

FIGURE 6. Visual condition of N30 concrete after soaking in 5% sulfuric acid (H_2SO_4)

Weight lost

Weight loss data was obtained from an average of 15 specimens in each variation of the immersion as presented in Tables 7 and 8. The test was carried out every 7 days until the age of 91 days. N20 concrete specimens immersed in a 2% H_2SO_4 solution experienced an increase in weight of 1.58% after being soaked for 7 days, but when they reached the age of 14 days, the concrete began to experience damage due to the sulfuric acid reaction until the age of 91 days. Total weight loss is 61.19% in N20 concrete.

For concrete specimens N30 immersed in a solution of 2% H_2SO_4 began to experience damage due to sulfuric acid reaction at the age of 7 days and a weight loss of 0.08% occurred. For N30, the weight measurement is only up to the age of 77 days because the test object is considered to have reached the maximum damage condition with a total weight loss of 78.16% of the initial weight.

TABLE 7. Weight loss test results due to a solution of 2% H_2SO_4 (gr)

Test Object	Immersion Age (Days)					
	0	**7**	**14**	**28**	**56**	**91**
N20	265.67	269.87	268.05	261.03	209.99	103.09
N30	263.47	263.27	245.72	223.27	118.51	57.53*

TABLE 8. Weight loss test results due to 5% H_2SO_4 solution (gr)

Test Object	Immersion Age (Days)					
	0	**7**	**14**	**28**	**35**	**42**
N20	264.07	247.78	218.53	137.77	112.23	78.58
N30	265.67	222.94	175.33	78.39	42.55	-

N20 concrete decreased in weight due to the reaction of sulfuric acid by 6.2% after 7 days of immersion in 5% H_2SO_4 solution and increased by 70.2% at the end of the test, namely at the age of 42 days. Meanwhile, N30 concrete experienced a weight loss of 16.1% after being immersed in a 5% H_2SO_4 solution for 7 days and reached a weight loss of 84.0% at the age of 35 days.

The weight loss of N20 and N30 concrete after being immersed in a solution of 2% and 5% H_2SO_4 is shown in Figure 7. N30 concrete experienced a faster weight loss than N20 concrete, where the paste component was more easily removed.

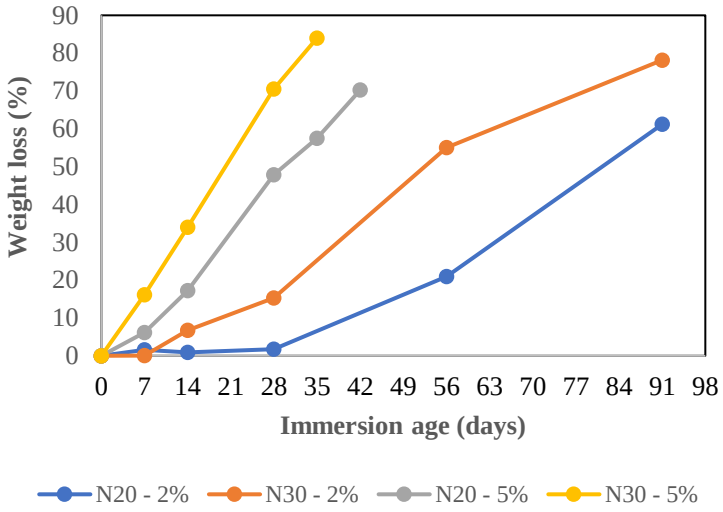

FIGURE 7. Weight loss (%) of concrete after soaking in a solution of 2% and 5% sulfuric acid (H_2SO_4)

Abrasion resistance

Abrasion testing is used to measure the abrasion resistance of concrete before and after it has been treated with sulfuric acid solution. The cumulative weight of eight test objects is used to calculate the percentage value of weight reduction in this test. Figure 8 shows the abrasion value of concrete cubes N20 and N30 in a normal environment (before immersion in sulfuric acid solution). The comparison of abrasion of N20 concrete cubes before and after being immersed in a 2% H_2SO_4 solution is shown in Figure 9. The test was stopped at the 700 rounds because only 4 concrete cubes were left out of a total of 8 concrete cubes. It can be seen in Figure 9 that the percentage of concrete abrasion increases in a sulfuric acid environment. The value of abrasion on the concrete indicates a decrease in the quality and level of resistance of the concrete to a low sulfuric acid environment.

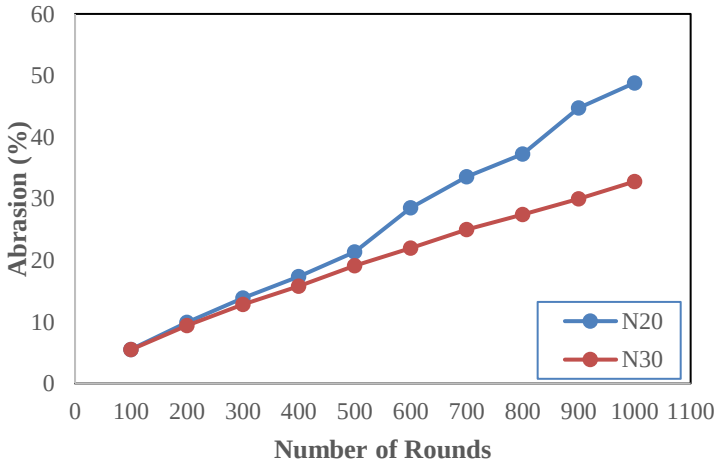

FIGURE 8. Abrasion resistance of concrete cubes N20 and N30 before being immersed in a solution of sulfuric acid (H_2SO_4)

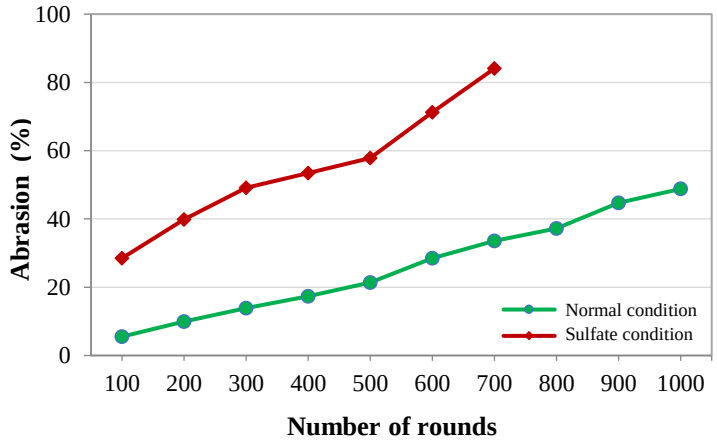

FIGURE 9. Abrasion resistance of N20 concrete cubes before and after immersion in a 2% H_2SO_4 solution

Compressive strength after soaking in sulfuric acid solution

This test was conducted to determine the change in the value of the compressive strength of concrete before and after reacting with sulfuric acid during the immersion period. The test object used was a concrete cube N20 with dimensions of 5x5x5 cm, 28 days of normal curing and after immersion in a 2% H_2SO_4 solution for 91 days. The compressive strength value is the average value of 5 test objects.

Figure 10 shows the decrease in strength of a concrete cube after reacting to a 2% H_2SO_4 solution. The compressive strength of concrete cube N20 had a compressive strength of 37.08 MPa before being immersed in sulfuric acid solution and decreased by 99.07% after immersion for 91 days.

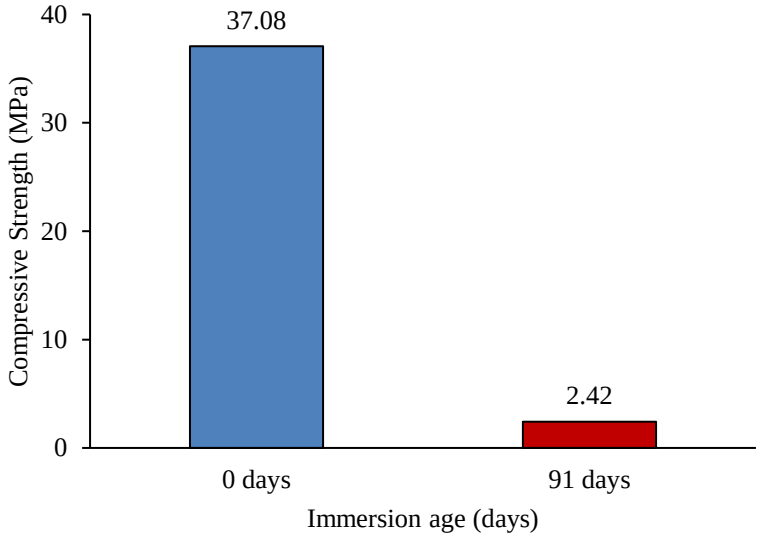

FIGURE 10. Compressive strength before and after immersion in a 2% H_2SO_4 solution in 20 MPa concrete (N20).

The decrease in the compressive strength of the concrete cube is influenced by changes in the dimensions and shape of the specimen after being immersed in sulfuric acid solution, which is one of the factors that determine the value of the compressive strength of the concrete. Changes in shape occur due to the reaction of sulfuric acid on the concrete. Sulfate attack causes swelling of the volume resulting in cracks and damage that makes the cement detached and reduces the durability and quality of the concrete.

CONCLUSIONS

The compressive strength of concrete cubes N20 decreased by an average of 99.07% after being immersed in a solution of 2% sulfuric acid (H_2SO_4) for 91 days, while the abrasion value increased which indicated a decrease in quality and resistance to abrasion. In addition, N20 concrete cubes immersed in a 2% H_2SO_4 solution for 91 days experienced an average weight loss of 61.19% and 70.2% in a 5% H2SO4 solution with a test life of 42 days. Meanwhile, for N30 concrete cubes immersed in a 2% H_2SO_4 solution for 77 days experienced an average weight loss of 78.16% and 84.0% in a 5% H_2SO_4 solution with a test life of 35 days. From the visuals, concrete cubes that have been soaked in sulfuric acid (H_2SO_4) solution with a concentration of 2% and 5%, experienced greater damage at high solution concentrations. N30 concrete cubes suffered greater damage than N20 concrete cubes even though they were immersed in a solution with the same concentration. Finally, the use of PCC cement in a sulfate environment accelerates the deterioration of concrete due to the large content of C_3A (Tricalcium Aluminate) so that the growth of ettringite in concrete increases.

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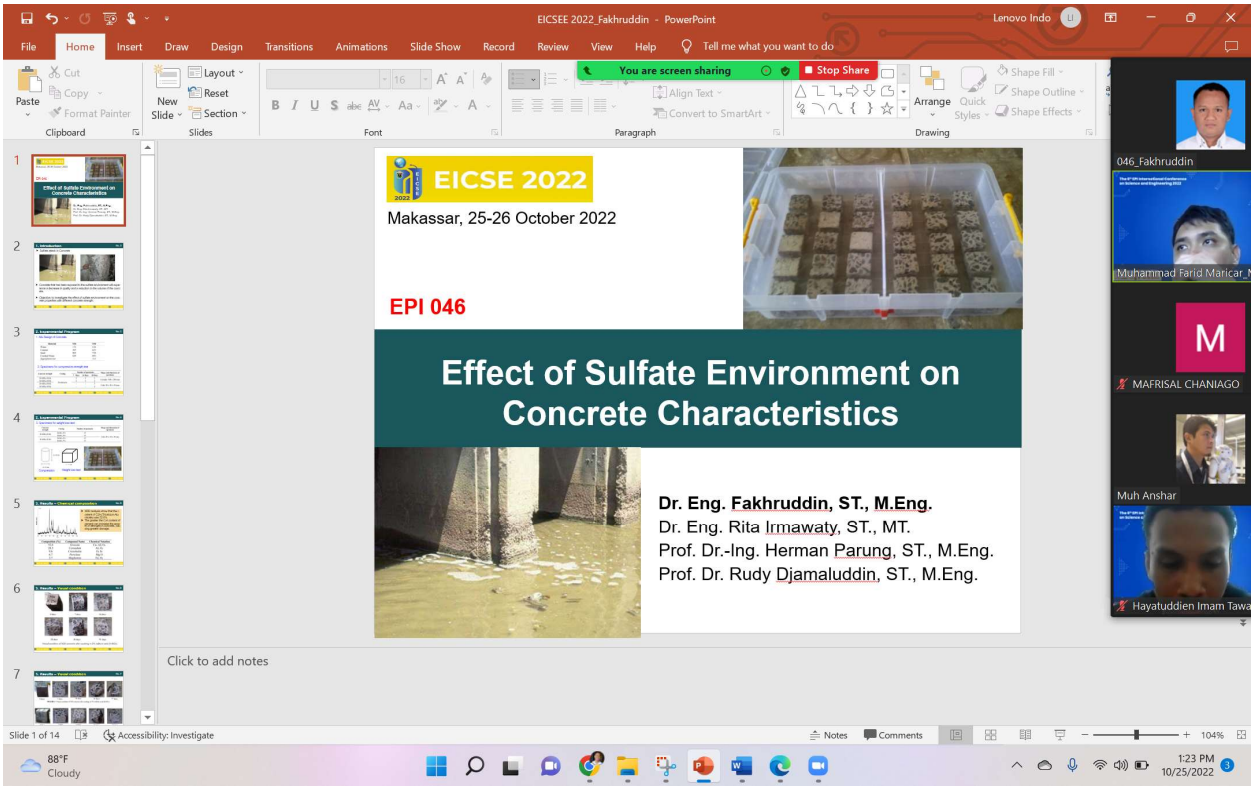
REFERENCES

1. ACI 211.1-91, *Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete* (1991).
2. S. Antiohos and S. Tsimas, Investigating the Role of Reactive Silica in the Hydration Mechanisms of High-Calcium Fly Ash/Cement Systems. Cement and Concrete Campsites **27(2)**, 171-181 (2005).
3. O. Cizer et al., *Microstructural Changes in Self-Compacting Concrete By-Sulphuric Acid Attack-2011*, Proceeding of the 13th ICCC International Congress on the Chemistry of Cement, pp. 1-7.
4. F. P. Torgal and J. Said, Resistance to Acid Attack, abrasion and leaching behavior of alkali-activated mine waste binders (2010).
5. A. M. Neville and J. J. Brooks, *Concrete Technology: 4th Edition* (New York: Longman Scientific & Technical, 2005).
6. A. M. Neville, *Properties of Concrete* (Prentice Hall, 1995).
7. P. Nugraha and Antoni, Translated by Nugraha. *Concrete Technology* (Yogyakarta: Andi Offset, 2007)
8. Skalny, J, et al., *Sulphate Attack on Concrete* (London and New York: Sponge Press, 2002).
9. Indonesian National Standard 1974-2011, *Method of Testing the Compressive Strength of Concrete with Cylindrical Test Objects* (National Standardization Body, 2011)
10. Indonesian National Standard 7064-2014, *Composite Portland Cement* (National Standardization Body, 2014).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