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ANALYSIS OF CORROSION RATE FOR STEEL CONCRETE REINFORCING PDA REINFORCED CONCRETE IN SEA WATER MEDIA

Helmy Alian*, Yoga Andresman
[1]Department of Mechanical Engineering, Sriwijaya University

ABSTRACT

There is so many buildings that built in corrosive environment, which is because lack of terrain or the functions of the buildings themselves. Many of the buildings use steel as reinforcement to strengthen the construction. The strength of buildings will Decrease if the reinforcing steel is corroded because the steel is very easily corroded. This research is to analyze kind of corrosion, corrosion rate of the steel frame in sea water or salty water. Plain reinforcing steel is used in this research with three different brands as specimens to compare the corrosion rate in sea water medium. Observation results show that the kind of corrosion that occurs in three different kinds of the steel is uniform corrosion. Calculation of corrosion rate in this research shows weight loss method. Calculation result of corrosion rate show that A steel brand has the highest endurance Compared to B and C brand. Difference of corrosion rate is because of chemical composition, Also in each kind of steel is added many elements such as chrome, manganese, copper and nickel to increase of corrosion endurance. Difference of elements that added in steel is Affect the corrosion endurance. Base on the research result can be concluded that corrosion endurance in every brand of stainless still in excellent category because the value of corrosion rate is between 0.02 to 0.01 mm / yr.

Keywords: corrosion, corrosion rate, reinforcing steel, reinforced concrete

1. INTRODUCTION

As the development of science and technology and human needs are increasingly complex, the need for physical facilities and infrastructures humans also evolved. Physical infrastructure can be either, buildings, houses, bridges, roads, docks, and so on. These buildings using steel reinforcement to strengthen its construction. Concrete reinforcing steel is shaped steel rod round used for concrete reinforcement, which is produced from raw materials billet by hot rolling process (SNI 07-2052-2002).

Generally, we find buildings built in areas with corrosive surroundings because according to the function of each building itself. In a certain period of time, reinforcing steel in concrete will undergo corrosion. Corrosion on concrete reinforcing steel will cause decreasing force construction on the building, due to reduced mechanical properties of concrete reinforcing steel.

Corrosion is defined as a process of destruction of the metal, where metals will be in a degraded(degradation)as it reacts with the environment either chemically or electrochemically on the time of use. Corrosion an environment of metals in an electrolyte (water) is an electrochemical process, (Chodijah, 2008). Corrosion as an electrochemical reaction that contributes to physical damage of a material significantly, therefore need to be considered to prevent and minimize losses incurred due to corrosion effects. Factors that influence the corrosion can be divided into two, namely the factor derived from the material itself and the factors of the environment. Factors of materials include purity of materials, structural materials, crystalline form, material mixing techniques, and so on. From environmental factors include air pollution levels, temperature, humidity, the presence of corrosive chemicals, and so on. According to SNI 03-2834-2002, concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water with or without the added material to form

*Corresponding author's email: helmyalian@yahoo.co.id

a solid mass. Fine aggregate was natural sand as a result of the natural disintegration of rock or in the form of crushed stone obtained from rock breaking industry has the largest grain size of 5.0 mm. Coarse aggregate is gravel as a result of the natural disintegration of rock or in the form of crushed stone obtained from stone-crushing industry and has a grain size of 5 mm - 40 mm. The main properties of concrete, which is very strong against compressive loads, but also is brittle / brittle against tensile loads. In the calculation of the structure, tensile strength of concrete is usually ignored. According to SNI 03- 2847-2002, reinforced concrete is concrete that reinforce with an area and the amount of reinforcement that is not less than the minimum value in otherwise require with or without pre-stressing, and planned based on the assumption that the two materials are cooperating in bearing styles. Concrete alkaline because they contain calcium, sodium oxide and potassium oxide in high concentrations. Concrete alkaline conditions cause the formation of a passive layer on the steel reinforcement surface. In macro concrete is seen as a strong and solid structure, but if the observed micro-concrete is a porous structure with a small diameter. The pores in the concrete called capillary pores. The pores in the concrete still allows water and ions aggressive to get into the concrete and causing corrosion of steel reinforcement inside. The process of corrosion of steel reinforcement in concrete is shown in Figure 1.

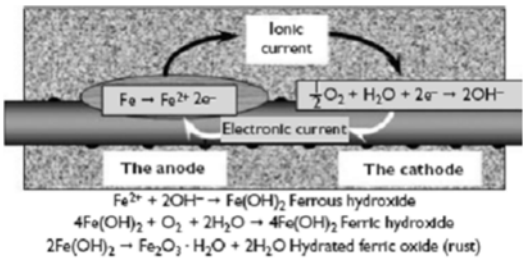

Figure 1. Mechanism of corrosion in steel concrete reinforcing (Broomfield, 2007)

Steel reinforcement has no smooth surface due to the composition of the imperfect, also due to differences in surface tension that is causing the potential in certain areas is higher than other areas. The corrosion of reinforcing steel due to the reaction between the elements iron (Fe) in the steel reinforcement and hydroxyl ion (OH-)of water. Penetration agersif ions such as chloride (Cl-)which diffuses into the concrete to the surface of the reinforcing steel causes damage to the passive layer of reinforcing steel. Steel surface passive layer is lost, becomes the anode reaction of corrosion of reinforcing steel. The sea water is water from sea or ocean. Sea water has a salinity average of 3.5%. This means that in 1liter(1000 mL) of sea water there are 35 grams of salts (mostly, but not entirely, salt / NaCl). Sea water has a salinity because the earth is filled with mineral salts contained in rocks and soil. If the river flows into the sea, bringing salt water. Sea waves hitting the beach also can produce the salt contained in rocks. Gradually the sea became salty because many contain salt. There are several factors that corrosive sea water, sea water is an environment containing chloride levels are high enough. This environment is highly corrosive environments the steel and alloy steel.
There are several kinds of methods to calculate the rate korosi. Calculation of corrosion rate by using the method of weight loss is done by calculating the weight change that occurs in the material during a material applied to a corrosive environment. Calculation of corrosion rate with the method of weight loss is calculated using the equation below (Callister, 2010):

$$\text{Corrosion rate} = (K \times W)/(D \times A \times T) \quad (1)$$

Where:
K = constant (see Table 2.9)
W = weight lost during the experiment (g)
D = density of the material (g / cm^3)
A = surface area corroded (cm^2)
T = length of time of exposure (hours)

Rated K on the calculation of the corrosion rate adjusted to units used. Different grades K will provide a different unit in corrosion rate is calculated.

Table 1. relations unit corrosion rate accordance with K value according to ASTM G1-03

Corrosion Rate Unit Desired	*Constant (K) in Corrosion Rate Equation*
mils per year (mpy)	3.45×10^6
inches per year (ipy)	3.45×10^3
inches per month (ipm)	2.87×10^2
millimeters per year (mm/y)	8.76×10^4
micrometres per year (ηm/y)	8.76×10^7
picometres per second (pm/s)	2.78×10^6
grams per square meter per hour (g/m².h)	$1.00 \times 10^4 \times D$
milligrams per square decimeter per day (mdd)	$2.40 \times 10^6 \times D$
micrograms per square meter per second (ng/m².s)	$2.78 \times 10^6 \times D$

Any material exposed to the corrosive environment will result in corrosion rates differ depending on the corrosion resistance of the material. The corrosion rate of materials can be used to determine and classify the resistance of this material on the environment in which the material is applied

Table 2. Endurance Material Based Corrosion rate (Jones, 1992)

Relative Corrosion Resistance	mpy	mm/yr	µm/yr	nm/h	pm/s
Outstanding	< 1	< 0.02	< 25	< 2	< 1
Excellent	1 – 5	0.02 – 0.1	25 – 100	2 – 10	1 – 5
Good	5 – 20	0.1 – 0.5	100 – 500	10 – 50	20 – 50
Fair	20 – 50	0.5 – 1	500 – 1000	50 – 150	20 – 50
Poor	50 – 200	1 – 5	1000 – 5000	150 – 500	50 – 200
Unacceptable	200+	5+	5000+	500+	200+

2. METHODOLOGY/ EXPERIMENTAL

The procedures in this study were as follows:

1. Sample Preparation
The specimens used in this study is the Reinforcing Steel Plain cylindrical diameter of 10 mm and a height of 100 mm is cast with three types of brand production in the concrete.

a.Test composition of
The three types ofthese specimens tested each composition, the testing is done in PT.Pusri using a composition test Niton XL2 XRFAnalyzer.

b.Cutting the specimen
For this test a cylindrical test specimen diameter of 10 mm was cut as many as 6 units with a height of 100 mm. With the provision of 6 pieces of reinforcing steel specimens plain brand A, 6 pieces of specimens BJA reinforcing the brand B, and 6 pieces of reinforcing steel specimens plain brands for testing C in sea water media.

c. Cleaning surface of the
After the cut specimen, the test specimen entire surface to be cleaned of dirt and rust that formed before testing is done. Once the size of the specimen is obtained, then the next specimen respectively sanded with grit sizes 100, 200, 400, 600, 800,1000, 1500.

d. Beginning the Weighing Of
Before reinforcing steel beams cast in concrete, reinforcing steel in advance of heavy weighed initially by using digital scales.

2. Manufacturing of reinforced concrete
test specimen casted in concrete cylinders with a size of 40 mm thick concrete cover. For reinforced concrete composition of the mixture is 1: 2: 3 (cement: fine aggregate: coarse aggregate). The cement used is Portland cement type 1. In these test samples of concrete made amounting to 18 pieces with a height of 10 cm and a diameter of 9 cm.

3. Immersion of samples in solution
Prepare a container filled artificial seawater, and then enter the test samples of concrete containing steel brand A in the first container. In a second bowl, insert test samples of concrete blocks that contain plain steel bars for the brand B. In the third container, insert test samples of concrete containing steel reinforcing plain brand C. Soak for 1 080 hours (45 days).

4. After 1080 hours (45 days) lift the three types of concrete samples, solve concrete samples by using a hammer and chisel concrete then download the reinforcing steel in it.

5. Make a visual observation on steel bars, rebars and photo analysis of corrosion that occurs then wash and dry.

6. Weigh the end of rebars after the specimen is cleaned of corrosion products.
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3. RESULTS AND DISCUSSION

Specimens used in this study consists of three types brands of concrete reinforcing steelare brands A, B, and C. The results of the testing material composition included in Table 3 as follows:

Table 3 The chemical composition of the material in weight%

Brand	Element compositions (%)					
	Fe	C	Cr	Mn	Cu	Ni
A	98,570	0.160	0.190	0.837	0.391	0.020
B	99,064	0.183	0.176	0.379	0.231	0.016
C	99,045	0.191	0.138	0.408	0.142	0.019

Graph comparison of test results the chemical composition of the three brands of reinforcing steel in the show in Figure 4;

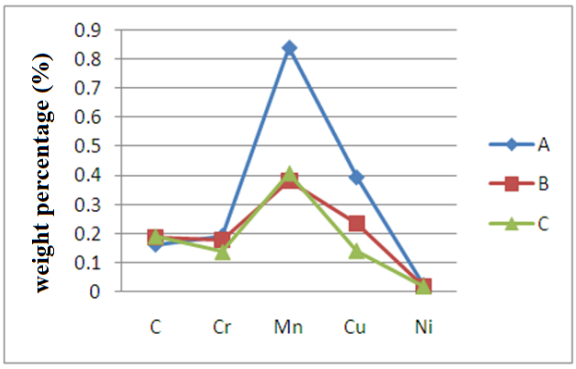

Figure 4. Chart comparison of the test chemical composition three brands reinforcing

Visual observations done in two ways: directly visible to the naked eye and photographed using a digital camera. The specimen is immersed in sea water media with the addition of 2% H2SO4 and 4% H2SO4 each 3 pieces for each media immersion. The addition of H2SO4 on media immersion in the study of sea water, aiming to speed up the process of the corrosion of the concrete specimen in

Figure 5. Reinforcing Steel Brand A After 45 Days Immersion In Media Seawater With Addition of 2% H2SO4

Figure 6. Reinforcing steel brand b after 45 days immersion in media seawater with addition of 2% H2SO4

Figure 7. Reinforcing Steel Brand C After 45 days immersion of Sea water in Media With Addition of 2% H2SO4

Figure 8. Reinforcing steel brand a after 45 days immersion in media seawater with addition of 4% H2SO4

Figure 9. Reinforcing Steel Brand B After 45 Days Immersion In Media Seawater With Addition of 4% H2SO4

Figure 10. Reinforcing Steel Brand C After 45 days Immersion of Sea Water In Media With Addition of 4% H2SO4

After calculating the corrosion rate of the three brands of steel reinforcement, then obtained a graph of brand reinforcement steel against corrosion rate shown in Figure 11.

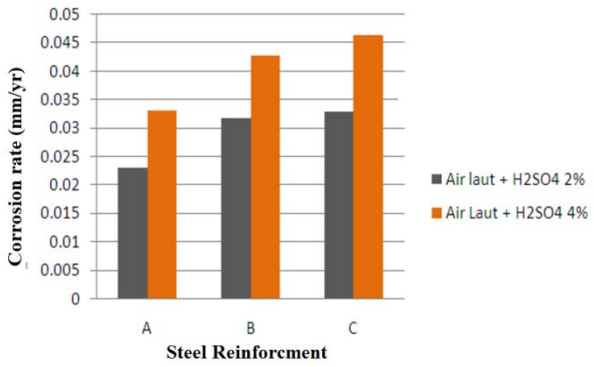

Figure 11. Brand steel reinforcement vs rate of corrosion in media immersion seawater with addition of 2% H2SO4 and 4% H2SO4

Value rate of corrosion of reinforcing steel brands A, B, and C which have been casted in the concrete and immersed in media sea water with the addition of 2% sulfuric acid in the amount of 0.02289 mm / yr, 0.03160 mm / yr, and 0.03285 mm / yr. The rate of corrosion of reinforcing steel value brands A, B, and C which have been casted in the concrete and soaked in sea water media with the addition of 4% sulfuric acid in the amount of 0.03292 mm / yr, 0.04262 mm / yr, and 0.04661 mm / yr.

4. CONCLUSION

Based on the data obtained from the testing of corrosion that has been done on the three brands of concrete reinforcing steel, it can be concluded as follows:

1. type of corrosion that occurs in all three brands of reinforcing steel is corroding evenly(uniform corrosion).
2. There are two factors that cause corrosion of reinforcing steel that is, the chemical composition of steel reinforcement and media immersion in this study using artificial sea water with the addition of sulfuric acid.
3. Reinforcement steel brand Ahas the best corrosion resistance when compared with steel reinforcement brands B and C.
4. The corrosion rate is highest in the steel reinforcement in brand C, where the reinforcing steel in concrete casted and soaked in sea water media with the addition of 4% sulfuric acid with the value of the corrosion rate of 0.04661 mm / yr.
5. Based on calculations of data rate of corrosion, corrosion resistance of reinforcing steel have all three brands into the category excellent for corrosion rate is still around 0.02 to 0.1 mm / yr.

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