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Bonding Capacity of Deform Bar in Sea Water Concrete

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ABSTRACT

The seawater contains about 35,000 ppm is dissolved salt which can increase the risk of corrosion in steel reinforcement embedded in concrete. This study aims to determine the value of bond strength of seawater concrete with steel reinforcement. This research uses experimental test method in laboratory which includes compressive strength test, concrete split tensile strength test, tensile strength of deform bar, pull out test and visual observation of carbonation test. The specimens in this study was made in 3 different types of curing, i.e. wet curing, dry curing and wet-dry curing. The result of the research obtain the compressive strength for 28 days for dry curing is 17.15 MPa, while for wet curing and dry-wet curing about 16.895 MPa and 19.367 MPa, respectively. The split tensile strength of concrete after 28 days for dry curing, wet curing, and dry-wet curing are 7.55 MPa, 8.85 MPa and 7.55 MP, respectively. The bond strength specimen for 28 days in dry curing was 5.46 MPa, whereas specimen in the wet curing and dry wet curing showed bond strength about 5.94 MPa and 4.90 MPa, respectively. Based on the result, compressive strength in wet-dry curing showed higher value than others curing types, while specimen in wet curing presented the value of split tensile strength and bond strength higher than dry curing and wet-dry curing.

Keywords: Bond strength, reinforced concrete, seawater concrete.

1. INTRODUCTION

In the present phenomenon, the requirement of fresh water in daily life is increasing but the potential of water source is constant so that clean water only for the primary needs only, so it is necessary to think about alternative water usage for concrete construction work. The research that aims to find out the bond strength of the reinforcement and concrete using seawater and sea sand as its constituent material.

The concrete is essentially a two-part mixture of aggregates and pastes. The paste consists of Portland cement and water, which binds aggregate (sand and gravel / crushed stone) into a mass like rock, then the paste hardened by the chemical reaction between cement and water [1]. Concrete is a material that is widely used and become the main

element in the building. The amount of concrete use in a construction requires the creation of good quality. This is because the concrete has several advantages, among others, easily shaped as needed, easy to work on and to maintain, strong resist compressive force, and resistant to fire and corrosion [2]. In addition, concrete also has shortcomings mainly due to its brittle and unable to withstand tensile. To withstand tensile strength, the concrete is reinforced by the steel so that it becomes reinforced concrete.

One of the basic assumptions that used in the design and analysis of reinforced concrete structures is that the bond between the steel and the concrete surrounding it goes perfectly without slipping or shifting. Based on these assumptions and also as a further result, when the reinforced concrete component works to withstand the burden there will be a sticky stress on the tangent surface between the reinforcement bar and the concrete [3]. Strong adhesion is a combination of the ability of reinforcing steel and concrete those cover it in resisting forces which can lead to loose the adhesions between the reinforcement bar and the concrete [4].

The strength of the adhesion is the result of several parameters, which include the adhesion between the concrete and the steel reinforcing surface [5]. Cooperation between reinforcing steel and concrete can be realized with the perfect attachment between steel reinforcement with hard concrete that covers steel reinforcement. Threaded reinforcing steel is preferably used as a concrete reinforcement bar. One of the objectives of this provision is that the reinforced concrete structures have reliability against the effects of the earthquake, because among others there is a better adhesion between the concrete and its reinforcement [6].

A structure can be collapse due to lack of adhesive between reinforcement with concrete, hence it is necessary to note the strong of adhesion between the concrete and steel reinforcement in order to obtain a better balance of it. The Pull Out experiment can provide a good distinction between the adhesive efficiency of different types of reinforcing surfaces and the length of embedment length, but the results have not yet given the actual adhesive stress on the frame structure. In this experiment the concrete is pressed and the steel is pulled, where the concrete and steel around it will have the same stress [7]. This study aims to examine the strength of concrete adhesion and steel reinforcement in order to obtain a balance of force between steel reinforcement and concrete.

2. METHODOLOGY

The research is experimental test and literature study about the adhesive force that occurs between reinforcement and concrete using a mixture of seawater, sea sand, and composite cement. The test specimens in this

study were made with 3 different types of curing treatments, which were wet curing (soaked in the sea water), dry curing (room temperature), and curing wet-dry. The study was conducted at the time of the test object was 3 days, 7 days, 28 days, and 90 days.

The test specimens used were cylinders with diameter 15cm and height 30cm. Based on the type of test, the number of cylinders for each trial is 33 pieces according to the curing type and the different age variations. Each variation was made by 3 samples, total 33 test pieces for concrete compressive test, 33 pieces for concrete tensile strength test, and 33 pieces for pull-out testing method, bringing total cylinder 99 pieces. This research was conducted in structural and material laboratory of civil department, Faculty of Engineering, Hasanuddin University. This research was conducted for approximately 5 months.

The value of concrete compressive strength was obtained from standard testing with commonly used which is cylindrical test specimens. The test procedure used was the ASTM C39-86 standard. Tensile strength testing was used to evaluate shear resistance of structural components. This test was in accordance with ASTM C 496. The Pull out test is performed by UTM (Universal Testing Machine) to obtain load data. The total slip that occurred on the specimen is measured from the relative displacement of the reinforcement against the surface area of the specimen by using a Linear Variable Displacement Transducer (LVDT) with a capacity of 50 mm.

3. RESEARCH RESULT

A. Material Characteristics

The material used in this research consisted of natural aggregate that was delicate aggregate (sand) originated from Barombong Beach and rough aggregate (crushed stone) originated from Bili-Bili, Gowa. Table 1 has shown the results testing of materials which included filter analysis, modulus of fineness, specific gravity, water absorption, water content, moisture content, mud content, organic content, and material wear. Testing was done according to ASTM standard (American Society for Testing Material).

Table 1. Result of Material Inspection (Sand Sea) Barombong Beach

NO	AGREGAT CHARACTERISTIC	OBSERVATION RESULT
1	Filter analysis	Gradation 1
2	Modulus of Smoothness	2.27
3	Specific gravity	
	a. BJ. Real	2.6
	b. BJ. Dry base	2.45
	c. BJ. Dry Surface	2.51
4	Water absorption	1.98%
5	Weight volume	
	a. Conditions off	1.71
	b. Solid condition	1.76
6	Water content	4.91%
7	Mud content	2.20%
8	Organic Content	No. 1

Source: Laboratory Structure and Materials Department of Civil Faculty of Engineering Hasanuddin University

B. Seawater characteristics

The seawater used in this study was taken from Barombong Beach, Kab. Gowa, which was then researched in the Oceanography Laboratory Faculty of Marine Science and Fisheries Unhas. Table 2 has shown the specific gravity, pH, salinity, and

major chemical composition of seawater. The results obtained were the density of seawater of 1.029 gr / cm3, pH of 8.53, salinity level 18 and contained chemical content of chloride (Cl), sodium (Na). Magnesium (Mg), Sulfate (SO_4).

Table 2. Chemical Composition of Sea Water of Barombong Beach

Specific gravity (gr/cm^3)	**pH**	**Salinity (‰)**	**Chemical composition (mg/L)**					
			Na	Ca	Mg	Cl^-	SO_4	CO_3
1,029	8,53	18	2085,22	348,348	1973,492	5303,70	134	576,576

Source: Oceanography Laboratory Faculty of Marine and Fishery Sciences Hasanuddin University

C. Analysis of Compressive strengths

Fig 1 has shown a percentage of compressive strengths of concrete to curing variations. The value of 28 days concrete compressive strength test obtained was to curing room temperature 17,155 MPa, curing soaked 16,895 MPa and curing wet-dry 19,367 MPa. While the compressive strengths at the age of 90 days in the results obtained, curing room temperature 16.155 MPa, curing soak 16.663 MPa and curing wet-dry 19,182 MPa. From the results of the diagram it can be seen that the method of soaking using wet-dry curing was better than two other variations of immersion. This result was due to the effect on the compaction and on the concrete treatment process.

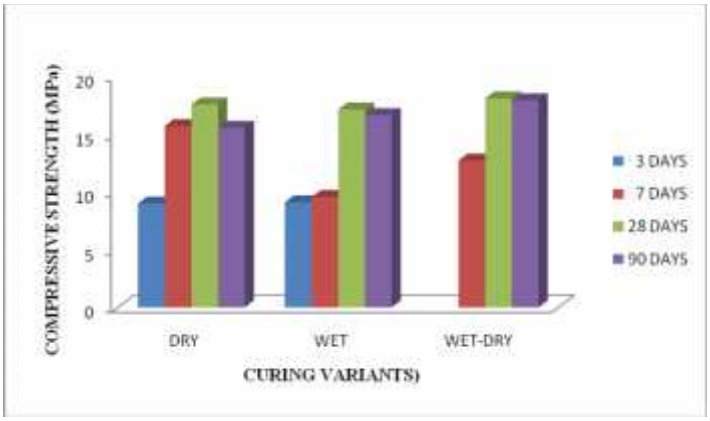

Fig 1. Percentage Chart of Concrete Compressive Strength on Curing Variation

D. Analysis of tensile strengths

Fig 2 has shown the comparative tensile strength ratio of concrete to curing variations. The test value of tensile strength of concrete At 28 days age obtained curing room temperature of 7.55 MPa, curing soak 8.85 MPa and wet-dry curing 7,55 MPa. While Strong pull at age 90 Days obtained

curing room temperature 8,29 MPa, curing soak 9,72 MPa, and Curing Wet Dry 7,94 MPa. The results of the diagram can be seen that the value of tensile strength of concrete with soaking method of curing wet sea water (wet) was greater than the tensile strength of concrete with curing room temperature and wet curing dry.

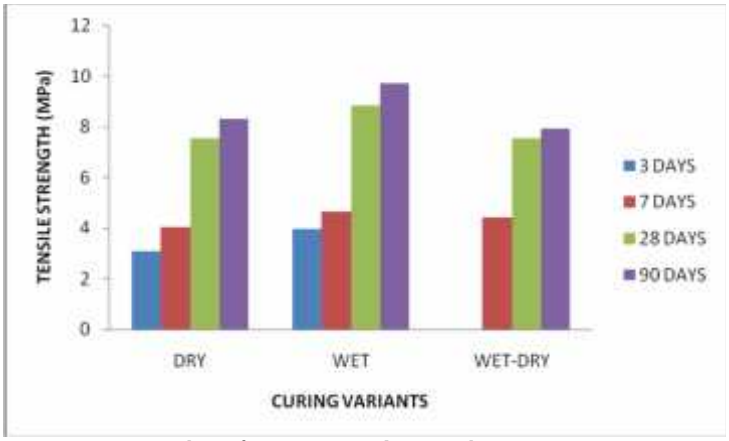

Fig 2. Comparison Chart of Concrete Tensile Strength on Curing Variation

E. Analysis of adhesive streghts

Fig 3 has shown the Bond Strength Percentage Chart Against the Immersion Variation (Curing). This Figure explained the strong relation of adhesion to the treatment and to the age of the concrete in accordance with curing variations that have been determined. The test value of strong concrete adhesive At 28 days age obtained curing room temperature 5.46 MPa, 5.94 MPa curing and wet-dry curing 4.90 MPa. While strong adhesive at age 90 Days obtained curing room temperature 5,61 MPa, curing soak 3,50 MPa, and Curing Wet Dry 5,42 MPa. Based on the results obtained data was known that there were a constant increased in adhesion constantly until the age of 28 days and decreased at the age of 90 days. For the result of curing variation used, it can be seen that soaking method using curing marine wading has the lowest bond strength compared to two other immersion variations.

4. DISCUSSION

This study as show that when fresh water was not available, seawater can actually be used in concrete mixing. This is supported by the high value of the strong attachment possessed by seawater concrete. The corrosion risk of the reinforcement can be reduced if the reinforcement had a strong concrete cover or reinforcing steel is coated, and also if the concrete is sealed and exposed to the maritime environment then it should have a cement water factor smaller than 0.45 and a thickness of concrete at least 75 mm.

Marine concrete can be grouped into three areas of exposure: submerged, splashed, and atmospheric. The submerged area is continuously covered by sea water, The spark area is subjected to continuous wetting and

draining, and the atmospheric area above the splash area and occasionally exposed to sea splashing [8].

The compressive strength is the ability of concrete to accept the broad press unity force. The compressive strength of the concrete identifies the quality of a structure. The higher the strength of the structure is desired, the higher the quality of the concrete produced [9]. The value of concrete compressive strength is obtained from standard testing with commonly used which is cylindrical test specimens. The standard test specimen's dimensions are 300 mm in height and 150 mm in diameter. The commonly used testing procedure is the ASTM C39-86 standard and is contained in ISO 1974: 2011. From the results of this test obtained the maximum load that can be held by concrete cylinders until the concrete cylinder destroyed.

The tensile strength of concrete is obtained through tensile strength testing method with ASTM C 496-96 (Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens) and contained in SNI 03-2491-2002. Tensile strength testing is used to evaluate shear resistance of structural components made of concrete using light aggregate. Direct testing of Tensile strength on the concrete is difficult to implement, unlike steel materials. For that, indirect testing known as tensile test as been conducted. This test also used an UTM tool; the concrete was placed horizontally on the bottom plate, in accordance with ASTM standard. At the top and bottom of the specimen was placed a thin plate to obtain a uniform load on the specimen. Then the UTM was turned on until the test object is split.

One method to get strong sticky is by testing the pullout test. This adhesion stress was assumed evenly along the channeling area embedded in the specimen test, although the stress value is different at the start and end of the pullout. When the maximum load is achieved there is a need for friction and interlocking between concrete and steel. The resistance force that occurs along the reinforcement is usually referred to as the adhesion stress or adhesion strength. In the condition of the maximum load, the load will gradually decreased due to friction and interlocking of the reinforcement which will cause the reinforcement will shift out of the concrete as the load drops to zero.

The result of pullout test is slip failure, there are four stages until there is a slip along the channeling area embedded in the concrete. In the first stage that happened is adhesive attachment, which is started from the initial voltage of 0 MPa, where adhesive force is the ability of early reinforcement balances of concrete adhesion. In the second stage, there was displacement in the reinforcement in the slip where interlocking occurred and produce radial cracked in the concrete. The resistance force that occurred along this reinforcement is called the sticky

or strong bond (Bond strength). In the third stage, it began with a radial crack until it reached the maximum adhesive stress value. At this stage the adhesive stress and rigidity are retained by the reinforcement thread along the channeling area within the concrete matrix. The end of the fourth stage there was a pull-out failure crack and a continues adhesion until the entire reinforcing embedded along the length of the discharge is pulled out [10]. From the results of the diagram can be seen that the method of soaking using curing seawater is better than two other variations of immersion.

5. CONCLUSIONS AND SUGGESTIONS

Different treatment of concrete has a strong effect on the adhesion resulting from the concrete. Adhesive strength on various curing variations (soaked, room temperature and wet-dry cycles) show different values. The highest adhesive stress occurred in the dry curing test (room temperature) while the curing of seawater, which had the lowest adhesive stress, compared to the other two curing variations.

Acknowledgment

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