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CORROSIVE WATERS: EVALUATING THE INFLUENCE OF SEAWATER ON CONCRETE DURABILITY

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Article Info

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Abstract

Concrete is a widely utilized construction material known for its exceptional compressive strength, durability, and cost-effectiveness. However, the quality of concrete heavily relies on the treatment it undergoes during manufacturing to achieve high compressive strength, water-tightness, resistance to wear, and dimensional stability. A critical challenge in the construction industry emerges when concrete structures are employed in coastal areas, exposing them to seawater containing compounds that degrade concrete's durability. Seawater's detrimental impact on concrete arises due to the continuous interaction during the treatment process, leading to chemical reactions that weaken the material, resulting in fragility and eventual breakdown. Consequently, the obtained durability often falls significantly below the predicted values.

In recent years, researchers have shown increasing interest in exploring the influence of seawater curing on concrete's strength and durability. Previous studies highlight the significant impact of seawater curing on concrete's compressive strength and durability (Neville, 2011). The use of seawater can lead to corrosion of reinforcement bars and degradation of concrete structures over time, diminishing their overall lifespan (Broomfield, 2007).

Coastal construction projects utilizing concrete unavoidably encounter seawater, housing compounds that reduce concrete durability. The high salt content in seawater, particularly chloride (Cl), poses a threat to concrete and seeps into the material through capillary action, filling voids. As a result, the chemical compounds in seawater progressively corrode the concrete, leaving it brittle and damaged. This discrepancy between predicted and achieved durability arises as aggressive seawater compounds interact with concrete constituents, causing mass loss, strength and stiffness reduction, and accelerated weathering (Mehta, 1991).

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Concrete properties are categorized into fresh concrete and hardened concrete, each holding specific quality criteria. Proper fresh concrete should be easily mixed, transported, poured, and compacted, without segregation or bleeding tendencies that compromise its quality. Good hardened concrete exhibits high compressive and tensile strength, exceptional resistance to water, air, and sulfate, low shrinkage, and long-term durability. Compressive strength is a critical indicator of structural quality, with higher strength correlating to superior concrete. This study aims to comprehensively investigate the impact of seawater curing on concrete's compressive strength by comparing the strength of seawater-cured concrete to that cured in fresh water. The findings will provide valuable insights into seawater curing's effects on concrete strength and durability, informing the design and construction of structures in coastal areas where seawater exposure is unavoidable.

INTRODUCTION.

Concrete is one of the most widely used construction materials due to its high compressive strength, durability, and low cost. However, the quality of concrete is greatly affected by the treatment given during its manufacture. Treatment is crucial for obtaining high compressive strength, water-tightness, resistance to wear and dimensional stability of the structure. One of the biggest challenges faced in the construction industry is the use of concrete in coastal areas, where the structures come in contact with seawater, which contains compounds that can reduce the durability of the concrete. Seawater is particularly dangerous because, during the treatment process, concrete is always interacting with the seawater. These chemical compounds undermine the concrete, leading to its fragility and eventual breakdown. This can cause the durability obtained to be significantly lower than the originally predicted.

In recent years, the impact of seawater curing on the strength and durability of concrete has been of particular interest to researchers. Previous studies have shown that seawater curing can have a significant impact on the compressive strength and durability of concrete (Neville, 2011). The use of seawater can lead to the corrosion of reinforcement bars and deterioration of the concrete structure over time, leading to a reduction in its overall lifespan (Broomfield, 2007).

In the manufacture of buildings using concrete in coastal areas, contact with seawater is sometimes unavoidable, where seawater contains compounds that will reduce the durability of concrete. Seawater itself has a high salt content which can undermine the strength and durability of concrete. This is because the chloride (Cl) found in seawater is a salt that is aggressive towards other materials, including concrete. Contact with seawater is dangerous because, during the treatment period, the concrete will always interact with seawater. Sea salt seeps into the concrete by capillary action and fills the voids. These chemical compounds will eat away at the concrete until the concrete is brittle and damaged. This will cause the durability obtained will not to match what was originally predicted.

Damage can occur in concrete due to the reaction between aggressive seawater that penetrates into the concrete with the compounds in the concrete which causes the concrete to lose some mass, lose strength and stiffness and accelerate the weathering process (Mehta, 1991).

The properties of concrete are divided into two, namely when the concrete is still fresh (fresh concrete) and when the concrete is hardened (hard concrete). Good fresh concrete is fresh concrete that can be stirred, transported, poured, compacted, there is no tendency for segregation to occur (separation of aggregate from mortar) or bleeding (separation of cement and water from mortar). This is because segregation and bleeding will result in poor quality of the concrete obtained.

The behavior of hard concrete is the ability of concrete to support the building structure. Good hard concrete performance is indicated by high compressive strength of concrete, good tensile strength, more detailed behavior, water, and air resistance, sulfate resistance, low shrinkage, and long-term durability. The compressive strength of concrete identifies the quality of a structure. The higher the desired level of structural strength, the higher the quality of the resulting concrete.

Based on the description above, this study aims to investigate the impact of seawater curing on the compressive strength of concrete. The study will compare the strength of concrete cured in seawater with that of concrete cured in fresh water. The results of this study will provide insights into the impact of seawater curing on the strength and durability of concrete structures. This information will be useful in designing and constructing structures in coastal areas, where contact with seawater cannot be avoided.

METHOD OF RESEARCH.

Concrete is a rock that occurs as a result of the hardening of a certain mixture. Concrete is obtained by mixing fine aggregate (sand), or other hydraulic cement, and water, sometimes with chemical or physical additives (admixtures) in certain ratios, to form a heterogeneous whole. The mixture will then harden like a rock.

Concrete is produced from a set of mechanical and chemical interactions of a number of constituent materials (Nawy, 1985: 8). So to understand and study the characteristics of each component that forms concrete consisting of a mixture of fine aggregate and coarse aggregate with water and cement as a binder.

Portland cement is the main binding agent for concrete mixes used to unite the materials into a strong unit. The type or type of cement used is one of the factors that affect the compressive strength of concrete.

Factors that affect the strength of concrete are water-cement factors and density, type of cement, amount of cement, aggregate properties, efficiency and curing, and age of concrete. In the manufacture of concrete, good maintenance greatly affects the strength (durability) of concrete. Good concrete treatment generally uses clean water / normal water (water that does not contain compounds or minerals that can damage the concrete) as the immersion water. Concrete is widely used as a building material in areas around the sea such as bridges, piers, breakwaters, and so on. Concrete was chosen because of the many advantages of concrete when compared to other construction materials. This is the reason why concrete is the first choice as a construction material, especially in areas around the sea.

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The properties of concrete are divided into two, namely when the concrete is still fresh (fresh concrete) and when the concrete is hardened (hard concrete).

Good fresh concrete is fresh concrete that can be stirred, transported, poured, compacted, there is no tendency for segregation to occur (separation of aggregate from mortar) or bleeding (separation of cement and water from mortar). This is because segregation and bleeding will result in poor quality of the concrete obtained.

The behavior of hard concrete is the ability of concrete to support the building structure. Good hard concrete performance is indicated by the high compressive strength of concrete, good tensile strength, more detailed behavior, water, and air resistance, sulfate resistance, low shrinkage, and long-term durability. The compressive strength of concrete identifies the quality of a structure.

The higher the desired level of structural strength, the higher the quality of the resulting concrete.

Concrete constituent materials in this study are:

The cement used is Portland cement type 1, Semen Padang

The fine aggregate of sand used from the material shop was taken from the Binjai area. Coarse aggregate of crushed stone used from a material shop originating from Binjai. Water from PDAM

Where to Check for Fine Aggregate Sludge Content

Purpose: To check the silt content in the sand

Research Guidelines: The mud content is not allowed to exceed 5% if it exceeds then the sand must be washed.

Research results: From the results of the examination, the content of mud in the sand is 2.21%.

Declared eligible for research.

Fine Aggregate Sieve Analysis Examination

Research Objectives: To determine the gradation and fineness modulus of sand (FM). Guidelines

Table 1. Fine Aggregate Inspection Results

Checking	Result
Sludge Content	2,21%
Sieve Analysis	2,65
Filling Weight (UW) kg/m^3	1231,70 kg/m^3
Specific Gravity (SSD)	2,49 gr/cm^3
absorption	1,5%

2.1. Examination of Coarse Aggregate Sludge of Crushed Stone

Research Objectives: To check the content of crushed stone mud

Research Guidelines: The content of silt in coarse aggregate does not exceed 1% if it exceeds the aggregate must be washed.

From the results of the study, the crushed stone mud content of = 0.73% so that crushed stone can be used in the experiment.

2.2. Analysis of Crushed Stone Coarse Aggregate Sieve

Research Objectives : To examine the gradation spread and determine the fineness modulus (FM).

Research Guidelines

FM=(Σ % cumulative retained 0.150 mm sieve)/100

Coarse aggregate that can be used in concrete mixtures must have a fineness modulus (FM) between 5.5 - 7.5. From the results of the examination obtained FM is 7.16 so it can be used in the experiment.

2.3. Check Weight of Crushed Coarse Aggregate Content.

Research Objectives: To determine the bulk density of crushed stone by means of solid and loose methods.

Research Guidelines: From the results of the research, the weight of the contents by means of a solid or by crushing is greater than the weight of the contents by means of a loose or by not ripping.

From the research results obtained:

Solid fill weight: 1785.40 kg/m^3

Loose fill weight : 1680.04 kg/m^3

Examination of Specific Gravity and Absorption of Coarse Aggregate

Research Objectives : To determine the specific gravity and water absorption of crushed stone. Research guidelines : Dry density < SSD density < Apparent density From the research results obtained:
Dry density : 2.53 g/cm^3
SSD density: 2.62 gr/cm^3
Apparent weight: 2.65 gr/cm^3
Absorption : 1.74%

2.4. Concrete Mix Design (Mix Design)

Planning of concrete mix with material weight ratio is done to determine the desired concrete strength. In this study, the Development Of Environment (DOE) method was used. The steps in planning a concrete mix using the DOE method according to SK SNI T – 15 – 1990 – 03 are as follows:

1. Determine the required compressive strength of concrete.
2. Set the standard deviation value / value added.
3. Calculate the added value (M).
4. Calculating the average compressive strength is necessary.
5. Determine the type of cement and aggregate.
6. Determine the cement water factor.
7. Set the slump value.
8. Set the maximum grain size.
9. Set the free water content.
10. Calculating cement needs.
11. Determine the appropriate cement requirements.
12. Determine the percentage of fine and coarse aggregate.
13. Calculate the density of the combined aggregate SSD.
14. Determine the specific gravity of concrete.
15. Calculate the weight of each aggregate.
16. Correction of aggregate weight and water weight.

2.5. Determination of Type and Number of Test and Treatment Objects.

It is planned in this study that the number of specimens for each test is 20 normal concrete specimens with fresh water treatment and 20 normal concrete specimens with salt water treatment. The mold of the test object is in the form of a cube 15x15x15 cm^2.

Treatment of the test object is done by immersion.

This concrete treatment aims to ensure that the cement hydration process can take place perfectly, so that cracks on the concrete surface can be avoided and the desired concrete quality can be achieved. In addition, the moisture of the concrete surface can also increase the resistance of the concrete to the effects of weather and is more watertight. The immersion method is as follows:

After 24 hours, the cube concrete mold was opened, then the concrete sample was soaked. Immersion is carried out until the age of the concrete is 28 days. Before the concrete is soaked, it is first given a name on the surface.

2.6. Compressive Strength Test of Concrete Samples

The compressive strength test of concrete was carried out at the age of 28 days of concrete. The test steps are:

1. The concrete cube is removed from the bath, then aired or wiped to dry the surface
2. Weigh and record the weight of the concrete sample, then observe whether there are defects in the concrete as report material
3. Compressive Strength Test using a concrete compression test machine
4. Put the concrete sample into the tester, then turn on the machine and the tool slowly presses the concrete sample
5. Record the results of the compressive strength of concrete for each sample.

ANALYZE AND RESULTS

3.1. K 250 Concrete Mix Planning

Tables 2. Mix Design K 250

No.	Description	Table	Graph Values
1.	Required strength	Established	K 250
2.	Standard deviation (S)	Known	45 Kg/cm^3
3.	Value added/margin M	-	73,8 Kg/cm^3
4.	The average compressive strength to be achieved (f'cr) 1+3		324 Kg/cm^3
5.	Type of cement (Cement Padang)	Established	Cement Tipe I
6.	Coarse aggregate type	Established	
		Established	Broken StonePasir
	Fine aggregate type	Established	0,6
	Water cement factor	Established	0,6
	Maximum water cement factor	Established	180 mm
	Slump	Established	20 mm
	Maximum aggregate size	Established	205 Kg/ ^{3}cm
	Free water content	11:8	341,67Kg/ m^3
	Cement content	Established	325 kg/m^3
14.	Maximum cement content	Established /SNI-03-2834-200	341,67kg/ m^3
	Minimum cement content	-	0,6
	Customized F.a.s	-	*Zone 3*
17.	The arrangement of the aggregate grains	-	55%
18.	Material percent<4.8 mm	-	2,430
19.	Aggregate relative density	-	2280 kg/
20.	Density of concrete	13-12-11	1733.33 kg/
21.	Combined aggregate rate	-	779,99 kg/
22.	Fine aggregate content	-	866,665 kg/

3.2. Slump Value

The calculation of the slump value in concrete is basically a simple experiment to determine the workability of fresh concrete before it is applied in casting. The experiment was carried out using an Abrams cone with an upper diameter of 10 cm and a lower diameter of 2 cm. The study refers to SNI 1972: 2008. In the normal concrete slump test, it is planned to be 1618 cm.

Tables 3. Data on normal concrete slump test results

Sample	Slump Value (cm)
1	16
2	14
3	18
4	18
Averages	16,5

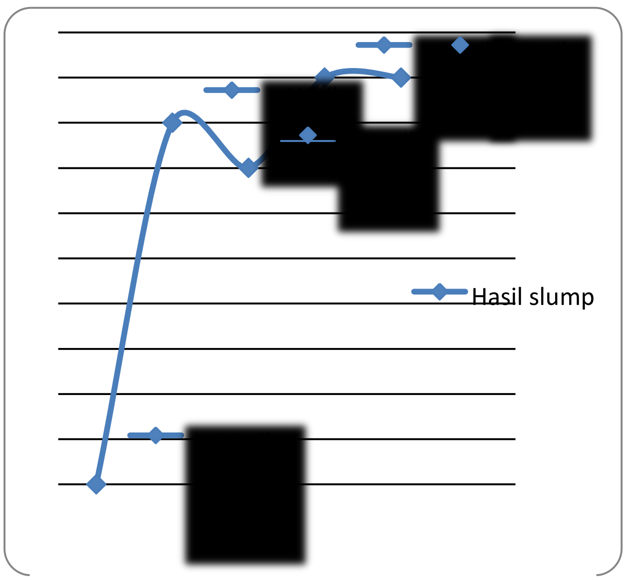

Figure 1. Concrete Graph

3.3. Compressive Strength Test of Cube Test Objects

The compressive strength test of concrete aims to determine the compressive strength of normal concrete with the characteristics of K 250 (with fresh and salt water treatment). In this study, the compressive strength test was carried out after 28 days from the manufacture of the test object. Basically strong testing compression refers to SNI 03 – 1974 – 1990 “Method of Testing the Compressive Strength of Concrete”. If according to the procedure, the compressive strength of normal concrete and concrete treated with salt water can be compared.

Tables 4. The results of the normal concrete compression test results (with treatment using fresh water.

No. Sample	**Fas**	**Slump (Cm)**	**Area Surface (Cm_2)**	**Strong Test Object Weight (x)**	**P Max (KN)**	**Press (Kg/Cm^2)**	**– (x x)**	**$(x – x)_2$**
1	0,6	18	225	8,406	580	257,78	-2,22	4,94
2	0,6	18	225	8,445	600	266,67	6,67	44,44
3	0,6	18	225	8,499	600	266,67	6,67	44,44
4	0,6	18	225	8,526	620	275,56	15,56	241,98
5	0,6	18	225	8,34	610	271,11	11,11	123,46
6	0,6	18	225	8,441	580	257,78	-2,22	4,94
7	0,6	18	225	8,282	560	248,89	-11,11	123,46
8	0,6	18	225	8,324	560	248,89	-11,11	123,46
9	0,6	18	225	8,341	570	253,33	-6,67	44,44
10	0,6	18	225	8,34	580	257,78	-2,22	4,94
11	0,6	18	225	8,342	560	248,89	-11,11	123,46
12	0,6	18	225	8,352	570	253,33	-6,67	44,44
13	0,6	18	225	8,415	600	266,67	6,67	44,44
14	0,6	18	225	8,518	630	280,00	20,00	400,00
15	0,6	18	225	8,481	600	266,67	6,67	44,44
16	0,6	18	225	8,314	600	266,67	6,67	44,44
17	0,6	18	225	8,378	600	266,67	6,67	44,44
18	0,6	18	225	8,218	560	248,89	-11,11	123,46
19	0,6	18	225	8,338	570	253,33	-6,67	44,44

					550			241,98
Averages					**585**			**95,80**
20	0,6	18	225	8,512		244,44	-15,56	
				8,390		**260,00**		

Tables 5. Normal concrete compression test results data (with treatment using salt water)

No. Sample	Fas	Slump (Cm)	Surface (Cm2)	Strong Area Object Weight	Test P Max (KN)	Press (Kg/Cm²)	(x- x)	(x –x)2	(x)
1	0,6	18	225	8,324	510		5,25	27,53	226,67
2	0,6	18	225	8,412	500	222,22	0,80	0,64	47
3	0,6	18	225	8,398	490	217,78	-3,64	13,27	
4	0,6	18	225	8,536	492	218,67	-2,75	7,58	
5	0,6	18	225	8,423	500	222,22	0,80	0,64	
6	0,6	18	225	8,512	520	231,11	9,69	93,92	
7	0,6	18	225	8,199	492	218,67	-2,75	7,58	
8	0,6	18	225	8,277	492	218,67	-2,75	7,58	
9	0,6	18	225	8,099	540	240,00	18,58	345,22	
10	0,6	18	225	8,179	510	226,67	5,25	27,53	
11	0,6	18	225	8,231	494	219,56	-1,86	3,48	
12	0,6	18	225	8,221	498	221,33	-0,09	0,01	
13	0,6	18	225	8,501	530	235,56	14,14	199,81	
14	0,6	18	225	8,509	500	222,22	0,80	0,64	
15	0,6	18	225	8,312	496	220,44	-0,98	0,95	
16	0,6	18	225	8,113	500	222,22	0,80	0,64	
17	0,6	18	225	8,091	420	186,67	-34,75	1207,79	
18	0,6	18	225	8,011	488	216,89	-4,53	20,53	
19	0,6	18	225	8,099	492	218,67	-2,75	7,58	
20	0,6	18	225	8,278	500	222,22	0,80	0,64	
Averages				**8,320**	**498,2**	**221,42**		**98,68**	

strength test, the average relationship between normal concrete and concrete treated with salt water was obtained. The results of the average compressive strength of normal concrete are 260.00 kg/cm^2 and the average compressive strength of concrete treated with salt water is 221.42 kg/cm^2, so that the characteristics of the concrete which were originally K 250 were reduced to almost reached K 200 (or a percentage of about 1.5%). The materials that make up the concrete are checked and analyzed properly so that the estimated compressive strength is slightly higher than planned.

The use of salt water in normal concrete treatment results in erosion of the concrete being treated. It is recommended that the use of salt water in the treatment of concrete be avoided due to a decrease in the compressive strength of concrete due to the salt content of ± 3% in salt water which will cause corrosion of the concrete. On the surface of the test object, erosion occurs on the test object which is treated with salt water. The salt deposit covers the entire surface of the test object.

CONCLUSION.

Based on the results of the research and discussion that have been described previously, several conclusions can be drawn as follows:

1. The average compressive strength of normal concrete is 260 kg/cm^2. As for the concrete treated with salt water is 221.42 kg/cm^2. Treatment using salt water was found to reduce the compressive strength of concrete. This is due to the nature of the salt contained in salt water which is corrosive to erode the concrete surface.
2. The planning of the K 250 mix design and treatment using salt water actually reduced the quality of the concrete to almost K-200. Because of the nature of the salt it contains.
3. The salt water used for the treatment of concrete is salt water with a salt content of about ±3%
4. Treatment using salt water should be avoided because it can damage the concrete surface due to its salt content.
5. There was erosion on the surface of the test object which was treated with salt water so that the shape of the test object no longer resembled a perfect cube.
6. In the saltwater treatment tub, salt deposition occurs at the bottom of the treatment tub. And salt deposition also covers all test specimens being treated with salt water.
7. The use of type 1 cement is not suitable for buildings to be built in coastal areas or which will interact directly with salt water.

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