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Development and Analysis of High-Quality Concrete Mixtures for Pier Structure in Indonesia

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ABSTRACT:
In this research with the K-250 concrete mixture, it is intended for general pier structures related to the threat of seawater in normal conditions. This mixture will withstand the salinity of seawater and other chemicals around the pier which can slowly damage the structure and other supporting structures. In the first stage, inspection/analysis of fine aggregate sieve or sand and analysis of coarse aggregate or gravel sieves will be carried out on samples that have been provided with a weight of approximately 40 kilograms each, then check the density and absorption of the aggregate, check the level of aggregate sludge pass the No. sieve 200 and finally checking the aggregate content weight. In the second stage, planning the concrete mixture using Mix Design K-250 according to Indonesian sea jetty and ADT (3 in 1 Concentrated Cement Toner 1%), with implementation steps: Cement Water Factor Planning (FAS), Free Water Planning (Liter / m3) Concrete, Cement Amount Planning, Minimum Cement Content Planning, Adjusted Cement Water Factor Planning, Aggregate Composition Estimation Planning, Concrete Content Weight Estimation Planning, Concrete Mix Composition Calculation, Mixture Correction Calculation for Various Moisture Content.

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I. INTRODUCTION

Several researchers have conducted tests that specifically increase the compressive strength of concrete compared to normal concrete, as was done by [1] with the addition of polymers to increase the compressive strength of concrete. Research [2], regarding the strength of concrete with the addition of foam to the concrete mixture, can also increase the compressive strength of building wall panels which is a breakthrough for concrete strength. Furthermore, [3] in his research said that the concrete mixture with the addition of coconut waste can increase the strength of the concrete so that it can increase the life of the structure.The use of latex can also increase the strength of the concrete mixture by adding three types of polymers as chemical additives, plus a superplasticizer which will increase the adhesion of concrete with other supporting materials [4].

To achieve good concrete strength, it is necessary to pay attention to the density and hardness of the aggregate mass, because in general, the denser and harder an aggregate can increase its strength and durability (resistance to deterioration due to weather effects). To form a solid mass, good grains of aggregate is required. So that the aggregate material must have sufficient hardness, conserved properties, not be reactive to alkalis, and does not contain sludge. The diameter or organic material is less than 0.063 mm. If the amount of sludge or organic material contained in the aggregate is greater than 1% dry weight, the aggregate must be washed [5].

Concrete is a result of mixing cement, water, fine aggregate, and coarse aggregate. Aggregate is the most important component of concrete, which functions as a filler in the mortar or concrete mixture. Aggregates are called coarse when their size exceeds 5 mm. The properties of coarse aggregates affect the final strength of the concrete, hardness, and durability of the concrete disintegration. This coarse aggregate must be free of organic matter and must have a good bond with the cement paste. Fine aggregate is a filler in the form of sand, the sizes vary between the size of the no.4 to no.100 American standard sieve. Good fine aggregate must be free of organic matter, clay, and other materials that can damage the concrete mixture. The size variation in a mixture must have a good gradation according to the standard filter analysis from ASTM (American Society of Testing Materials) [5].

Cement is a filler of the pores between the grains of fine aggregate and coarse aggregate also functions as an adhesive in the hardening process so that the aggregate grains are tightly and densely bonded. In the concrete mixture, the water has a function as a smoothing agent for the mixture of aggregate and cement to facilitate stirring and molding. In certain concrete materials and test conditions, the amount of mixed water used determines the strength of the concrete, as long as the mixture is sufficiently plastic and workable. The concrete that is widely used today is normal concrete. Normal concrete is concrete that has a content weight of 2200-2500 kg/m^3 [6] using natural aggregate that is broken down or without being broken and which does not use additives or admixtures.

The addition of added materials will affect the ease of workmanship and without having to reduce the level of compressive strength planned. Concrete that uses added materials can usually be compacted so that air cavities can be removed/reduced, besides that, concrete can be more homogeneous, coherent, and stable during work and can be vibrated without having to segregate/separate the grains from the main materials and can flow into the mold around the reinforcement [5].

The cement used for the concrete material in this study is Portland cement or Portland pozzolan cement, which is a hydraulic cement produced by refining the clinker which consists of hydraulic calcium silicates with additional casts. Portland cement is an important bonding material and is widely used in physical construction. Also, cement functions to fill the cavities between the aggregate grains. Although cement only fills 10% of the volume of concrete, because it is an active ingredient, it needs to be studied and controlled scientifically according to its intended use [5].

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The additive is a powder or liquid material, which is added to the concrete mix during mixing, to change the properties of the mix or the concrete. There are 2 types of added ingredients, namely additives and admixtures. The additive is an added material that is added during the cement-making process at the factory, the added material is added to the concrete to increase the compressive strength performance of the concrete. Concrete that lacks fine grains in the aggregate becomes non-cohesive and bleeds easily. To overcome this condition, additives in the form of fine solid grains are usually added. Additives are added to concrete that lacks fine aggregate and concrete with ordinary cement content but needs to be pumped over long distances. The types of additives include pozzolan, fly ash, slag, and silica fume [5].

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The compressive strength of concrete increases with age of the concrete. This is influenced by several factors. The higher the treatment temperature, the faster the concrete strength increases. If the slump value is the same (the cement water factor value changes), concrete with more cement content has a higher compressive strength. This is because if the slump value is the same and the amount of water is almost the same, it will affect the addition of cement, this means a reduction in the value of the cement water factor which increases the compressive strength of the concrete [6].

The properties of the aggregate that most influence the strength of the concrete are the surface roughness and the maximum size. Smooth and rough surfaces affect adhesion and the amount of stress when cracks begin to form. While the maximum size of the aggregate will affect the compressive strength of the concrete [5]. The stages of material inspection are as follows:

a. Fine aggregate check.
b. Cement inspection.
c. Coarse aggregate inspection.
d. Water check.
e. Added material check.

In general, the properties of concrete are combined as two properties related to excess concrete and also properties related to lack of concrete. The advantages of concrete include:

1. Can be easily formed according to construction requirements.
2. Able to carry heavy loads.
3. Resistant to high temperatures.
4. Small maintenance costs.

The disadvantages of concrete include:
1. The shape that has been made is difficult to change.
2. Implementation of work requires high expertise
3. Heavy.
4. Great sound reflectivity.

II. RESEARCH OBJECTIVES AND BENEFITS

The purpose of this study was to determine the effect of adding ADT (3 in 1 Concentrated Cement Toner 1%) added to the concrete mixture and to find out what percentage of the optimum amount of ADT added material (3 in 1 Concentrated Cement Toner 1%) added to achieve strength. press the concrete at the age of 28 days. A preliminary study by [7], states that a mixture of palm oil can also be used for lightweight concrete mixtures. This study obtained the compressive strength of concrete which can also be used for housing in disaster areas. The research results have been published in the Journal of Civil Engineering Research in 2014. Furthermore [8] stated that the use of K-300 concrete mixture can be used for housing structures to withstand earthquakes, and can also be used for foundation structures in general. And for docks only in a small capacity and can be visited by only small passenger ships in river areas.

Research by [2] which has been published in the IJAR journal states that waste materials can also be used for structures above the wharf, thus allowing for overall cost reduction, by using waste materials. The strength of the concrete mixture which will be the basis for the compressive strength test in 28 days is to use a test with a cube, a cylinder for each sample. These results will be recalculated according to the standards for sea docks in Indonesia. The average compressive strength of concrete will generally increase in height in 28 days which will be required for the pier structure and other structures supporting the pier.

Figure 1. The cylindrical specimen is weighed.
(Fahrizal Z, 2018).

III. USE OF CHEMICALS FOR PIER

Concrete mixtures with ADT (3 in 1 Concentrated Cement Toner 1%) will be used for the pier and the supporting structures, including the foundation that supports the pier. These chemicals are used to resist the ingress of sulfates into foundations and piers. Seawater rights will affect the age of the pier and foundation if the ratio of the concrete mixture used is not correct.

A study [9], said that the production of mycotoxin in water will damage building materials. This will result in damage to the piles which will then have an impact on the cracking of the pier floor. To prevent this from happening it is necessary to mix concrete with chemicals so that the entry of sulfates can be prevented by a ratio of cement, sand, and gravel by existing regulations. Previous research has also been conducted by [1], illustrating that the use of cement can be modified to suit several applications in civil engineering. With the initial research that has been carried out, it becomes the basis that the use of modified cement and the presence of a mix design can withstand sulfate when used in sea or saltwater in general, of course with the help of chemicals. With this preliminary research, it motivates us to be able to produce a sulfate-resistant K-250 concrete mixture that can be used on Indonesian sea docks.

The choice of aggregate is also important, as has been done by [10] the use of silica powder also plays an important role in increasing the compressive strength of concrete in general. Thus the compressive strength for docks and other supporting structures can be used by adding said silica powder. The compressive strength value has been met and other added materials are needed that can withstand the entry of seawater into the pier or other supporting structures which will be carried out in further research for 2020 funding.

In construction that uses composite building materials, it is often made of a material consisting of a mixture of cement, water, aggregate (coarse and fine), and additives when needed. Ordinary fresh concrete weighs between 2200-2500 kg / m³ using natural aggregates that are broken down or not naturally damaged on the outside [11]. Concrete itself is a function of the preparation material consisting of cement or portland cement, coarse aggregate, fine aggregate, water, and additives or mixtures. Concrete also has several advantages compared to other construction materials, including having a large compressive strength, fire resistance, easy shape, no special expertise is required in its manufacture, and the raw material is easy to obtain so that the concrete contains about 1% -2% air cavities, paste cement (cement and water) about 25% -40%, and aggregate (fine and coarse aggregate) about 60% -75% [11, 12].

Concrete preparation materials include water, Portland cement, coarse and fine aggregates, and additives, each of which has a different function and effect. The factors that affect the compressive strength of concrete include the quality of the constituent materials, the value of the cement water factor, the grading of the aggregate, the maximum aggregate size, the method of processing (mixing, transportation, compaction, and maintenance) and the age of the concrete [11, 13]. Along with the increasing price of cement as the main material for making concrete, the cost of making concrete is a problem that needs to be resolved to develop technology in the construction sector, especially in the cost of building structures. For this reason, there is a need for cement substitution in the manufacture of concrete or just a filler to reduce the amount of cement needed in making concrete, but it does not reduce the quality of the concrete so that it still meets the requirements in construction work. The utilization of marble waste is based on research [14].

The research was conducted using marble as a partial cement filler with a composition of 10% by volume of cement. In general, the most marble content is Calcium Oxide (CaO) and the least amount of Magnesium Oxide (MgO), Aluminum Dioxide (Al_2O_3), and Silicon Dioxide / Silicate (SiO2) chemical content of marble which is also found in cement. Meanwhile, the utilization of glass waste is based on [15]. The research was conducted by utilizing glass waste as a partial sand filler with a percentage variation of 8% of the volume of fine aggregate. The chemical content in the glass is silicate (SiO2), Calcium Oxide (CaO), Magnesium Oxide (MgO), Aluminum Dioxide (Al2O3), and Soda Flux (Na2O) [11].

IV. RESEARCH METHODS

The steps or activities carried out are divided into 4 (four) main elements, namely: 1) Checking the Aggregate Characteristics or the method used, 2) Planning the Mixture Composition including the materials used, 3) Making the Experimental Mixture (3 cubes and 3 cylinders) in this is the mix design with the DoE Method, 4) Mixed Quality Inspection with an estimated 28 (two eight) days with the K-250 results for marine docks in Indonesia.

The determination of these values by prioritizing that the ADT (3 in 1 Concentrated Cement Toner 1%) provides several tests that can represent how the mixture is suitable for the basic material for making jetty. Absorption will also affect the quality of the mixture so that it can prevent water from entering the foundation or into the pier quickly. In the first year of research all materials to be used in the sulfate resistant K-250 concrete mix will be prepared, including sand of A quality with good quality for the concrete mix.

Aggregate Inspection Data

1. Coarse Aggregate Sieve Analysis (Split)

∅ Sieve	RESTRAINED		CUMULATIVE	
(mm)	Gram	%	restrained	pass
37,5		0,00	0,00	100,00
19	0,00	0,00	0,00	100,00
9.5	12815,80	85,46	85,46	14,54
4,75	2006,69	13,38	98,85	1,15
2,36	0,00	0,00	98,85	1,15
1,2	0,00	0,00	98,85	1,15
0,6	0,00	0,00	98,85	1,15
0,3	0,00	0,00	98,85	1,15

0,15	0,00	0,00	98,85	1,15
PAN	172,95	1,15	100,00	0,00

Fine Modulus = $\frac{678,54}{100} = 6,79$

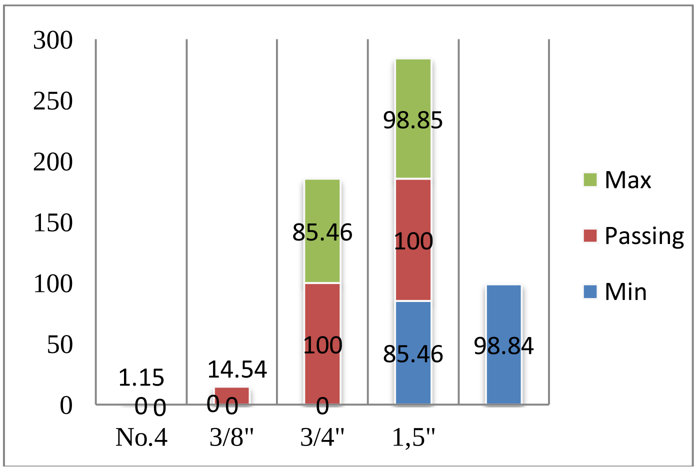

Figure 2. Graph of analysis of coarse aggregate sieve (Split

Table 2. Analysis of fine aggregate/sand sieve

∅ Sieve	RESTRAINED		CUMULATIVE	
(mm)	Gram	%	restrained	pass
9,5	0,00	0,00	0,00	100,00
4,75	0,00	0,00	0,00	100,00
2,36	17,58	3,52	3,52	96,48
1,18	41,64	8,33	11,85	88,15
0,6	168,41	33,70	45,56	54,44
0,3	221,34	44,30	89,85	10,15
0,15	46,12	9,23	99,08	0,92
PAN	4,58	0,92	100,00	0,00
TOTAL	499,67		249,86	

Fine Modulus $= \frac{249,86}{100} = 2,50$

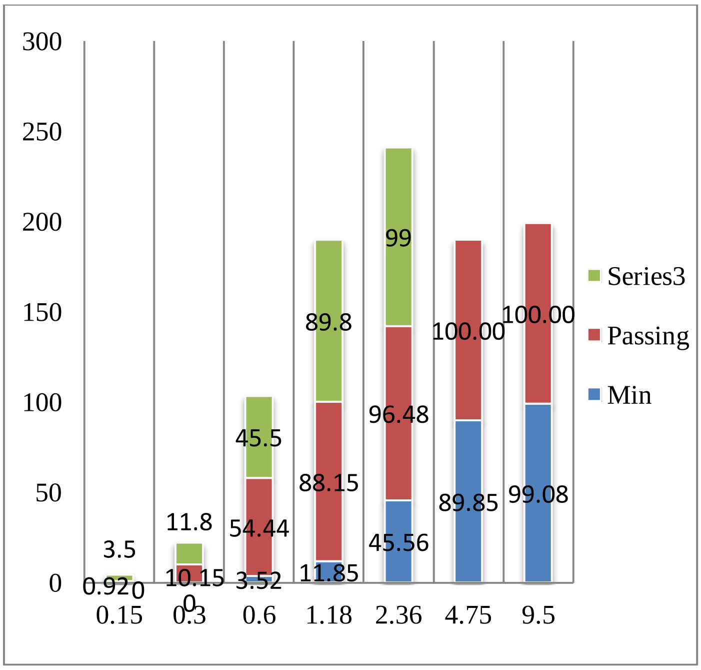

Figure 3. Graph analysis of fine aggregate/sand sieve.

2. **Specific gravity and aggregate absorption**

Furthermore, the examination of fine aggregate/sand will be continued with inspection steps which include checking the weight of the sample weight and also the vessel in an empty state, up to the weight of dry aggregate and the last is the absorption capacity in the form of percent, then the calculation will be made in the table, with data -data as follows:

Table 3. Analysis of fine aggregate/sand sieve

EXAMINATION STEP	Fine Aggregate	Coarse Aggregate
1. Aggregate weight SSD (A) Gram	500,00	938,17
2. Aggregate weight SSD + Vessel + Water (A1) Gram	867,71	1567,14
3. Vessel + Water (A2) Gram	557,39	978,56
4. Oven dry aggregate weight (A3) Gram	493,11	931,02
Calculation		
BJ SSD = (A):(A2 + A - A1)	2,64	2,68
BJ Dry = (A3):(A2+A - A1)	2,60	2,66
Absorption (%) = {(A-A3) x 100%} : (A3)	1,40	0,77

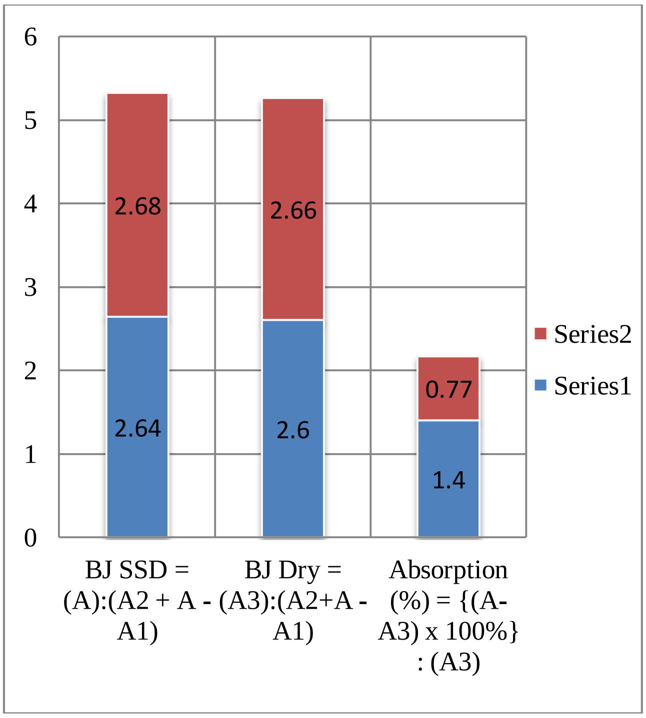

Figure 4. Graph analysis of fine aggregate/sand sieve.

Aggregate sludge content

3. Aggregate sludge content (pass the sieve No.200)

Table 4. The aggregate sludge content passes the sieve No. 200

EXAMINATION STEP	Fine Aggregate	Coarse Aggregate
1. Oven dry aggregate weight (X) gram	500,00	1047,36
2. Oven dry aggregate weight after washing (Y) gram	496,85	1039,65
Calculation: sludge levels (%) = $\frac{(X-Y)X\ 100\%}{X}$	0,63	0,74

4. Aggregate content weight

Table 5. The aggregate sludge content passes the sieve No. 200

EXAMINATION STEP	Fine Aggregate	Coarse Aggregate
1. The weight of vessel + aggregate (W1) gram	6107.23	16083,00
2. Weight of vessel (W2)	2201,10	4775,00
3. Volume of the vessel (v) cm^3	2649,38	6908,00

Calculation: Aggregate content weight = $\frac{(W1-W2)X\ 100\%}{V}$	1474,36	1636,94

V. DATA AND MATERIAL USED

The aggregate sludge content passes the sieve. The data and materials used during the research process are as follows:

a. Concrete quality: K-250
b. Slump plan: 10-12 cm
c. Material:

- Fine Aggregates:
  Type = Natural Sand
  SSD Specific Gravity = 2.64
  Absorption power = 1.40%
  Gradation = Zone 2 BS
- Coarse Aggregates:
  Type = Broken Stone (split)
  SSD Specific Gravity = 2.68
  Absorption power = 0.77%
  Grain size max. = 20 mm
- Cement: Holcim Versatile

Planning steps

1. Cement Water Factor Planning (FAS)

Estimated compressive strength of concrete (kg/cm^2) with FAS 0.5 according to cement and aggregate type using Table 6.

Table 6. Cement Water Factor Planning (FAS)

Types of cement	Types of aggregate	Aggregate compressive strength (kg/cm^2)			
		3 hari	7 hari	28 hari	91 hari
Ordinary Portland cement (Type I	Natural	200	280	400	460
	Stone broke	230	320	450	530

Based on the graph of the relationship between compressive strength and the Cement Water Factor, the FAS relationship is 0.61. The maximum FAS value for this plan is 0.51.

1. Planning free water (Liter/m^3) concrete

Estimates of the amount of free water (kg/m^3) required for the various working levels using Table 7.

Table 7. Planning free water (liter/m^3) concrete

Aggregate		Value slump plans (mm)			
Maximum diameter (mm)	Types	0 – 10	10 – 30	30 – 60	60 – 180
20	Natural	135	160	180	190
	Stone broke	170	190	210	225

40	Natural	115	140	160	175
	Stone broke	155	175	190	205

The coarse aggregate used is a type of crushed stone with a maximum diameter of 20 mm and a natural type of fine aggregate. With a planned slump value of (8-12) cm, it is planned to use 202.50 liters/m^3 of concrete free water.

3. Perencanaan Jumlah Semen

Berdasarkan nilai FAS yang terkecil dan Air Bebas maka direncanakan penggunaan semen sebanyak:

$$\text{Jumlah Semen} = \frac{202,50}{0,51} = 397,06 \text{ kg/m}^3$$

4. Minimum Cement Content

The minimum amount of cement in this plan is determined to be 375 kg/m^3. Thus, the amount of cement used is the amount of cement calculated, which is 397.06 kg/m^3.

5. Adjusted Cement Water Factor

Because the amount of cement used has not changed, there is no need to adjust the FAS value, so the FAS value remains at 0.51.

6. Estimated Aggregate Composition

From the graph of the relationship between the maximum size of coarse aggregate (20 mm), the gradation of fine aggregate (Zone 2 BS), the design slump value (8-12) cm and FAS = 0.51, the composition is obtained: Fine aggregate: Coarse aggregate = 40%: 60%.

7. Estimated Content of Concrete Weight

From the graph of the relative density of the surface dry aggregate and the amount of free water, it is estimated that the weight of wet concrete is 2385 kg/m^3.

8. Calculation of Concrete Mixture Composition

From the mixed planning steps above, the composition per m^3 of the mixture (aggregate in SSD conditions) is obtained as follows:

- Cement: 397.06 kg.
- Fine Aggregate (Sand): 714.18 kg.
- Coarse Aggregate (Split): 1071.26 kg.
- Water: 202.50 kg.

9. Calculation of Mixed Corrections for various Moisture Content

The composition of the mixture per m^3 of concrete in step 8 above is based on the assumption that the aggregate used is in SSD conditions (water saturation and surface dryness). For aggregates that are not in SSD condition, the following mix corrections are made:

- Cement: Fixed
- Fine Aggregate (Sand): SSD sand + (KA sand - DS sand) x SSD sand
- Coarse Aggregate (Split): Split SSD + (KA split - DS split) x Split SSD
- Water: SSD Water - Sand Correction - Split Correction

10. Approx

VI. CONCLUSION

The purpose of this study was to determine the effect of adding ADT (3 in 1 Concentrated Cement Toner 1%) to the concrete mixture and to find out what percentage of the optimum amount of ADT (3 in 1 Concentrated Cement Toner 1%) added material is added to achieve strength. press the concrete at the age of 28 days. The mixture obtained from this research will be tested on its use on a small pier, by looking at its development in seawater absorption, water pressure, and water pressure that can come together.

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