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Compressive Strength Of Mortar Mixing Sea Sand With Portland Cement Composite (PCC)

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Abstract. *Indonesia is an area rich in sea sand. The aim of this research is to determine the comparison of the compressive strength of mortar derived from sea sand and river sand, as well as the feasibility of using sea sand as a material in construction in coastal areas. The results of the research showed that the compressive strength of the mortar from the two materials tested at 28 days had a difference in compressive strength of up to 37.45%, the mortar made from sea sand aggregate produced a mortar compressive strength of 14.13 Mpa which can be categorized as type S mortar with minimum value 12.5 MPa, meanwhile, mortar made from fine river sand aggregate produces a mortar compressive strength of 22.59 MPa and is included in the type M mortar category which has a minimum value of 17.2 Mpa.*

Keywords: *Compressive strength of mortar; River sand; Sea sand*

1. INTRODUCTION

Infrastructure development in the regions is growing faster and faster as time goes by. Indonesia as an archipelago that has more than 3700 islands (National Law Development Agency, 2015). Of course, it has a very large quantity of sea sand, however, the quality of sea sand in each region must be different, and it is not recommended as a material in concrete/mortar mixtures. Along with the continuous development of science. Development and research on the utilisation of sea sand as one of the building materials used in the manufacture of mortar in all fields of construction.

Mortar is a mixture of sand, adhesive and water. Adhesives can be clay, lime or cement. The main function of mortar is to increase the durability of the bond and adhesion between the constituent parts of a construction, the strength of the mortar depends on the paste of the adhesive material to the sand particles as a fine aggregate (Sika, 2022). The factors that greatly affect the compressive strength of mortar (Panjaitan & Herlina, 2020) include the cement water factor, the amount of cement, the age of the mortar and the nature of the aggregate.

Construction of buildings or other physical facilities requires sand material. People on the coast have long used beach sand for mortar mixes or specs and plastering in warehouses or other buildings. Research on the mixture of beach sand with clay as a mortar mix is needed to provide information on an alternative material to replace river sand fine aggregate in mortar mixes.

In Indonesia for now there is no shortage of fresh water, but there are small islands in Indonesia that are isolated or difficult to obtain fresh water. There are small islands in Indonesia that are isolated or difficult to obtain fresh water, to get fresh water is done with the effort of

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the distillation process. To reduce this process, in the case of concrete construction, it should be considered to use seawater as mixing water for concrete, although the suggestion of its use is still reserved for non-structural concrete, such as massive concrete, concrete slabs (without reinforcement) for concrete pavements, plastering of building walls, floor work and others. So far, the opinion of concrete construction practitioners is that when using seawater, the concrete will cause losses due to the damage caused. This opinion needs to be rectified with research to prove that for non-structural concrete (without reinforcement) it is actually more beneficial to use seawater as mixing water, due to the increase in compressive strength that occurs in concrete mixtures when mixing water uses seawater.

Using seawater as mixing or curing water in concrete production, makes the cost of concrete production more economical, in terms of time and cost. The concrete produced becomes more economical if the strength of the concrete that occurs after casting can be controlled as early as possible, for the purpose of quality assurance. It is important to recognise that the concrete quality control method can identify the possibility of failure to achieve the required concrete quality specifications as early as possible. The quality of concrete referred to here is the compressive strength of characteristic concrete representing the test results of specimens when the concrete is 28 days old.

The study was conducted to compare the compressive strength of mortar from sea sand and river sand, as well as the feasibility of using sea sand as one of the materials in the development of coastal areas.

2. LITERATURE REVIEW

The compressive strength value of mortar using river sand is 26.667 Mpa, while the beach sand mortar increases as the percentage of clay mixture increases, namely the addition of 10% has a compressive strength value of 17.333 Mpa, the addition of 20% has a compressive strength value of 18.667 Mpa, and the addition of 30% has a compressive strength value of 19.333 Mpa (Hadi, 2018).

The main source of sand comes from rivers or coastal areas that have different characteristics, both compressive strength and physical colour appearance. The compressive strength test results showed that the compressive strength of concrete bricks for CPP material reached a maximum of 28 days in mixture A with a value of 151.77 kg/cm² while CPB material in mixture A with a value of 161.10 kg/cm². The correlation of both CPP and CPB materials illustrates a high relation of R^2=0.9738 in mix A (Sulaiman & Nurhidayah, 2018).

The use of beach sand, river sand mixed and combined with seawater and fresh water as mortar making materials is still a big question for engineers and researchers for construction materials. The results showed that in general the characteristics for the composition of PPC-AT, PPC-AL, and PPTC-AL mortar mixes met the physical and mechanical analysis standards to be used as an alternative construction material for infrastructure buildings (Songka et al., 2022).

The sand of the beach was taken in : Pacitan, Tulungagung, Malang, Jember, and Banyuwangi. The examination of sand characteristics was carried out without washing the sand. Weight ratio of mortar mix was 1 cement: 3 sand, with a cement water factor of 0.46. The 14-day compressive strength of ps mortar cubes was 1.7% lower than that of 20% pp: 80% ps mortar, then the average compressive strength of 40% pp : 60% ps mortar cubes was 91% of the compressive strength of ps mortar. At 28 days, the compressive strength of ps mortar had the highest strength, further decreasing in 20% pp : 80% ps mortar to 82%, and, to 75% in 40% pp : 60% ps The smallest compressive strength value is pp mortar at 16% of the compressive strength of river sand mortar (Siswoyo, 2009).

The utilization of coal ash waste (Fly ash) which is processed into raw material in making mortar, is expected to be useful in daily life, in addition to improve the economy of the community, can also reduce the impact of environmental pollution due to waste from coal ash (Fly ash). Thus the use of coal ash with a content of 9% is the optimum mixture content in this mixture. If a mixture of coal ash exceeds that level, it will decrease the strength of mortar. This decrease is thought to be due to the less strong bonds between aggregates (mixed materials) on the use of coal ash over 9% (Yunanda, 2019).

A mortar that is well used in a construction project is able to adhere easily, is able to dry quickly, lasts for a long time, is easy to work with, and does not cause cracks in the walls of the building. Modifications were made to the constituent materials with the aim of making the mortar environmentally friendly. The environmental problem caused by making mortar is the use of fine aggregate, namely one type of sand, namely Muntilan Sand. Therefore, the use of one type of sand will threaten the availability of natural resources in the Muntilan area. Modification by using various sands such as Kaligarang Sand, Jepara Beach Sand aims to replace Muntilan Sand as a mortar building material (Adrithia et al., 2022).

The sand was taken from Sendangbiru beach in southern Malang Regency, while the river sand was taken from Brantas river in Tulungagung Regency.The composition of the mortar mix was in the weight ratio of 1 cement : 3 sand, with a cement water factor of 0.5. The average compressive strength of pc cementitious mortar was higher than ppc cementitious

mortar at 28 days of age. The compressive strength of 1pc : 3 sand in the 100% pc-cemented Brantas ps mixture was 373.2 kg/cm2 . Furthermore, the compressive strength of 20%, 40%, 60%, 80%, and 100% beach sand substitution mortar decreased to 97.4%, 74.5%, 58.2%, 31.5%, and 22.8% of the control, respectively (Wahyudi, 2013).

In the research, Bogowonto River and Gebang River sand from Purworejo were used, which had never been used as construction material due to its mud content above 5%. Variations of soil stabiliser additives used were 1%, 1.25%, 1.5%, 1.75%, and 2% by weight of cement. From the research results, the specific gravity of gebang sand 2.63 kg/cm3, and bogowonto river 2.59 Kg/cm3, fine grain modulus of gebang river 2.874, and bogowonto river 2.85, mud content of gebang river 6.7%, bogowonto river 14.87%. In the manufacture of mortar test objects with a size of 5x5x5 cm with the age of test objects 7, 14, and 28 days. The highest mortar compressive strength test result was 23.63 MPa in the addition of soil stabilizer 1.75% while bogowonto river was 12.94 MPa in the addition of soil stabilizer 1.5%. Adding the right proportion of soil stabiliser to muddy sand will increase the compressive strength of mortar (Nusantoro et al., 2021).

This study aims to determine the effect of two mixtures of fine aggregate, namely river sand from Kadong-Kadong village and beach sand from Labombo beach, Palopo City, which have different gradations on the compressive strength of mortar. The results of the compressive strength test at the age of 28 days showed that the highest compressive strength value of mortar in a mixture of 50% beach sand and 50% river sand was 249.9 kg/cm2, then for the next mixture, 25% beach sand and 75% river sand was 198.9 kg/cm2. cm2, 75% beach sand and 25% river sand at 178.5 kg/cm2. And for the controlling mortar it has a mortar compressive strength value of 132.6 kg/cm2 for 100% beach sand and 229.5 kg/cm2 for 100% river sand (Kartika Dian Pratiwi, Lusman Sulaiman, 2021).

3. METHODS

The experimental research method used was laboratory experimental research method by making cement mortar using fine aggregate of sea sand from Lumpue beach and river sand from Karajae river in Parepare. The treatment method was carried out at the age of 3 days, 7 days, 14 days, 21 days and 28 days.

In this research, the materials to be used are Portland Cement Composite (PCC) from PT Semen Tonasa, fine aggregate consisting of 2 types of sand, namely sea sand and river sand, the aggregate used is first tested in accordance with ASTM material testing. And the water used

is clean water, does not contain mud, salt and other substances that are considered capable of reducing the quality of the mortar to be tested.

1) Cement: according to the Indonesian National Standard (SNI 15-7064-2004, 1999), Portland composite cement is a hydraulic binder resulting from the joint grinding of Portland cement slag and gyps with one or more inorganic materials or from the mixing of Portland cement powder with other inorganic material powders.The methods section outlines the steps followed in executing the study and provides a brief justification for the research methods used. This section should contain sufficient detail to allow the reader to evaluate the appropriateness of your methods and the reliability and validity of your findings. Additionally, the information should enable experienced researchers to replicate your study.
2) Fine aggregate: according to the Indonesian National Standard Decree (Indonesian Standardisation Agency, 1991), aggregate is defined as granular material such as sand, gravel, crushed stone and iron furnace crust which are used together in a binding medium to form mortar or hydraulic cement beto or mortar.
3) Water is needed in the manufacture of mortar to trigger the chemical process of cement, water containing harmful compounds, contaminated with salt, sugar oil or other chemicals when used as a mortar or concrete mixture can reduce the quality of concrete, and can even change the properties of the concrete produced (Mulyono, 2004).

Outline the flow of the research process carried out in the laboratory as follows:

1. Material preparation: at this stage all materials and equipment needed in the research are prepared in advance so that the research can run well.
2. Inspection of mixed materials: inspection is carried out on fine aggregates and cement to be used. As for the standard testing of materials used is the ASTM standard (ASTM, C39/C39M, 2023).
3. Mix design: preparation of mortar mix plan in accordance with Indonesian National Standard (SNI 03-6825-2002, 2002) (SNI 03-6825-2002, 2002) and Indonesian National Standard (SNI - 6882:2014, 2010).
4. Preparation of test specimens: test specimens will be made in the form of cubes with a side length of 5 cm Indonesian National Standard (SNI 03-6825-2002, 2002), made from a mixture of portlan cement, sand and water, for each aggregate made test specimens consisting of 3 pieces each for one test.

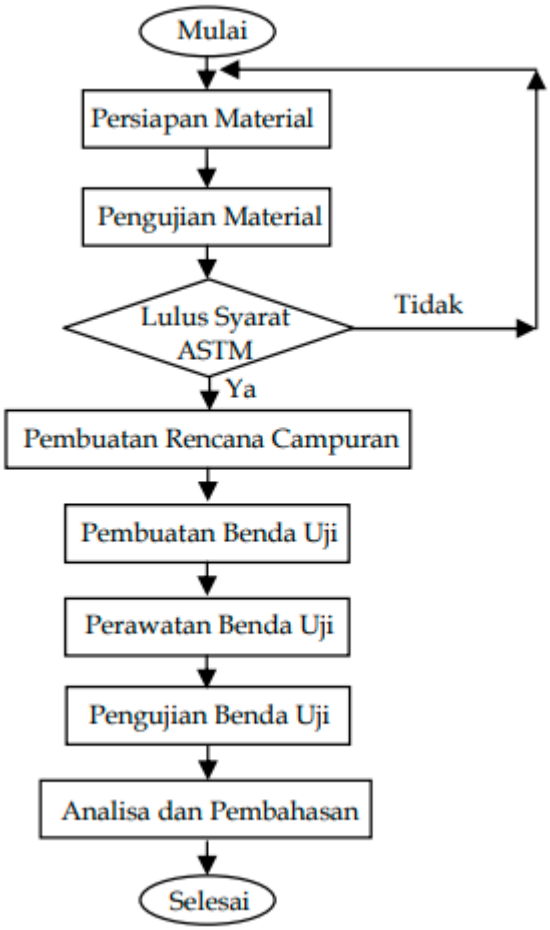

Figure 1: Flowchart of the research

4. RESULTS

1. Aggregate Inspection Results

Before carrying out the mix design, an examination / testing of the material to be used in this study was first carried out.

Table 1. Characteristic inspection results of marine sand

No	Karakteristik agregat	interval	Hasil pengamatan		Nilai rata-rata	ket
			I	II		
1	Kadar Lumpur	Max 5%	2,78%	2,48%	2,63%	Memenuhi
2	Kadar Organik	< No. 3	Baik	Agak Keruh		Memenuhi
3	Kadar Air	2%-5%	2,40%	2,15%	2,27%	Memenuhi
4	Berat Volume					
	a.Kondisi lepas	1,4-1,9 kg/liter	1,54	1,56	1,55	Memenuhi
	b.Kondisi padat	1,4-1,9 kg/liter	1,68	1,70	1,69	Memenuhi
5	Absorpsi	0,2-2%	1,87%	1,67%	1,77%	Memenuhi
6	Berat jenis spesifik					
	a. Bj. Nyata	1,6-3,3	2,82	2,79	2,80	Memenuhi
	b. Bj. Dasar kering	1,6-3,3	2,68	2,66	2,67	Memenuhi
	c. Bj. Kering Permukaan	1,6-3,3	2,73	2,71	2,71	Memenuhi
7	Modulus Kehalusan	1,50-3,8	2,91	2,93	2,92	Memenuhi

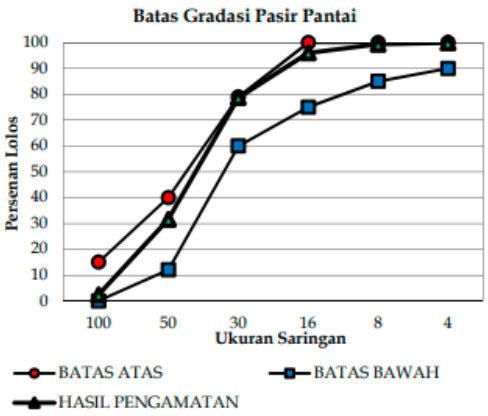

Figure 2: Gradation limits of marine sand

Shown in Table 1, for the gradation limit of sea sand, a gradation graph is drawn along with the gradation limit required by ASTM C-136, with the results of the analysis of sieve number 3 of 99.97%, sieve number 8 of 99.39%, sieve number 16 of 96.03%, sieve number 30 of 78.73%, sieve number 50 passes by 31.58%, and sieve number 100 of 2.39%. So it is concluded that the gradation limit of beach sand is included in zone 3, namely rather fine sand. And for graphical analysis can be seen in Figure 6: Graph of fine aggregate gradation of beach sand.

2. Mix Design

The mortar mix planning carried out in this study used a method derived from the Indonesian National Standard (SNI 03-6825-2002, 2002):

Table 2: Composition of mixtures for making test specimens

Material	Jumlah	Satuan
Pasir	229,17	Gram
Semen	83,34	Gram
Air	40,34	ML

Sumber SNI 03-6825-2002

5. DISCUSSION

The discussion section is arguably the most important part of an article, as it is the last section a reader sees and can significantly impact their perceptions of the article and the research conducted. Different authors take varied approaches when writing this section. The discussion section should:

1. Deployment Flow Calculation

In this study, the flow or consistency of the mixture is important to know in order to obtain an indication that shows the wetness of the cement paste, flow testing is carried out based on the Indonesian National Standard (SNI 03-6825-2002, 2002) in this study the flow to be achieved is DR =1.00-1.15 Ds.

Table 3. Slump test results

Diameter cincin (D_s)	Diameter setelah digetarkan	Rata-rata	Nilai Flow (D_{RJ})	Standar	Ket
9	18,1 18,25 18,5 18,15	18,25	1,028	1,00-1,15	memenuhi

2. Testing for compressive strength

Testing the compressive strength of mortar refers to the Indonesian National Standard (SNI 03-6825-2002, 2002) and Standard Test Method for Compressive Strengh of Cylidrical Concrate Speciment (ASTM, C-21, 2023). The results of the mortar compressive strength test can be seen in Table 4.

Table 4. Results of mortar compressive strength test

Benda Uji	Kuat tekan ($f'c$)(Mpa)				
	3	7	14	21	28
Mortar Pasir Pantai	7,20 7,60 7,60	12,00 10,40 9,60	12,00 11,20 11,20	12,40 12,80 13,60	13,60 14,00 14,80
Rata-Rata	**7,47**	**10,67**	**11,47**	**12,60**	**14,13**
Mortar Pasir Sungai	7,20 8,40 8,00	13,20 12,00 10,40	14,40 13,60 14,00	18,80 20,00 18,00	22,80 22,40 22,40
Rata-Rata	**7,87**	**11,87**	**14,00**	**18,93**	**22,53**

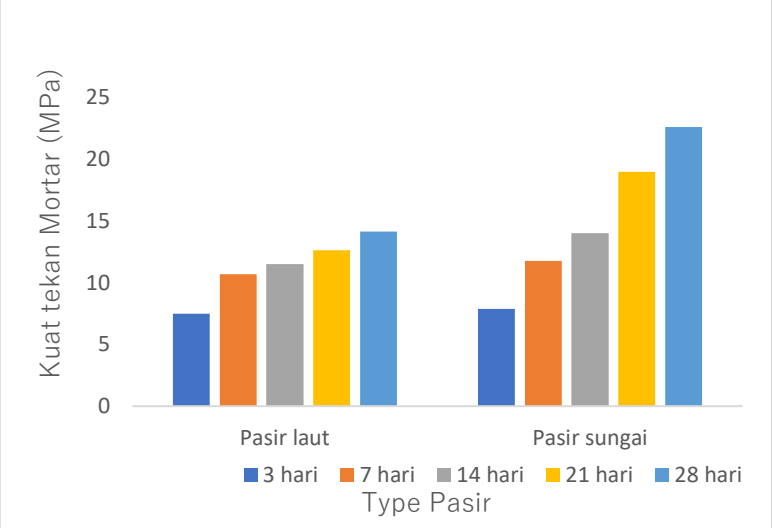

Figure 3. Comparison chart of compressive strength of sea sand and river sand mortar

Based on the results of the study, the average compressive strength obtained at the age of 3 days was 7.47 MPa, at the age of 7 days, 10.67 MPa, age 14 days, 11.47 MPa, age 21 days 12.60 MPa and the compressive strength achieved on day 28 only reached 14.13 MPa. The compressive strength achieved is in the category of type S mortar which has a compressive strength of min. 12.5 MPa, the decrease in mortar quality from the expected results is due to the uniform gradation of sea sand so that the resulting cubes have many voids.

Based on the results of the study, the average compressive strength obtained at 3 days 7.87 MPa, 7 days 11.73 MPa, 14 days 14 MPa, 21 days 18.93 MPa and the compressive strength achieved on day 28 only reached 22.53 MPa. The compressive strength achieved is in the category of type M mortar which has a compressive strength of min. 17.2 MPa, the high quality of the mortar produced is due to the various gradations of beach sand used. So that the cubes produced are so dense and the binding between the aggregates is very good.

Comparison of the compressive strength of cement mortar between sea sand and river sand, the compressive strength of cement mortar derived from sea sand is always below the compressive strength of mortar derived from river sand. at the age of 3 days the difference in compressive strength is only 5.08%, at the age of 7 days the difference reaches 9.03%, at the age of 14 days the difference is increasingly visible, namely 18.07%, and at the age of 21 the difference reaches 33.43% while at the age of 28 days.

Table 4 and Figure 3 show that the cement mortar derived from marine sand is always below the cement mortar derived from river sand. The compressive strength of the marine sand cement mortar at 28 days was 8.46 MPa or 37.45% lower than the compressive strength of the river sand cement mortar at the same age of 22. 59 MPa, due to the lack of specimen mass, as stated (Neville, 1981) and (Tjokrodimuljo, 1996) that the specimen density factor formed by

the arrangement of aggregate gradation greatly affects the quality of mortar, almost 70% of the strength of the test specimen is supported by the quality of the aggregate, the density of the cube composed of river sand aggregate is more compact due to the gradation of river sand, the grains fill the space between the grains.

6. CONCLUSION

Based on the results of laboratory testing, cement mortar using beach sand aggregate is included in category S of the Indonesian National Standard (SNI 6882: 2014), which is a mortar that has a minimum compressive strength of 12.5 Mpa, this type S mortar can be used as an alternative in the construction of parts of the building that are not too load-bearing, parts of the building that do not have reinforcement, non-load-bearing walls and backrest walls. The decrease in compressive strength is due to grains derived from predominantly smaller sea sand against diverse river sand. Making mortar from sea sand should be washed first to reduce the NaCI content.

7. LIMITATION

Research with similar types of concrete mixes needs to be continued with the temperature/temperature recording time carried out up to 3×24 hours for consideration of the accuracy of estimating the compressive strength of concrete using the 3-day basic age maturity method.

The research needs to be continued with the duration of the research until the testing age is more than 1 year to validate whether the increase in concrete strength is still high enough according to the calculation using the maturity method in predicting the compressive strength of concrete.

The study of concrete mixing methods, especially the use of different types of mixers, along with the sequence of input of concrete constituents into pan mixers / other types of mixers to be able to ensure the similarity of treatment between types of concrete with different grades.

Research by measuring the temperature of the mixing water before mixing into the concrete mix needs to be further investigated in order to formulate the effect of the concrete maturity index on the temperature of the mixing water.

Research using different curing methods should be considered with immersion of specimens in seawater to examine the effect of immersion of specimens on the value of the coefficient of prediction of compressive strength in similar concrete mixtures.

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