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Early Age Compressive Strength of Concrete Made With Mountain Sand, River Sand and Portland Composite Cement

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Abstract:

The use of fine aggregate as a concrete mixture in the construction of the building certainly can't be separated from the availability of sand material in the mine. One of them is in Lembang Marinding, Mengkendek Subdistrict, North Toraja District there are materials that can be used as fine aggregate in concrete mixture. This study was conducted to determine the feasibility of sand from Lembang Marinding as a mixture of concrete. This research method is done with experimental in laboratory, that is a research which try to get physical properties of material to be used in concrete mixture with quality f'c 25 MPa. In this research make 2 concrete mixture were mixture I (using river sand) and mixture II (using mountain sand). To get the result done a series of test to concrete cube test object based on Standard National of Indonesia to get the compressive strength of concrete made with mountain sand, river sand and portland composite cement in early age of 3 and 7 days. This shows that the use of natural sand from Lembang Marinding is feasible to be used as fine aggregate in concrete mixture, the result of the average compressive strength of concrete produced mixture I at the age of 3 and 7 days were 13.36 and 16.60 MPa. Compressive strength of concrete produced mixture II at the age 3 and 7 days were 16.31 and 18.67 MPa. The results of the inspection of mountain sand in Lembang Marinding are suitable for use as fine aggregate in concrete mixtures.

Keywords: Early age, Compressive strength, Fine aggregate, Portland composite cement

I. INTRODUCTION

Concrete was widely used as a building material. The material is obtained by mixed Portland cement, water and aggregate in a certain ratio and the mixture when poured into a mold and then allowed to harden like rock [1,2]. Normal concrete was concrete that has a unit weight of 2200-2500 kg/m^3 and made using crushed stone natural aggregate, and concrete is a function of its

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

constituent materials consisted of hydraulic cement (portland cement), coarse aggregate, fine aggregate, water and additives (admixture) [3,4].

In the process forming of concrete, cement and water will form a cement paste which functions as an adhesive/binder in the hardening process. In the hardening process, the cement paste and fine aggregate (sand) will form a mortar that will close the cavities between the coarse aggregate (gravel or crushed stone) while the pores between the fine aggregates are filled with cement paste which is a mixture of cement and water so that the aggregate grained were tightly bound together and form a compact or solid mass [5-9].

The concrete structure influenced by the composition and quality of the concrete mixing materials, which are limited by the compressive strength of the concrete as stated in the design. It also depends on the bearing capacity of the soil. Thus, concrete is a function of its constituent materials, one of which consists of cement paste formed from water and cement [10].

Casting is carried out at least within one day, then you have to wait for the concrete to be 7 days old, then the formwork can be dismantled and the next work done. The length of time this process takes and waiting for the strength of the concrete to be at a safe limit to carry out the next work makes construction projects often take longer to complete [11]. The compressive strength of concrete will increase with increasing age of concrete. What is meant here is that since the concrete begins to be molded, the rate of increase in the initial compressive strength of the concrete fast, but over time, the rate of increase slows down. So as a standard compressive strength of concrete is compressive strength of concrete at 28 days [12].

This paper reported the results of compressive strength testing at the early age of 3 and 7 days from 2 concrete mixtures, namely concrete using river sand and concrete using mountain sand as fine aggregate. Compressive strength testing is carried out using compressive strength equipment. The compressive strength test carried out at this early age aims to determine the hydration process that occured in concrete at an early age, both using river sand and mountain sand as fine aggregate.

II. RESEARCH MATERIALS AND METHOD

A. Physical Properties of Fine Aggregate

Physical characteristics testing of fine aggregates carried out on river sand and mountain sand. River sand and mountain sand were obtained at Lembang Marinding, Mengkendek Subdistrict, North Toraja. The tests carried out are in the form of testing water content, volume weight, sludge content, specific gravity (bulk, apparent and saturated surface dry) and water absorption. Table 1 shows the results of testing the physical characteristics of fine aggregate. There were also characteristics of Lembang Marinding sand, included black sand, sand shaped of mountain and hard sand. Figure 1 shows the visual observation of mountain sand. Based on the results of physical characteristics of river sand and mountain sand, it is known that all test results meet the specifications of concrete materials according to ASTM and SNI standards.

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

TABLE I Physical properties of fine aggregate

No.	Characteristics	Results		Spesification (ASTM/SNI)
		River sand	Mountain sand	
1	Water content (%)	4.90	2.59	3 - 6
2	Volume weight (kg/l)			
	-Loose condition	1.27	1.43	1.2 – 1.9
	-Dense condition	1.36	1.55	1.2 – 1.9
3	Sludge content (%)	1.30	2.50	0.2 – 6.0
4	Bulk specific gravity	2.67	2.71	1.6 - 3.1
5	Saturated surface dry specific gravity	2.70	2.73	1.6 – 3.1
6	Apparent specific gravity	2.66	2.68	1.6 – 3.1
7	Water absorption (%)	4.60	4.71	0.2 – 5.0

Fig 1: Visual observation of Mountain sand

B. Physical Properties of Coarse Aggregate

Table 2 shows the results of testing the characteristics of the coarse aggregate used in this study. Coarse aggregate in the form of crushed stone is an aggregate in which all the grains are retained on 4.80 mm sieve. Aggregates that conform to ASTM or SNI specifications do not always have an economic value in use and are for example unapproved materials but have good appearance. Thus, non-conforming material required special approval if acceptable evidence of appearance is desired as completeness. The tests carried out are in the form of testing water content, volume weight, sludge content, specific gravity (bulk, apparent and saturated surface dry), water absorption and abrasion.

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

TABLE II Physical properties of coarse aggregate

No.	Characteristics	Results
1	Water content (%)	2.25
2	Volume weight (kg/l)	
	-Loose condition	1.45
	-Dense condition	1.30
3	Sludge content (%)	1.30
4	Bulk specific gravity	2.48
5	Saturated surface dry specific gravity	2.50
6	Apparent specific gravity	2.54
7	Water absorption (%)	2.35
8	Abrasion (%)	27.16

C. Physical Properties of Portland Composite Cement

Portland cement is the most widely used construction material in the manufacture of concrete. According to ASTM C-150, portland cement is defined as a hydraulic cement produced by grinding clinker consisting of hydraulic calcium silicate, which generally contains one or more forms of calcium sulfate as generally containing one or more calcium sulfate as an additive which is ground together. same as the main ingredient. Table 3 shows the chemical constituents contained in cement. But basically there are 4 most important elements, namely:

1. Tricalcium silicate (C_3S) or $3CaO.SiO_2$
2. Dicalcium silicate (C_2S) or $2CaO.SiO_2$
3. Tricalcium Aluminate (C_3A) or $3CaO.Al_2O_3$
4. Tetracalcium Aluminoferite (C_4AF) or $4CaO.\ Al_2O_3.Fe_2O_3$

Cement and water will react to produce a plastic and workable cement paste. But after some time, the pasta will become stiff and begin to be difficult to work. This process is called initial binding. Furthermore, the cement paste will increase in stiffness so that a solid solid is obtained. This process is called final binding. Then the process continues until the paste has a strength called hardening.

TABLE III Physical properties of Portland composite cement

No.	Oxide	Percentage (%)
1	Lime	60-65
2	Silica	17-25
3	Alumina	3-8
4	Ferro	0.5-6
3	Sulfur	1-2
4	Potash	0.5-1

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

D. Research Method

The basic ingredients for forming concrete include cement, coarse aggregate, fine aggregate, water, and admixtures are usually used. The standard used for testing concrete-forming materials is the American Society For Testing And Materials (ASTM) standard. "1993 Annual Book of ASTM Standard.

In carrying out a research, researchers must first know the procedures for carrying out research in the laboratory, starting from the preparation of tools and materials. This is done to facilitate the research process. After all the tools and materials are ready, then aggregate testing is carried out, where this test is only based on testing coarse aggregate and fine aggregate.

The coarse aggregate test includes tests on sieve analysis, silt content, specific gravity, water absorption and aggregate density. Meanwhile, for testing fine aggregates, among others, tests on sieve analysis, silt content, specific gravity and water absorption. From the results of testing the coarse aggregate and fine aggregate material, if they do not meet the requirements, return to the retrieval or material preparation. then repeat the material test by taking a different sample from the previous one, and if it meets the specified requirements then proceed to the concrete mix design (mix design).

After obtaining the proportions of the ingredients used in the concrete mixture, the test specimens were made using a 15 x 15 cm mold. then after the manufacture of the test object has started to dry (can be removed from the mold), then the next process is the treatment of the test object by immersing the test object into an immersion bath. After proceeding with testing the compressive strength of concrete where this test is carried out when the concrete is 3 and 7 days old.

After getting the results of the compressive strength of concrete and if it does not meet the standard specifications, we return to the planning of the concrete mix, then repeat the procedure for making test objects and testing the compressive strength of concrete. If it meets the specifications, the results of the concrete compressive strength test will be obtained and analyze the test results to obtain data that will be used in the results for conclusions.

E. Compressive Strength Test

The compressive strength of concrete is the magnitude of the load per unit area that causes the concrete to crumble. The compressive strength test was carried out using a universal testing machine with a capacity of 1500 kN. Concrete must be designed in accordance with the proportion of the mixture in order to produce the planned compressive strength. Figure 2 shows the compressive strength equipment test using in this research. This test is carried out according to ASTM C 469-02. Based on research conducted according to the standard gives the following formula:

$$F'c = \frac{P}{A}$$

where :
$f'c$ = compressive strength of concrete (MPa)
P = maximum load (kN)
A = cross-sectional area of the test object (mm^2)

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

Fig 2: Compressive strength test equipment

III. RESULTS AND DISCUSSION

A. Combined Aggregates Gradation

Combined Aggregates Gradation is the mixing of fine aggregate and coarse aggregate, into a homogeneous mixture and has a grain arrangement according to the standard. There are several ways that can be done in combining aggregates, namely: the trial and error method, the diagonal method, the graphical method, and the analysis method. The results of the sieve analysis test showed that the mountain sand in Lembang Marinding district, fine aggregate and coarse aggregate have fine grained modulus values of 3.831, 3.826 and 8.493, respectively.

B. Mixtures Design

The mixtures design in 1 m^3 can be seen in Table 4. The design of the concrete mix made was concrete with f'c design of 25 MPa.

TABLE IV Mixtures design (1 m^3)

Material	Concrete mixture (kg)	
	Coarse aggregate + river sand	Coarse aggregate + mountain sand
Cement	488	488
Water	205	205
Coarse aggregate	1,080	1,123
River sand	557	579
Mountain sand	-	-

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

C. Compressive Strength

Testing the compressive strength of concrete in the laboratory produces the raw value of the concrete compressive strength machine and must be processed first to get the compressive strength of the tested concrete. Before testing the compressive strength of the concrete, first weighing the concrete made of river sand and mountain sand at an early age of 3 and 7 days as shown in Figure 3.

It can be seen that the weight of concrete using river sand as fine aggregate at the age of 3 and 7 days were 11.36 and 11.70 kg, while the concrete using mountain sand as fine aggregate at the age of 3 and 7 days were 11.41 and 11.68 kg, respectively. Figure 4 shows the comparison of the compressive strength of concrete produced in concrete using river sand and mountain sand as fine aggregate.

The compressive strength obtained is different for each sample and the age of treatment. This is influenced by several factors, starting from the time of mixing the material, when the concrete mixture is punctured in the mold and in the concrete treatment (immersion) process. This causes each sample to have different pores, so that the compressive strength of the resulting concrete will be different.

From Figure 4, it can be explained that at the age of 3 days the compressive strength of the sand concrete of Mount Lembang Marinding the average yield was 16.31 MPa from the normal compressive strength (river sand) 13.35 MPa, 7 days the compressive strength of the sand of Mount Lembang Marinding the average yield was 18.67 MPa from the normal compressive strength of 16.6 MPa (river sand).

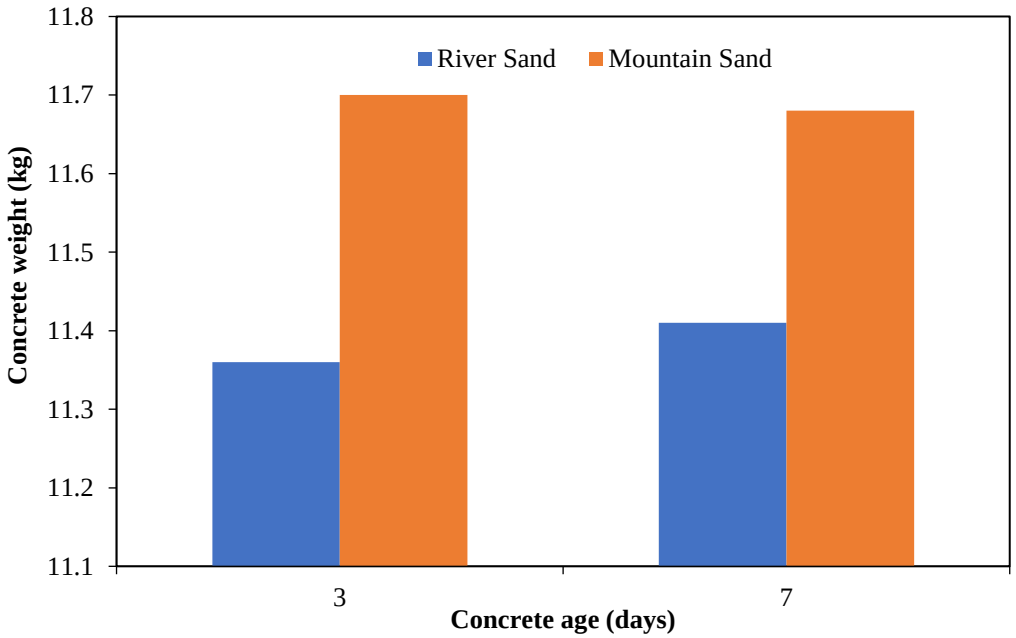

Fig 3: Weight of concrete

ISSN: 0011-9342 | Year 2021
Issue: 9 | Pages: 10398-10406

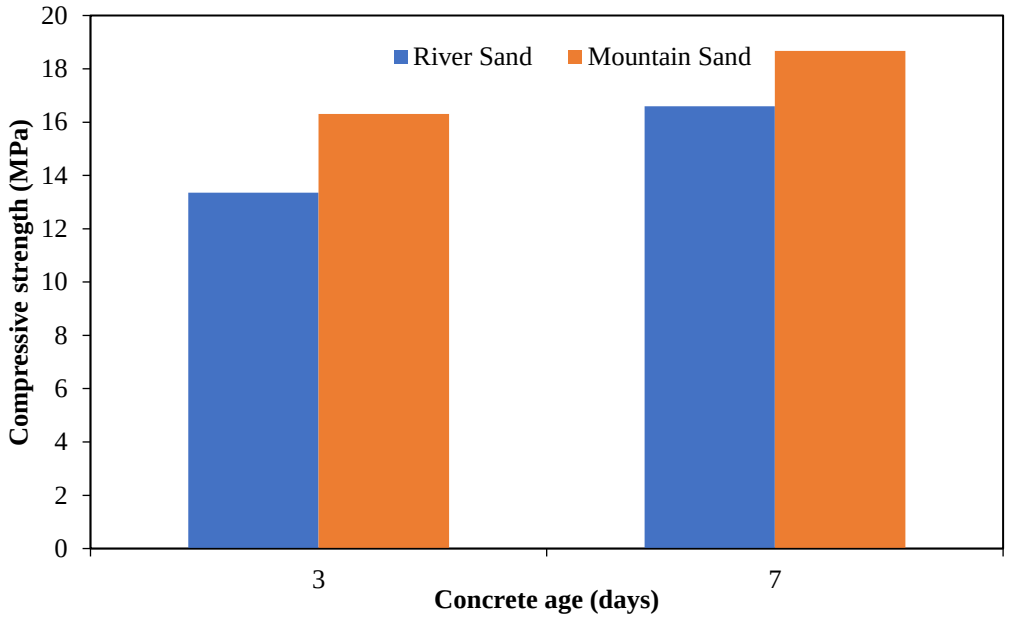

Fig 4: Compressive strength of concrete

Based on the compressive strength test result, it is worth to note that an the interaction between all materials through an excellent bond between coarse aggregate, fine aggregate (mixture I: river sand and mixture II: mountain sand) and PCC based concrete can obtain a good capability to produce high quality of concrete mixture where such attribute provide a good capacity to bear the compressive load.

IV. CONCLUDING REMARKS

The result of the average compressive strength of concrete produced mixture I at the age of 3 and 7 days were 13.36 and 16.60 MPa. Compressive strength of concrete produced mixture II at the age 3 and 7 days were 16.31 and 18.67 MPa. The results of the inspection of mountain sand in Lembang Marinding are suitable for use as fine aggregate in concrete mixtures.

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