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Compressive Strength Characteristic of Concrete Using Mountain Sand

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Abstract. The used of fine aggregate as concrete mixture in building construction is certainly inseparable from the availability of materials. One area that has abundant reserved of fine aggregate was in Lembang Marinding, Tana Toraja Regency, South Sulawesi Province which can be used as fine aggregate in concrete mixture. This research was conducted to determine the compressive strength of concrete from Lembang Marinding sand which was classified as mountain sand as concrete mixture. This research method was carried out experimentally in the laboratory, which was this study aims to obtain the physical properties of the material and which will be used in concrete mixture with a concrete quality plan of f'c 25 MPa. To obtained the results, a series of tests were carried out on 15 cm × 30 cm concrete cylindrical specimens based on Indonesia requirements, SNI 03-2847-2019 standard, to produce compressive strength of concrete. The results showed that the use of natural sand (mountain sand) from Lembang Marinding can be used as fine aggregate in the concrete mixture. The average compressive strength of the concrete produced at the age of 28 days was 26.83 MPa. The compressive strength results obtained have met the planned concrete quality in this research.

1. Introduction

The current development of concrete is the most widely used material in construction, both in buildings, bridges, weirs, and other constructions. Concrete is a mixture of fine aggregate (sand), coarse aggregate (crushed stone or other types of aggregates) and cement (PCC, PPC or OPC types) which are held together by water in a certain ratio and admixture [1-3].

The quality of characteristics of fine aggregate used as a structural component of concrete play an important role in determination the quality characteristics of the resulted concrete structure, because fine aggregate as used for fills most of the 65% volume of concrete. Mountain sand as a type of fine aggregate material has availability in large quantitied but in quality it still needs to be investigated further on the concrete structure. Fine aggregate is natural sand as a result of natural disintegration of rock or sand produced by the crushed stone industry and had the largest grain size of 5.0 mm [4-6].

The use of fine aggregate as a concrete mixture in building construction is certainly inseparable from the availability of sand material at the mining site. One of them is in Lembang Karua, Balusu sub-district, North Toraja Regency, South Sulawesi province where the sand has been investigated by [7,8]

which is used for produced geopolymer mortar and asphalt mixture. where the results of the study stated that mountain sand was suitable for use as fine aggregate in mortar, concrete and asphalt mixtures.

There is also sand material at the mining site in Lembang Marinding, Mengkendek District, Tana Toraja Regency, there is black mountain sand, most likely the sand can be used as fine aggregate in concrete and asphalt mixtures [9,10]. Lembang Marinding mountain sand itself has not been managed and utilized by the government and the people of Lembang Marinding and the availability of mountain sand is quite a lot, if the sand is not managed or utilized it will only become a useless pile.

The use of Lembang Marinding mountain sand can be used as fine aggregate in the manufacture of concrete if the quality of the resulted concrete can meet the concrete strength standards for structural buildings in accordance with applicable regulations. This research was conducted to determine the compressive strength of concrete from Lembang Marinding sand which was classified as mountain sand as concrete mixture.

2. Materials and Method

2.1. Overview of Research Sites and Materials Collection Locations

One of the important things that need to be considered in conducting research is the selection of research locations and the location of material collection for the manufacture of test objects. While the location of fine aggregate collection used is in Lembang Marinding which is approximately 28 km from Rantepao, Lembang Marinding is an area located in Mengkendek District, Tana Toraja Regency with geographical coordinates located at 2 54’50” South Latitude and 119 56' 56 BT. The boundaries of the Lembang Karua area are the north is Lembang Palipu, the east is Lembang Simbuang, the west is Lembang Rantekarua and the south is Lembang Kepe Tinoreng.

2.2. Visual and Physical Characteristics of Mountain Sand in Lembang Marinding

There were also characteristics of Lembang Marinding sand, included black sand, sand shaped of mountain and hard sand. Figure 1 and Table 1 shows visually and physical characteristics of mountain sand in Lembang Marinding district, North Toraja district, South Sulawsi Privince. Based on the results of physical characteristics of mountain sand in Lembang Marinding, it is known that all test results meet the specifications of concrete materials according to ASTM and SNI standards.

Figure 1. Visually of mountain sand in Lembang Marinding district

Table 1. Physical characteristics of mountain sand in Lembang Marinding distric

No	Types of inspection	Results of inspection	Spesification (ASTM/SNI)

1	Water content (%)	2.59	3 - 6
2	Volume weight (kg/l)		
	-Loose condition	1.43	1.2 – 1.9
	-Dense condition	1.55	1.2 – 1.9
3	Sludge content (%)	2.50	0.2 – 6.0
4	Bulk specific gravity	2.71	1.6 - 3.1
5	Saturated surface dry specific gravity	2.73	1.6 – 3.1
6	Apparent specific gravity	2.68	1.6 – 3.1
7	Water absorption (%)	4.71	0.2 – 5.0

2.3. Physical Characteristics of Fine and Coarse Aggregate

Table 2 shows the physical characterisics of fine and coarse aggregate. 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. Based on the results of physical characteristics of fine and coarse aggregate, it is known that all test results meet the specifications of concrete materials according to ASTM and SNI standards.

Table 2. Physical characteristics of fine and coarse aggregate

No	Types of inspection	Results of inspection	
		Fine aggregate	**Coarse aggregate**
1	Water content (%)	4.90	2.25
2	Volume weight (kg/l)		
	-Loose condition	1.27	1.45
	-Dense condition	1.36	1.30
3	Sludge content (%)	1.30	1.30
4	Bulk specific gravity	2.67	2.48
5	Saturated surface dry specific gravity	2.70	2.50
6	Apparent specific gravity	2.66	2.54
7	Water absorption (%)	4.60	2.35
8	Abrasion (%)	-	27.16

2.4. Research Stage

The stages in this research start from collecting data on stirred, make concrete mixture, treatment and testing.

2.4.1. Collected Data

Data is an influential factor and is needed to determine the compressive strength of concrete. In this study the data needed from experiments in the laboratory.

2.4.2. Making Concrete Mix

1. Weighing of materials, such as cement, fine aggregate, coarse aggregate and added materials according to the needs of the concrete mix planned.
2. Put cement, fine aggregate, coarse aggregate and cement into the mixer, followed by turning on the mixer.
3. When the mixer starts to rotate, always try to keep it tilted at about 45 C, so that there was an even mix of concrete
4. Prepared the mold that will be used to maked the test object by first smearing it with oil
5. Insert the concrete mixture into the mold using a squeezer, is done little by little while stabbed to make it porous.

6. The printed mixture was placed in a place protected from sunlight and rain and allowed to stand for ± 24 hours.
7. The mold can be opened by giving a code/information to the concrete.

2.4.3. Concrete Treatment

The test object that has been removed from the mold and given a mark was treated by immersed in a water until the time limit for testing the strength of the concrete. The treatment of this test object is carried out according to ASTM 171-03. Treatment of this test object is carried out with the aim of :

1. Prevent the evaporation of water that is too fast in early concrete, so that it can caused cracking of the surface of concrete.
2. Stabilized hydration of cement so as to increase the possibility of achieved the required concrete strength.

2.4.4. Compressive Strength Test

When the concrete age was 28 days, the compressive strength test can be carried out using a compressive strength equipment.

2.5. Compressive Strength Test

Compressive strength is one of the main performance of concrete. Compressive strength is the ability of concrete to accept compressive forces per unit area. The 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. The compressive strength is represented by the maximum stress $f'c$ in N/mm^2 or MPa. Figure 2 shows the compressive strength equipment.

Compressive strength test equipment is UTM with a capacity of 3000 KN. The compressive speed of the compressive strength test equipment ranges from 4 kg/cm^2 to 6 kg/cm^2 per second. Based on research conducted according to the standard (ASTM C 469-02) gives the following formula:

$$f'c = P/A$$

Where :

$f'c$ = compressive strength of concrete
P = maximum load
A = cross-sectional area of the test object

Figure 2. Compressive strength test equipment

3. Results and Discussion

3.1. Combined Aggregate Gradation

The results of combined aggregate gradation for concrete mixture based on the combined aggregate gradation with the coarse aggregate and fine aggregate (river sand) and coarse aggregate and fine aggregate (mountain sand) in concrete mixture are shown in Table 3 and Table 4.

Table 3. Combined aggregate gradation with coarse aggregate and fine aggregate (river sand)

Sieve Size	Fine Aggregate	Coarse Aggregate	Aggregate Percentage		Aggregate
	% Pass		34%	66%	
1 1/2	100	100	34	66	100
1"	100	100	34	66	100
3/4"	100	97.2	34	64.15	98.15
3/8"	100	38.2	34	25.21	59.21
No. 4	100	0	34	0	34.00
No. 8	99.45	0	33.81	0	33.81
No. 16	96.55	0	32.83	0	32.83
No. 30	83.40	0	28.36	0	28.36
No. 50	37.05	0	12.60	0	12.60
No. 100	7.35	0	2.50	0	2.50
No. 200	1.85	0	0.63	0	0.629
Pan	0	0	0	0	0

Table 4. Combined aggregate gradation with coarse aggregate and fine aggregate (mountain sand)

Sieve Size	Fine Aggregate	Coarse Aggregate	Aggregate Percentage		Aggregate
	% Pass		34%	66%	
1 1/2	100	100	34	66	100
1"	100	100	34	66	100
3/4"	100	97.2	34	64.15	98.15
3/8"	100	38.2	34	25.21	59.21
No. 4	100	0	34	0	34.00
No. 8	99.7	0	33.90	0	33.90
No. 16	99	0	33.66	0	33.66
No. 30	77.5	0	26.35	0	26.35
No. 50	31.85	0	10.83	0	10.83
No. 100	11.35	0	3.86	0	3.86
No. 200	4.85	0	1.65	0	1.65
Pan	0	0	0	0	0

3.2. Mixtures Design

The design of the concrete mix made was concrete with f'c design of 25 MPa.

Table 5. 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	-	-

3.3. Compressive Strength

Compressive strength testing was carried out to determine the compressive strength value of concrete made of coarse aggregate fine aggregate (river sand) and coarse aggregate and fine aggregate (mountain sand). The compressive strength test was carried out at the age of 28 days using the UTM equipment.

The results of the compressive strength test show that the average compressive strength of 3 specimens at the age of 28 days for concrete made of coarse aggregate fine aggregate (river sand) and coarse aggregate and fine aggregate (mountain sand) is 25.57 MPa and 26.83 MPa. This shows that the concrete made from coarse aggregate and mountain sand is 4.93% higher than the concrete made from coarse aggregate and river sand. 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 resulted concrete will be different.

4. Concluding Remarks

The resulted of the inspection of fine aggregate in Lembang Marinding which are classified as mountain sand were suitable for used as fine aggregate in concrete mixtures. The resulted of testing the compressive strength of cylindrical concrete measuring 15 x 30 cm used sand from Lembang Marinding (mountain sand) experienced an increased in the compressive strength of concrete, which was 26.83 MPa from the design strength of 25 MPa.

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