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RESEARCH ARTICLE

Characteristics Of Saddang River Sand, Pinrang Regency, South Sulawesi, Indonesia Based On Grain Gradation, Mud Content And Specific Gravity

Arsyad [1*], Moch. Aris Arifin[1], Muh. Ihsan Mukrim[1], Jamaluddin [1] Hamzah [1], Abd. Rauf [1], Ruslan Bauna[1], Reno[1], Nurhikmah[1], Abdul Latif[1]

[1]*Civil Engineering Department, Baramuli Engineering College, Jalan Pole Baramuli, Poros Polman - Pinrang, South Sulawesi, Indonesia*

* Corresponding author : achayunus@gmail.com
Tel 081245202123
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Abstract

The research aims to determine the characteristics of sand grain gradation, mud content and specific gravity of Saddang River sand. Saddang river sand is the main source of sand used in construction activities in South Sulawesi and West Sulawesi. In order to ensure that Saddang river sand meets the quality standards used in the construction world, it is necessary to conduct research related to Gradation of grains, mud content and specific gravity of sand. These three factors are part of the factors that determine the quality of concrete and cement mixtures. The research was located at the Saddang River sand mine in Pincara Village, Patampanua subdistrict, Pinrang Regency, South Sulawesi, Indonesia. The research method uses field surveys and laboratory analysis to analyze the gradation of sand grains, mud content and specific gravity. The results of the sieve analysis show that the Saddang River sand is classified as gradation zone no. 4 or classified as fine sand based on the fine aggregate gradation table SNI 03-2834-2000 and ASTM C-33. The results of the analysis of the Saddang River sand mud content ranged from 2.233% to 2.250%, fulfilling SNI 03-4804-1998 which has been determined at a maximum of 5%. The specific gravity analysis show the average value of bulk specific gravity (2,489 gr/m3), dry specific gravity (2,524 gr/m3), and visible specific gravity (2,600 gr/m3). meets SNI 03-1970-2008 standards ranging from < 1.6 gr/m3 to 3.2 gr/m3. The ater absorption in fine aggregate ranged from 1.5% to 3.8%, meeting SNI 03-1970-2008 with a maximum of 5%.

Keywords: Saddang River, Sand Mining, Mud Content, Sand Specific Gravity, Sand Grain Gradation, Pincara

1. Introduction

As a country's population increases, the need for infrastructure will also increase. In order to meet the need for construction materials, the need for river sand also tends to increase (Simatupang, et al. 2024). The main and largest part of concrete is aggregate. As the main and largest element of concrete, aggregate certainly plays a key and important role in determining the properties of the material, especially the strength and durability of concrete. Among the aggregates contained in the concrete mixture, sand is an important and most determining component of concrete. This is because sand aggregate can provide mass and stability to the concrete mixture and can provide the required compressive strength of concrete. (Simatupang, et al. 2024; Abdias, et al. 2023). The source of fine aggregate for construction materials is currently mostly obtained from river sand mining activities (Simatupang, et al. 2024; Kusumayudha, et al. 2020; Rukmana, et al. 2020).

The Saddang River in Pinrang Regency, South Sulawesi Province is the main source of sand building materials in South Sulawesi. Saddang River sand, which is known in local and regional markets as pincara sand, is used not only in the South Sulawesi region, but also extends to the West Sulawesi province. In order to ensure that Saddang river sand meets the quality standards used in the construction world, it is necessary to conduct research related to Gradation of grains, mud content and specific gravity of sand. These three factors are part of the factors that determine the quality of concrete and cement mixtures. According to Rukmana *et al*, (2020), Therefore, it is important to know the characteristics of Saddang river sand based on grain size gradations, silt content and specific gravity. Sand is one of the most important aggregates and is needed in cement and reinforced concrete mixtures for the modern construction sector, road construction and paving, bridge and dam construction, buildings, housing, irrigation channels and so on. (Simatupang, et al. 2024). Abundant reserves of sand and gravel aggregate resources due to erosion and sedimentation from upstream rivers, as well as easy and affordable transportation access, mean that most sand and gravel mining activities are carried out along river basins (Juez and Franca, 2023; Magnus, 2023). Sand and gravel are extracted each year globally, with demand increasing, especially in developing countries (de Bortoli, 2023; Christina and Bert, 2023; Rangel-Buitrago *et al*., 2023). Demand for sand material for various purposes, such as construction and filling materials, increases (Schandl *et al*., 2017; Asare *et al*., 2023).

According to industry estimates, river sand accounts for more than 60% of the total sand used in concrete production worldwide (Dinh, *et al*, 2022; Prakash and Loganathan. 2022). The demand for construction-grade sand is growing at a tremendous rate and the world is expected to run out of this resource by 2050 (Simatupang, et.al.2024; Rentier and Cammeraat, 2022). Natural sand resources are increasingly scarce along with the rapid development of infrastructure (Zhou, *et al*. 2024; Chen, *et al*. 2024). One of the obstacles faced in the world of construction is that river sand aggregates have variations in quality and characteristics that are influenced and dependent on their origin, and than these variations in quality and characteristics significantly affect the properties of concrete and mortar. (Supriani, *et.al*. 2019; Abdias, *et al*. 2023). The increasingly scarce resources of natural stone and sand as well as economic and environmental considerations encourage the construction industry to looking for material alternatives to substitution of natural agregate in making mortar and concrete. (Liu, *et al*. 2024).

Sand functions as a material used as a building material to glue cement. Apart from that, sand is also the main ingredient for making concrete blocks and bricks. As stated in the Indonesian national standard (INS-S-04-1989-F;28), there are several important requirements for sand used in building materials. Below we will mention some of them. Fine sand aggregates should consist of granules with a sharp and hard texture. The hardness index for this type of sand is < 2.2. The grain size and type of aggregate and mineral additives are the main factors that influence of permeability and compressive strength of concrete (Huang, *et al*. 2020). Concrete should contain little or no very fine aggregate because this can result in a significant reduction in the durability and strength of the concrete (Zhong, et al. 2018).

According Indonesian National Standard , If sand is used with sodium sulfate, the maximum destroyed portion is 12% and is used with magnesium sulfate, the maximum crushed portion is 10%. The standard for sand is that it must not have a mud content of more than 5%. If the sand aggregate contains more than 5%, it must be washed first. There should not be too much organic material in the sand before the sand must be tested for a brane-harder color using a saturated solution of 3% NaOH (SNI-S-04-1989-F;28),. For large-grain sand types, it must have a fineness modulus of 1.5 to 3.8. Sand also consists of different grains. Sand must have a negative alkaline reaction to make concrete with a high level of durability.The research results of Piotrowska et al and Zhou et al show that aggregate size gradations have a significant impact on the strength and cracking of concrete. One of the important factors that causes mortar and concrete to have higher durability and strength is the use of well-graded aggregates (Liu, *et al*. 2024). It is important to pay attention to the gradation and morphology of the sand aggregate because it greatly influences the strength of the concrete (Wu, *et al*.2024; Cosic, *et al*. 2014). Aggregate size and gradation affect the strength and durability of concrete.(Shan, *et al*. 2022).

2. Research Methods

The research was carried out in 2 stages, referring to the Indonesian national standard number SNI-S-04-1989-F;28. namely field research and laboratory research. Field research is located in the Saddang River, Patampanua District, Pinrang Regency, South Sulawesi Province. Laboratory research was carried out in the Pinrang Regency Public Works Department laboratory. The diameter of the sand can be determined using the sieve analysis method. The sand sample test that we have prepared is a sieve analysis test. Because the sample consists of small stones and sand. Where the test is intended to determine the size of the sand grains retained by filter no. 100. The steps for sieve analysis testing are :

a. Oven dried sample of 1000 g, which passed sieve No.4.
b. Clean the #3/8, #4, #8, #16, #30, #50, #100 filters used, then weigh each filter according to the standards used.
c. Insert the sample into the filter arrangement.
d. Then shake the filter for ±15 minutes.
e. After shaking, leave it for 5 minutes to give the dust a chance to settle.

The formula used to calculate the filter analysis value is:

$$BST - BS = MS \quad (1)$$

Formula Description :

BST = Filter weight with retained mass (gr)
BS = Filter weight
MS = Retained mass (gr)

Mud Content Calculation used formula :

$$\frac{B1-B2}{B2} \text{ x } 100\% \quad (2)$$

Formula Description :

B1 = Weight of sand before oven (gr)
B2 = Weight of sand after oven (gr

Dry bulk specific gravity Used formula

$$\frac{A}{B+S-C} \quad (3)$$

Surface dry specific gravity used formula

$$\frac{S}{B+S-C} \quad (4)$$

Apparent specific gravity used formula

$$\frac{S}{B+A-C} \quad (5)$$

Formula Description :

C = Weight of pycnometer filled with sand + water (gr)
A = Weight of sand after drying (gr)
B = Weight of the pycnometer filled with water (gr)
S=Weight of dry face sand (gr)

3. Result and Discussion

3.1. Sieve Analysis Result

Based on SNI ASTMC136:2012 concerning Sand Sampling Methods, to determine the characteristics of Saddang River sand in Pincara village, Patampanua subdistrict, Pinrang district. The sand sampling location consists of 6 points, each consisting of 3 points upstream and 3 points downstream of the Lasape bridge. Each point consists of 15 samples which are placed in a bottle to prevent contamination with air.

Sampling was carried out at 6 locations, with the number of samples at each point consisting of 5 samples each with sample identification as follows:

1. Sampling location A each consists of sampling points A-1, A-2, A-3, A-4 and A-5.
2. Sampling location B each consists of sampling points B-1, B-2, B-3, B-4 and B-5
3. Sampling location C each consists of sampling points C-1, C-2, C-3, C-4 and C-5
4. Sampling location D each consists of sampling points D-1, D-2, D-3, D-4 and D-5
5. Sampling location E each consists of sampling points E-1, E-2, E-3, E-4 and E-5

6. Sampling location F each consists of sampling points F-1, F-2, F-3, F-4 and F-5

Sample Analysis Results in this research, analysis was carried out on samples of Saddang River sand, which consisted of sieve analysis of the number of samples tested, 1000 gr, mud content analysis of the number of samples of 500 g, and specific gravity analysis of the number of samples of 500 gr, with the following results in table 1.

Based on the results of laboratory tests on Saddang River sand samples using sieve no. 4, 8, 16, 30, 50, 100 and pan, results were obtained according to SNI ASTMC 136: 2012 where the fine grain modulus value was between 1.50-3.80 mm with grain variations according to gradation standards.
With the formula (1)

Table 1. Results of sieve analysis

No. Sieve	Sampling Location						Average
	A	B	C	D	E	F	
100	36.7	35.0	36.0	35.6	35.2	35.4	30.3
50	46.2	45.7	47.9	80.2	48.4	41.9	51.7
30	59.4	57.9	58.7	95.1	63.4	52.9	64.6
16	95.5	93.5	92.6	98.8	93.1	92.5	94.3
8	99.4	98.5	98.1	99.5	98.0	98.6	98.7
4	99.8	99.7	99.8	100	99.7	99.9	99.8
3/8	100	100	100	100	100	100	100

Referring to the fine aggregate gradation based on SNI 03-2834-2000 and ASTM C-33, the average result of the Saddang River sand sieve analysis is included in gradation no. 4 or is classified as fine sand, with a fine grain size ranging between 1.5 - 3.8 mm. Thus, in terms of the size of the fine aggregate gradation, Saddang river sand meets the quality standards for construction sand.. The gradation size of sand that meets quality standards is very important in the construction world. In addition to maintaining the quality of the building, it also plays a role in the use of mineral resources and cost efficiency (Wijaya, et.al. 2024., Zhang, Y, et al, 2024). Aggregate size can affect the yield stress, viscosity and compactness of concrete (Jiajian & Wenxue, 2025). Aggregate characteristics such as shape, maximum size, and volume content can significantly affect the properties of concrete under dynamic loading. Aggregate behavior, which is also affected by the loading rate, can further affect the properties of concrete (Mohmad, et al. 2025; Lei, et al. 2025; Singh & Gupta, 2024).

The mechanical characteristics or behavior of concrete are influenced by the aggregate size as a size effect (Jue, et al. 2024; Min, et al. 2024). The size effect is an important factor of quasi-brittle fracture mechanics or cohesive softening and damage mechanics. It has a direct impact and influence on the theory of structure (Duofa, et al. 2024). Aggregate size also greatly affects the quality of concrete because it can result in high porosity in the concrete mix (Harmiyati, et.al. 2024). Porosity is an important factor that affects the macroscopic mechanical behavior of concrete and is also closely related to the effect of aggregate size (Lei, et al. 2025; Bassam, et al. 2022). High porosity can cause cracks in the concrete and construction failure. Porosity can result in microcracks that can potentially increase the permeability of concrete. Furthermore, as concrete resists external pressure, mechanical cracks form in existing microcracks and propagate through the coarse aggregate and paste matrix, potentially leading to concrete failure (Chandrabhan & Pramod, 2024; Yu & Oğuzhan, 2022).

As one of the main components of concrete, aggregate constitutes approximately 70–80 % of the volume of concrete It exerts a direct influence on the workability, mechanical properties, and durability of the concrete, thereby significantly impacting the service life, safety, and engineering economy of building structures. Consequently, meticulous selection and utilization of appropriate aggregate pose a critical challenge

3.2. Mud Content analisis Result

The mud in the sand will prevent the bond between the cement paste and the sand surface, which will result in the strength of the mortar being reduced, and ultimately the compressive strength of the concrete will also be reduced.

The mud content in sand is limited, namely it cannot be more than 5%, if more, the sand must be washed according to SNI. Based on SNI 03-4804-1998 concerning Testing Methods for mud Content, to determine the mud content of Saddang River Sand, use a test mass of 500 grams using the formula (2). Based on SNI 03-4804-1998 concerning mud content testing methods, an average sludge content result was obtained with a value of 2.233%. SNI requirements for a maximum sand mud content of 5.0%. So the test results meet the specified SNI. Calculating of mud content using formula (2) and than the result of mud content analysis in table 2.

Mud is a particle measuring 0.075 microns or more. Mud does not mix well with cement, so preventing mixing between cement and aggregate. In engineering, aggregates used to make concrete often have a mud content that exceeds the specified threshold. Mud covers the surface of the aggregate, forming a covering layer on the contact area between the surfaces. The surface of the aggregate covered with mud prevents the bonding between the aggregate and the cement material, thereby reducing the strength of the concrete. The mud layer on the aggregate has a direct and significant effect on the reduction in performance and strength of the concrete, making it difficult to obtain high-quality concrete. The nature of the mud on the surface of the aggregate absorbs more water than cement. The mud content in the aggregate affects the hydration of cement. Low cement hydration can reduce the permeability, water absorption, pore structure and connectivity of concrete or mortar.

The bond between cement and aggregate is very important in concrete mixes, thus affecting the strength and durability of concrete. The higher the mud content in the concrete mix, the lower the compressive strength of the concrete. Mud prevents strong adhesion between aggregate and cement paste so that the compressive strength of the concrete becomes low. Mud particles can disrupt the cement hydration process by interfering with the bonding between cement grains, hindering the development of a strong concrete matrix In addition, mud also affects the workmanship, the more mud content, the more difficult the workmanship level. Mud contamination is one of the three biggest threats to concrete performance, alongside cracking and syneresis bleeding (Wu, et al. 2025).

The compressive strength of hardened mortar will decrease as the mud content increases. Most studies show that incorporating mud into concrete, even in small quantities, effects of compressive strength reduction compared to standard concrete (Venkatesh, et al. 2021). The other studies show thatAlthough the presence of mud in minimal amounts does not reduce the compressive strength and static compressive modulus of elasticity of concrete. However, it results in a decrease in the tensile properties and durability of concrete. The mechanical properties, freeze-thaw resistance, and antipermeability of concrete are significantly reduced when the mud content reaches 1.6% (Chenglin, et al. 2024).

As we know that the concrete surface layer plays an important role as a protective barrier between the steel reinforcement and the external environment. However, this layer is often adversely affected by the condition of aggregate containing mud, which can cause damage. When the concrete surface layer is disturbed, it accelerates the corrosion of the reinforcement, thereby reducing the durability of the reinforced concrete structure. Therefore, it is important to study the properties of the surface and inner layers of concrete with varying clay content in order to provide a complete picture of the influence of mud on the performance of reinforced concrete. The results of this study can be used as refenece for the industry of construction in selecting and determining aggregates as a fundamental part in planning and implementing construction work.

Therefore, in the field of construction, it is very important to pay great attention to the aggregate mud content. This is done to keep the mud content within the specified limits to ensure the destructive impact of mud content on Concrete and mortar layer properties. The mud cover on the aggregate surface also affects the tensile and reliability of concrete. Thus, controlling the mud content in aggregate is important to ensure that the content in aggregate does not exceed 1.2%. The mud content in aggregate less than 1.2% is very important to improve mechanics and reliability of concrete properties. The impact of mud on the reliability and mechanical properties of concrete can be seen and assessed at the age of 90 days. The findings and explanations of several researchers emphasize that the mud can affect the durability of concrete, however, researchers have different views on the concrete strength related to the effects of mud content. However, These findings provide a different perspective and require further research (Chenglin, et al. 2024).

Table 2. Average Mud Content analysis results

No	Description	Sampling Locatiaon						Average
		A	B	C	D	E	F	
1	Sand weight before oven (B1) (gr)	500	500	500	500	500	500	500
2	Sand weight after oven (B2) (gr)	490	489	492	484	488	490	489
3	Water content (B1-B2) (%)	10	11	8	16	12	10	11
4	Sludge levels (%)	1.92	2.28	1.52	3.28	2.36	2.04	2.23

3. Specific Gravity analysis Result

Specific gravity is the ratio of the mass and volume of the material. Specific gravity is very necessary in construction work SNI 03-1970-2008 maximum specific gravity 3.2 g/m3. Based on SNI 03-1970-2008 concerning specific gravity testing methods, to determine the specific gravity of Saddang River Sand, the results of laboratory tests on samples of Saddang River sand, with a test mass of 500 grams, obtained results using the following formula (5), Calculating Dry bulk specific gravity using formula (3), calculating Surface dry specific gravity. (4) and to calculating Water absorption of fine aggregate using formula (6). The result of the analysis are shown in table 3.

Table 3. Results of analysis of specific gravity of saddang river sand

Description	Average
Dry bulk specific gravity	2.48 gr/m^3
Surface dry saturated specific gravity	2.74 gr/m^3
Apparent specific gravity	2.60 gr/m^3
Water absorption	1.78 %

Specific Gravity Test is conducted to assess the Density of Sand. Specific gravity test is another important sand testing method used in the construction field. This test determines the density of sand particles relative to water. This test is performed by comparing the weight of a given volume of sand with the weight of an equal volume of water. In general, the specific gravity of coarse aggregate is a value that shows the comparison of the mass of one volume of coarse aggregate to the mass of water with the same volume at a certain temperature 23℃ This value is dimensionless and is considered as the main factor to evaluate the strength and quality of the material. Specific gravity of aggregate generally ranges from 2.6 to 3.0. Specific gravity is used to separate the damaging particles, which are lighter than other particles, from the good aggregate. This value is used in calculating the solid volume of aggregate in the concrete mixture.

The importance of using aggregate specific gravity in concrete mixtures is intended to correlate the voids (porosity) and solid mass of the aggregate and to determine the volume proportions of the concrete. Aggregates with a higher specific gravity are generally stronger than aggregates with a lower specific gravity. The need for specific gravity tracking can indicate a tendency for material changes or the possibility of contamination.

Specific gravity test helps in assessing the quality, density and suitability of sand for various construction applications, especially in concrete mixes. The specific gravity of aggregate has a close relationship and influence with the ratio of water and cement. The interface properties and strength of concrete are greatly influenced by the specific gravity of aggregate. The specific gravity of coarse aggregate that is higher than the specific gravity of water can improve the interface properties and strength of concrete. Therefore, ideally in a concrete mixture, the specific gravity of coarse aggregate should be higher than water and lower than cement.In the condition of the specific gravity of sand has high compressive strength, water absorption and other properties will be appropriate and than his will also affect the compressive strength of concrete or mortar (R. Vandhiyan, et al. 2021; Gashaahun, 2020).

Specific gravity is inversely proportional to water content, where aggregates with low specific gravity have high water content. Thus, in general, aggregates with high porosity show high water absorption rates and low specific gravity, while aggregate types with low water absorption rates and have high specific gravity. The higher the compressive strength, the higher the specific gravity. This shows that heavy aggregates, without weak areas and cracks show high compressive strength. This is caused by the finer sand filling the pores of the coarser sand thereby reducing the porosity of the concrete and increasing its density (Ramesh, et al. 2022).

4. Conclusion

The results of the sieve analysis show that the Saddang River sand is classified into gradation zone no. 4 or is classified as fine sand based on the fine aggregate gradation SNI 03-2834-2000 and ASTM C-33. The results of the analysis of the Saddang River sand mud content ranged from 2.233% to 2.250%, fulfilling SNI 03-4804-1998 which has been determined at a maximum of 5%.. The specific gravity analysis show the average value of bulk specific gravity (2,489 gr/m3), dry specific gravity (2,524 gr/m3), visible specific gravity (2,600 gr/m3). meets SNI 03-1970-2008 standards ranging from < 1.6 gr/m3 to 3.2 gr/m3. The water absorption in fine aggregate ranged from 1.5% to 3.8%, meeting SNI 03-1970-2008 with a maximum of 5%. Aggregates that have a water absorption rate above 5%, when used in cement or concrete mixtures, can cause reduced or low compressive strength of the concrete, easy cracking, low durability and structural failure.

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