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The Effect of Using Iron Ore Sediment Waste as a Substitute for Fine Aggregate on Concrete Characteristics

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ABSTRACT

Concrete is the main material in infrastructure development throughout the world. Its high mechanical strength and durability make it the main choice in various construction applications, from roads to high-rise buildings. However, behind its benefits, concrete production also triggers serious environmental problems. Natural aggregates such as river sand are used on a large scale. One of the materials that can be used as a substitute for fine aggregate is iron ore sediment waste. This study aimed to analyze the characteristics of fresh concrete using iron ore sediment waste as a substitute for fine aggregate using experimental methods. This study aimed to analyze the characteristics of fresh concrete using iron ore sediment waste as a substitute for fine aggregate using experimental methods. From the results of testing iron ore sediment waste aggregates such as the characteristics of iron ore sediment waste aggregates, 71% met the requirements as a material for making concrete, except for the mud content and organic content so special treatment is needed, namely the iron ore sediment waste material must be washed clean before use. The characteristics of iron ore sediment waste concrete have requirements from the average slump test value of 9 cm and there is no segregation and bleeding in the fresh concrete mixture.

Keywords: characteristics, concrete, waste, iron ore sediment, fine aggregate.

INTRODUCTION

Currently, the industry in Indonesia is developing along with the development of technology and the increasing need for development in the industrial sector, one of which is the iron ore industry. Iron ore is the main element in the steel industry with a deposit in the form of resources of 8,297,110,474 tons and iron ore reserves of 1,630,807,240 tons. These resources and reserves have diverse characteristics, both in terms of quality and the type of iron minerals contained in them [1]. One of the industrial sectors that is currently developing more and more is the steel smelting industry and the nickel processing industry. As industrial growth increases, the waste produced by the industry also increases [2]. The use of concrete construction for infrastructure is still an option. Currently, the government is also pursuing infrastructure development that requires large funds and the support of the latest technology. The public generally wants to build a construction in a short time. With the presence of technology, the selection of concrete as the main material that can support infrastructure development is expected to be easier, faster, stronger, better and still economical and environmentally friendly in its use [3].

Concrete is a composite of materials consisting of fine aggregate, coarse aggregate, water, cement, or other materials that function as hydraulic binders, with or without the use of additional materials. These materials are then mixed with a certain predetermined composition to produce concrete that is durable, easy to work with, has high strength, and is economical [4]. Concrete is the main material in infrastructure development throughout the world. Its high mechanical strength and durability make it the main choice in various construction applications, from roads to high-rise buildings. However, behind its benefits, concrete production also triggers serious environmental problems. The large-scale use of natural aggregates such as river sand, as well as the high carbon emissions from cement production, are increasingly concerning issues. Sand extraction from rivers, which is often uncontrolled, causes a decrease in water quality, soil erosion, damage to ecosystem habitats, and threatens the sustainability of natural resources. On the other hand, the production of cement, which is one of the main components of concrete, produces about 8% of total global carbon emissions, which contributes greatly to climate change [5], [6]. Conventional concrete is widely used in the construction sector, concrete can offer several advantages in its use such as its low price and wide application [7]. In principle, to obtain good quality concrete is greatly influenced by the quality of the constituent materials, namely fine aggregate, coarse aggregate, cement and water and how it is processed. Fine aggregate as a basic material for making concrete plays an important role in determining the quality of concrete, because aggregate is a filler that is bound by cement and water into a solid mass, so that the quality of fine aggregate directly affects the quality of concrete. Fine aggregates are widely available directly in nature, such as rivers or made from breaking down natural rocks, so that each source of aggregate will have different qualities depending on the source and if used as a material in making normal concrete, it will certainly produce concrete with different qualities [8].

To overcome this problem, there is a need to find alternative materials that are more environmentally friendly, which can replace some or all of the natural aggregate components in concrete without sacrificing the quality and performance of the concrete. One alternative is the use of industrial waste, such as iron ore sediment waste, which is produced in large quantities by the mining sector. This waste, which is generally considered a hazardous waste material, can be used as a substitute for fine aggregate in concrete. Its use not only helps reduce dependence on natural resources but also provides a solution to the problem of industrial waste disposal which often pollutes the environment [9], [10]. Various studies have shown that iron ore tailings (IOT) have great potential as a substitute for river sand in concrete mixtures. Several studies have reported that with a fine aggregate substitution of 20% to 40%, concrete with iron ore sediment waste shows increased compressive strength, resistance to carbonation, and resistance to freeze-thaw. At the optimal substitution level, this waste is able to provide performance that is equal to or even better than conventional concrete. Other research results show that the use of IOT can improve the Interfacial Transition Zone (ITZ), a critical area where aggregate particles interact with cement paste, which plays an important role in determining the strength and durability of concrete [6], [10].

Basically, heavy metals have properties that bind and settle at the bottom of the water and blend with sediment, so the levels of heavy metals in sediment are higher than in water [11]. Iron Slag is a waste product of the steel smelting industry and mostly contains iron oxide, silicate and lime and has stable chemical properties and the same physical properties as sand [12].

However, in addition to the positive impact on the strength of hardened concrete, the use of iron ore sediment waste also affects the characteristics of fresh concrete. One of the main challenges is the decrease in workability or ease of concrete work. Research shows that substitution of fine aggregate with IOT can reduce the fluidity of fresh concrete, which has the potential to complicate the mixing and casting process. This is most likely due to the physical properties of IOT, such as coarser texture and uneven particle size distribution, which affect the interactions between components in the mixture [5], [6]. However, this decrease in workability can still be overcome by adding additional materials (admixtures) such as superplasticizers that can increase fluidity without reducing the strength of the concrete [13].

Concrete is usually composed of binder and fine aggregate with some fibers. The excellent properties of high-strength concrete mainly depend on its low porosity and tight packing density, which are the result of fine particles and low water-to-binder ratio [14]. With the continuous improvement of living standards, the construction industry has consumed more natural aggregates than ever before. The excessive use of river sand for construction projects has caused a series of serious environmental problems. Therefore, artificial sand is considered as an alternative material to replace river sand in high-strength concrete. However, the artificial sand supplied in some regions of China does not meet the market demand due to the unmatched construction industry, and its price has been rising. In view of this, there is an urgent need to choose low-cost materials such as fine aggregates in the production of high-strength concrete [15].

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With the increasing demands for sustainable development, the use of waste iron ore sediment in concrete is one of the innovative solutions that can help reduce the environmental impact of the construction industry. In addition, the use of this waste material can also reduce the production cost of concrete, considering that the cost of natural materials is increasing due to limited resources. Therefore, further research is needed to optimize the composition of concrete mixtures with IOT, as well as explore other potential benefits of this material, including improving the mechanical performance and durability of concrete under various environmental conditions.

RESEARCH METHODS

Materials

Research Implementation

As a scientific-research, this research was conducted with a systematic and planned method, so that the results of this research can be accounted for. For this reason, this research was conducted in several stages, including:

Experimental Design

The design of the test object in this study refers to the mix design according to SNI 03-2834-2000 Procedures for Making Normal Concrete Mixtures. The concrete test object is placed in a cylinder measuring 10 x 20 cm with a mixture of iron ore sediment waste as a substitute for fine aggregate.

Working Steps

The working steps in this research are as follows:

1. **Stage I (Preparation Stage/Literature Study)**

   At this stage, a search for material related to the research will be carried out as a reference.

2. **Stage II (Preparation Stage of Materials and Tools)**

   At this stage all materials and equipment to be used are prepared in advance so that the research runs smoothly.

3. **Stage III (Material Testing Stage)**

   At this stage, testing is carried out on materials which are concrete mixtures intended to determine the properties and characteristics of the materials. Material testing in this study only focuses on testing natural materials with heterogeneous conditions, quality and size, so strict control is needed to obtain the required material. This test uses requirements that are in accordance with the aggregate characteristic specifications standardized by the Indonesian National Standard (SNI):

Coarse Aggregate Testing (Split)

a. Silt content
b. Water content
c. Volume weight
d. Absorption and specific gravity
e. Sieve analysis

Fine Aggregate Testing (Sand and iron ore sediment waste)

a. Silt content
b. Organic content
c. Wear
d. Water content
e. Volume weight
f. Absorption and specific gravity
g. Sieve analysis

4. **Stage IV (Mix Design Planning Stage)**

The planning of making this test object in this study refers to the mix design planning in accordance with (SNI 03-2834-2000, 2000) concerning concrete mix design planning. In this process, the manufacture of test specimens for the dimensions of the 10 cm x 20 cm cylinder mold will be planned.

5. Stage V (Test Object Manufacturing Stage)

One of the requirements for obtaining good concrete quality is that the implementation process in the field must be appropriate and correct by following the previously determined requirements. This is related to the process of mixing concrete materials such as cement, coarse aggregate, fine aggregate, water and substitute materials in the form of iron ore waste sediment from pond sediment, which must be mixed evenly. The process of mixing and making test objects refers to the guidelines for the Implementation of Concrete Work of the Engineering Agency of PT. Wijaya Karya as follows:

a. Concrete components (cement, aggregate, water) are prepared and weighed according to the results of the mix design calculation.
b. The sequence of inserting materials into the mixing machine starts with coarse aggregate, fine aggregate then cement. After the cement is added, water is added and the mixing machine (molen) is continued.
c. Mixing must be carried out continuously for at least 3 minutes after all materials are in the mixing container.

6. Stage VI (Slump Test Measurement)

Testing on concrete slump can be done if the combination of materials to form concrete has reached plastic properties. Basically, the purpose of testing the slump value is to determine the level of fluidity or thinness of the concrete mixture made. The effect of this fluidity is useful for assessing the workability of concrete.
Methods
The iron ore waste sediment material comes from Taliabu Island, North Maluku and the research was conducted in the Civil Engineering Material and Concrete Testing Laboratory of Fajar University, Makassar, South Sulawesi. This research was conducted for 2 months, from August 2024 to September 2024.

Data Analysis

Data analysis was carried out using an experimental method on the effect of iron ore sediment waste as a substitute for fine aggregate on concrete characteristics. In addition, data analysis is also supported by literature studies related to this research.

RESULT AND DISCUSSION

The characteristics of iron ore sediment waste aggregates as a substitute for fine aggregates on concrete characteristics meet the requirements as a material for making concrete. If the requirements of the material do not meet the specified requirements, it will reduce the value of the mechanical properties of the concrete.

Table 1. Recapitulation of Aggregate Test Results (Iron Ore Sediment Waste)

No	Test Type	Fine Aggregate Test Results	Interval	Description
1	Sludge Content	5,18%	0,2% - 5%	Does not meet the
2	Water Content	3,09%	3% - 5%	Fulfil
3	Volume Weight			
	a. Loose Condition	1,66	1,4 - 1,9 kg/liter	Fulfil

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No	Test Type	Fine Aggregate Test Results	Interval	Description
	b. Solid Condition	1,69	1,4 - 1,9 kg/liter	Fulfil
4	Absorption	0,40%	0,2 - 2%	Fulfil
5	Specific Gravity			Fulfil
	a. Real Material	2,74	1,60 - 3,30	Fulfil
	b. Dry Base Material	2,71	1,60 - 3,31	Fulfil
	c. Dry Material survace	2,72	1,60 - 3,32	Fulfil
6	Modulus Fineness	3,02	2,3 - 3,1	Fulfil
7	Organic content	No.3	<No.3	Does not meet the

Source: Primary Data, 2024

From the results of testing the characteristics of iron ore sediment waste aggregates as in Table 1. that the characteristics of 71% of iron ore sediment waste aggregates meet the requirements as concrete constituent materials, except for the mud content and organic content so that special treatment is needed, namely the iron ore sediment waste material must be washed clean before use If the requirements of the material do not meet the specified requirements, it will reduce the value of the mechanical properties of the concrete.

Slump Test, Segregation and Bleeding Testing

The slump test aims to determine the viscosity (workability) of the concrete mixture. The viscosity of the concrete mixture is a measure of the level of ease in the mixture to be worked on in construction work without causing separation of the concrete constituent materials (segregation). The level of concrete viscosity is influenced by the amount of water, the amount of cement, the shape of the aggregate grains and the size of the aggregate grains.

For the slump test in this study, it was carried out 2 times for 6 cylinders. The slump test value requirement for normal concrete in the mix design calculation is 10 (± 2) cm.

Table 2. Results of Slump Test Measurement Values 10 (± 2) cm.

Number of Cylinders	Mix Variation (%)	Slump Test I (cm)	Slump Test II (cm)	Average Value (cm)
6	0	9,6	10,7	10,15
6	0,5	8,4	8,5	8,45
6	1	8,2	8,5	8,35
6	2	9,7	9,9	9,8

Source: Primary Data, 2024

Table 2. can be seen that the slump test value for normal concrete and concrete with a mixture of iron ore waste sediment as a substitute for fine aggregate meets the standard slump test requirements and it can be concluded from Table. 2 that the higher the presentation of iron ore waste sediment into the concrete mixture will cause the slump test value to be smaller from the slump test measurement results.

From all the slump test measurement results, the results obtained show that there is very good ease of mixing and the results of the Slump Test can be seen in Figure 1. For Segregation and Bleeding, see Figure 2.

Figure 1. Slump Test Source: Primary data, 2024

Figure 2. Fresh Concrete Source: Primary data, 2024

In the characteristics of fresh concrete, segregation and bleeding aim to determine whether the fresh concrete mixture experiences gravel separation (segregation) and water separation (bleeding) during concrete mixing. From Figure 2, it can be seen that segregation and bleeding do not occur because the ingredients of the concrete mixture meet the requirements using the Department of Environment (DOE) method.

CONCLUSION

From the results of testing the iron ore sediment waste aggregate, such as the characteristics of the iron ore sediment waste aggregate, 71% meets the requirements as a material for concrete, except for the mud content and organic content so that special treatment is needed, namely the iron ore sediment waste material must be washed clean before use. The characteristics of iron ore sediment waste concrete meet the requirements from the average slump test value of 9 cm and there is no segregation and bleeding in the fresh concrete mixture.

REFERENCES

[1] Kognisi Bidori, at all. (2021). Pengaruh Variasi Bijih Besi (Sebagai Substitusi Pasir) dan Waktu Perendaman Terhadap Komposisi, Struktur Fase dan Sifat Fisis pada Pembuatan Mortar. *Industry and Higher Education*, *3*(1), 1689–1699. http://journal.unilak.ac.id/index.php/JIEB/article/view/3845%0Ahttp://dspace.uc.ac.id/handle/123456789/1288

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[2] Suwindu, K. S., & Sandy, D. (2020). Karakteristik Beton Mutu Tinggi dengan Substitusi Slag Baja dan Slag Nikel Sebagai Agregat Kasar. *Paulus Civil Engineering Journal*, *2*(1), 8–15. https://doi.org/10.52722/pcej.v2i1.115

[3] Restu Meihadi, S. (2021). Pengaruh Filler Serbuk Kaca terhadap Karakteristik Beton Substitusi Pasir Besi dengan Curing Air Panas. *Pengaruh Filler Serbuk Kaca Terhadap Karakteristik Beton Substitusi Pasir Besi Dengan Curing Air Panas*.

[4] Sari, R. A. I., Wallah, S. E., & Windah, R. S. (2015). Pengaruh Jumlah Semen dan FAS Terhadap Kuat Tekan Beton dengan Agregat yang Berasal dari Sungai. *Jurnal Sipil Statik*, *3*(1), 68–76.

[5] Siddique, R., & Aggarwal, Y. (2014). Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates. Construction and Building Materials, 54, 210–223. https://doi.org/10.1016/j.conbuildmat.2013.12.051.

[6] Farouk Deifalla, A., et al. (2022). Concrete made with iron ore tailings as a fine aggregate: A step towards sustainable concrete. Materials, 15(18), 6236. https://doi.org/10.3390/ma15186236.

[7] Afrizal Halim. (2021). *Pengaruh Variasi Komposisi Bijih Besi Dengan Batu Split Terhadap Sifat Fisis dan Mekanis Beton K.350 dengan Umur Perendaman 7, 14 Dan 28 Hari*.

[8] Sains, F., & Teknologi, D. A. N. (2016). *Studi pemanfaatan limbah ampas nikel pt. antam pomalaa untuk konstruksi beton*.

[9] Subathra Devi, V., & Gnanavel, B. K. (2014). Properties of concrete manufactured using steel slag. Procedia Engineering, 97, 95-104. https://doi.org/10.1016/j.proeng.2014.12.229.

[10] Yang, C., Cui, C., Qin, J., & Cui, X. (2014). Characteristics of fired bricks with low-silicon iron tailings. Construction and Building Materials, 70, 36-42. https://doi.org/10.1016/j.conbuildmat.2014.07.075.

[11] Galih, Y. D. dkk. (2019). *Pengaruh Penambahan Tailing Bauksit Terhadap Uji Kuat tekan dan Kadar Logam Besi Pada Pembuatan Paving Blok* (p. 4).

[12] Hijriah, H., & Yunianti, N. H. (2021). Pemanfaatan Limbah Iron Slag Sebagai Material Pengganti Sebagian Pasir Pada Produksi Beton. *TAPAK (Teknologi Aplikasi Konstruksi) : Jurnal Program Studi Teknik Sipil*, *10*(2), 117. https://doi.org/10.24127/tp.v10i2.1580

[13] Hk, T., & Hossiney, N. (2022). A short review on environmental impacts and application of iron ore tailings in development of sustainable eco-friendly bricks. Materials Today: Proceedings, 61, 327–331. https://doi.org/10.1016/j.matpr.2021.09.522.

[14] SNI 03-2834-2000. (2000). SNI 03-2834-2000: Tata cara pembuatan rencana campuran beton normal. *Sni 03-2834-2000*, 1–34.

[15] Zhang, W., Gu, X., Qiu, J., Liu, J., Zhao, Y., & Li, X. (2020). Effects of iron ore tailings on the compressive strength and permeability of ultra-high performance concrete. *Construction and Building Materials*, *260*, 1–15. https://doi.org/10.1016/j.conbuildmat.2020.119917.