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Analysis of the Physical Strength of Buildings using Concrete with a Mixture of Steel Slag Waste

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Abstract:
Concrete is a construction material that is widely used in various building structural elements such as columns, beams, slabs, and so on. High compressive strength, stiffness, and low electrical conductivity are characteristics of concrete, so that concrete is widely used in the design of structural elements. The use of additives in concrete technology has long been developed. Concrete has a flexural strength of 8% - 15% of compressive strength. Some effort is required to increase the flexural strength. One way is to add additional materials, namely Slang Waste or Steel Slag. The purpose of this study was to find out how the effect of adding steel slag waste as a concrete mixture material to increase the physical strength of buildings. Experimental method founded on previous research is utilized. The test object is a cylinder with a 15 cm diameter and a 30 cm height. Normal variations in the amount of steel slag refuse added to sand range between 20 and 50 percent by weight. Normal concrete testing revealed that the maximum addition of 20% concrete compressive strength was 22.63 Mpa, while the highest addition of 50% concrete strength was 20.28 Mpa, compared to 20.27 Mpa for normal concrete. Steel Slag Waste, Compressive Strength, and Concrete are key terms. This indicates that the addition of steel slag waste will increase the flexural strength of concrete, thereby increasing the building's physical durability.

Keywords: Concrete, Steel Slag Waste, Buildings

A. INTRODUCTION

Concrete is a widely used construction material for a variety of building structural elements, such as columns, beams, and plates (Tanubrata, 2015). Due to its high compressive strength, stiffness, and minimal electrical conductivity, concrete is widely used in the design of structural elements (Agutisnus & Lesmana, 2019). Additionally, concrete is comprised of cement, grit, gravel, and water. High compressive strength but low tensile strength is a problem that requires continued development and refinement (Soelarso & Baehaka, 2016).

Current global warming necessitates civil engineering innovation, specifically the use of environmentally favorable concrete materials (Yunianti, 2020). The use of steel production waste in concrete mixtures is one of the materials to be studied (Hijrah & Yunanti, 2021). Currently, the accelerated growth of the construction industry has increased the demand for concrete. Theresia and Susanti (2017) state that as the demand for concrete rises, a mixture of concrete that is both environmentally favorable and economically valuable is required in order to contribute to the reduction of rising global warming.

To increase the quality and strength of concrete, you can add mineral additives to the concrete mixture (Ervianto et al, 2016). Mineral additives are additional materials that are easy to find around us (Zulkarnain & Pasaribu, 2022). Some examples of mineral additives include glass powder, iron ore powder, granite powder, limestone, etc.

Concrete is a construction material that is commonly used for buildings, bridges, roads and others . As time goes by and the many demands in the field affect developments in concrete technology (Dewi & Prasetyo, 2021). One of these demands is how to create concrete that has a lighter specific gravity than ordinary concrete (Ervianto et al, 2016). In its development, concrete began to use substitute materials to anticipate the properties of concrete which has a high specific gravity in order to reduce its specific gravity. Substitute materials are materials that can replace concrete materials, be it fine aggregate, coarse aggregate, or cement with other materials, such as cement actort with steel slag, crushed stone (coarse aggregate) with tile waste and others (Amiruddin et al, 2017) .

In the current era, there are many buildings that use light brick wall materials, so it is not too difficult to find steel slag waste used for the construction of buildings or other structures (Bahrudin et al, 2020) And this is where the author feels the need for a discussion on the use of steel slag waste maximally . (Ridwan et al., nd) With its structural properties, lightweight brick can be used as a substitute for fine aggregate. Therefore, there is a need for research on concrete problems. (Cahyo, 2020).

B. LITERATURE REVIEWS

1. Concrete

Concrete is a mixture of sand, gravel, cement and water. This mixture then forms a rocky mass. In some cases, additives are added to make concrete with special properties that increase workability, durability, and setting time (Nugraha, 2007).

Mixtures using other similar materials can be used to determine the level of quality of concrete when mixed with other materials. Concrete is made by mixing cement, water and aggregate with or without additives. The concrete mold material is stirred until it is homogeneous with a certain composition to form a plastic mortar, so that it is easy to pour into any shape and be printed. The ratio of mixed stacking materials is sorted from the smallest particle size (soft) to the largest particle size: cement, sand, gravel. Therefore, if the mixture in concrete uses a composition of 1: 2: 3, the concrete variations are 1 cement, 2 sand and 3 gravel (Pane et al, 2015).

2. Steel slag waste

The definition of steel slag / slag is a non-metallic product which is a fine, granular material from combustion which is then cooled, for example by immersing it in water. slag is a waste material from casting iron (pig iron), where the process uses a fuel furnace (Suryo et al., 2018).

In Indonesia, steel slag is still classified as a Hazardous and Toxic Material (B3), this classification into B3 materials causes the use of steel slag to be constrained (Dermawan, 2011). Instead of taking advantage of slag, what has happened is a significant addition to operational costs, such as having to provide storage land that can reach 1 to 2 hectares, handling and transportation costs. In addition, because of its status as B3, potential users do not dare to take the risk to take advantage of this slag because it has the potential to cause legal and social consequences.

3. **Fine Aggregate**

"Concrete aggregates, including sand, must be between 0.0625 and 2 mm in size. Weathering of rocks, both chemical and physical, produces sand (Gardjito et al., 2018). Fine aggregate's interlocking particles and intergranular friction keep the road from permanently deforming. Angularity and particle surface roughness are two external qualities necessary for this.

4. **Coarse Aggregate**

Rock with a grain size between 5 mm and 40 mm is considered coarse aggregate. Coarse aggregate is classified as either gravel (made from naturally occurring rock) or gravel (made from naturally occurring rock that has been broken down into smaller pieces). Gravel is the common name for coarse aggregate, which can be either natural stone that has been broken down or crushed stone with grains ranging in size from 4.76 millimeters to 150 millimeters in diameter.

5. **Slump test**

Slump is the vertical collapse value for concrete due to insufficient yield stress limitations; this is because the links between the particles are still weak, and the concrete cannot support its own weight. (SNI 1972, 2008) A slump test is an empirical test/method used to establish whether or not a fresh concrete mix is workable in terms of its consistency/stiffness.

C. METHODS

This investigation blends experimental methodology with a theoretical analysis of existing literature. This study involves making both regular and modified concrete with a steel slag waste mixture. The first step in the research process is to gather the necessary supplies and equipment. Next, the concrete-making ingredients will be put through their paces in a series of tests. Once the components have been evaluated and found to be satisfactory, the process of creating the concrete mix and the concrete test object can begin, followed by curing. Compressive strength testing, cure time testing, fresh concrete production testing, viscosity testing, specimen making, and curing are all part of the battery of tests performed. The goal of a compressive strength test is to evaluate the actual value of the concrete's compressive strength in relation to the design value of fc' = 20 MPa. The values are evaluated afterward. Treatment durations varied from 14 to 28 days, and between 20 and 50 percent of the total mixture was employed.

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D. RESULTS AND DISCUSSION

1. Material Test Results

Portland cement, water, crushed stone, sand, and steel slag waste are among the components and materials utilized in this investigation. The aforementioned materials and substances are analyzed for their qualities before being employed to create test specimens.

Table 1 Fine Aggregate Test Results

No	Characteristics	Test results	Information
1	Water content	1.02%	Fulfil
2	Sludge levels	1.01%	Fulfil
3	Mud Weight		
	Free	1.63	Fulfil
	Congested	1.67	Fulfil
4	Absorption	1.03%	Fulfil
5	Specific gravity		
	Curak	2.72	Fulfil
	Surface Dry	2.68	Fulfil
	Pseudo	2.72	Fulfil
6	Fineness Modulus	2.43	Fulfil

The results of the tests on the fine aggregate are presented in Table 1, and they reveal that they are up to the required standard.

Table of Coarse Aggregate Test Results

No	Characteristics	Test results	Information
1	Water content	1.03%	Fulfil
2	Sludge levels	1.01%	Fulfil
3	Mud Weight		
	Free	1.69	Fulfil
	Congested	1.77	Fulfil
4	Absorption	1.02%	Fulfil
5	Specific gravity		
	Curak	2,11	Fulfil
	Surface Dry	3,18	Fulfil
	Pseudo	2,21	Fulfil
6	Fineness Modulus	6,1	Fulfil

The findings presented in Table 2 demonstrate that the coarse aggregate test was successful in achieving the desired outcomes.

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2. Resistance Test Results

Table 3 displays the results of the concrete compressive strength test that was conducted after the concrete had aged for 28 days. The results are broken down by each variant of the mixed concrete mix as well as each specimen.

Table 3 results of the concrete compressive strength test

Sample	Beton-N	Concrete-F 20%	Concrete-F 50%
1	17,91	18.40	16.52
2	18.79	17.03	17.03
3	20,27	18.79	17.93
4	19.78	22,63	17,46
5	18.79	18.79	20,28
6	19.15	19.15	17.83

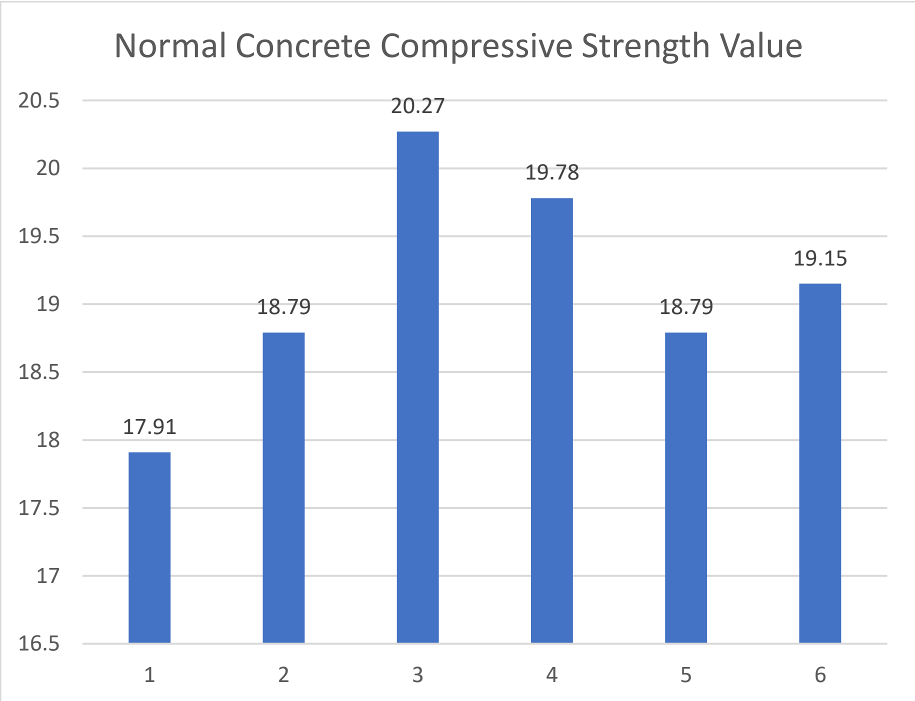

Figure 1 Graph of Normal Concrete Strength Value

From the line in Figure 1, we can see that normal concrete has an average compressive strength of Fc' 19.11 Mpa.

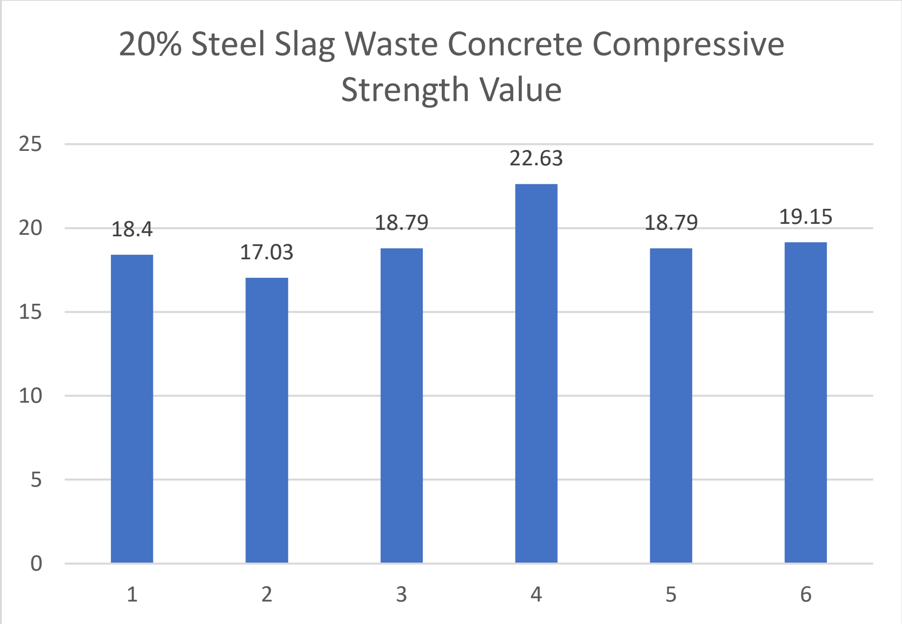

Figure 2 . Graph of 20% Steel Slag Waste Concrete Compressive Strength

Sample 4's steel slag waste has a higher compressive strength (22.63 MPa) than the other samples (see Figure 2).

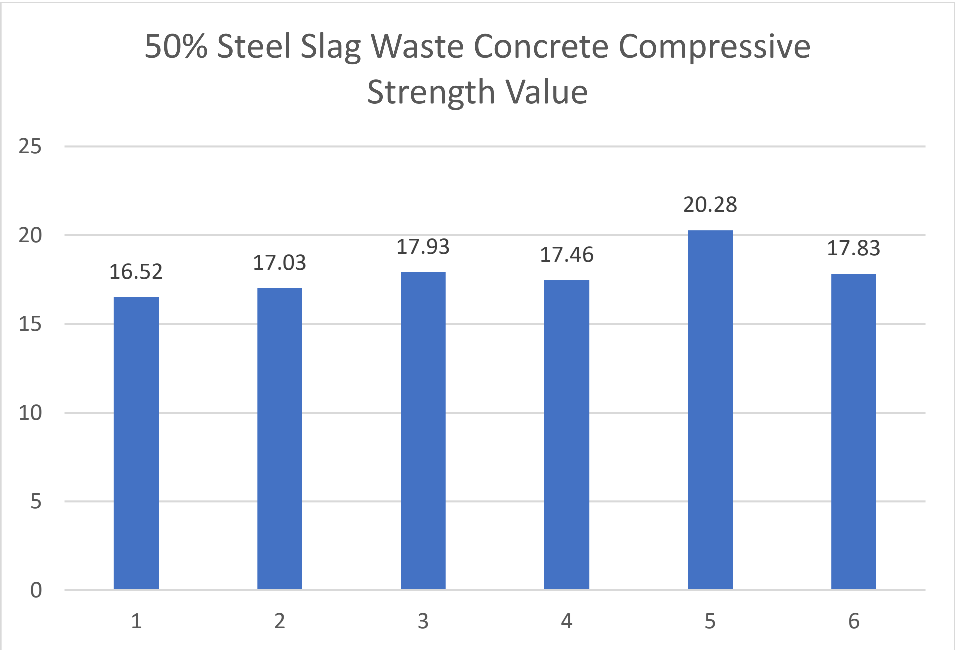

Figure 3. Graph of 50% Steel Slag Waste Concrete Compressive Strength

Sample 5 has the maximum compressive strength, at 20.28 MPa, as shown in Figure 3.

3. Slump test

Figure 4 depicts a graph of the slump test results for each variant of adding steel slag waste.

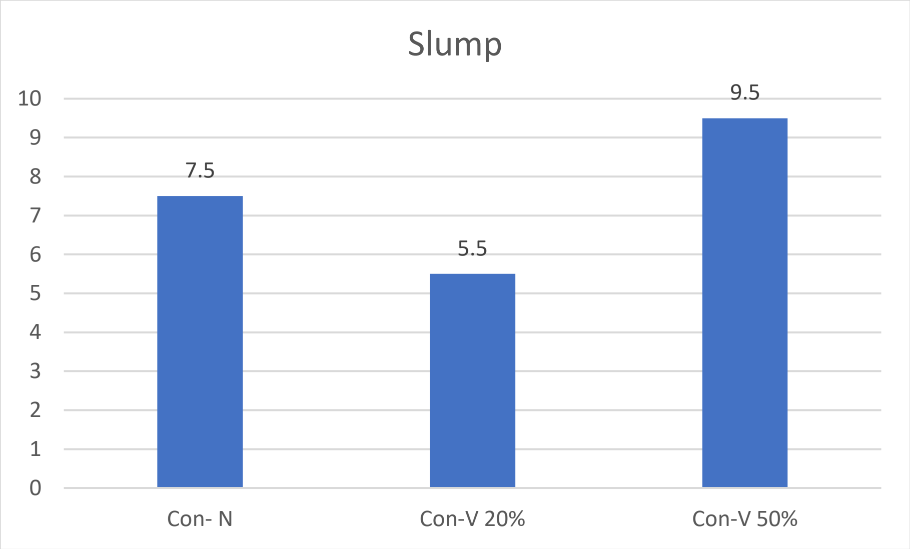

Figure 4 Slump Test Results

Discussion

Concrete has a high pressure resistance. It's no surprise that this single construction material is frequently employed as the raw material for building structures ranging from bridges to houses to train sleepers. The strength of concrete to bear pressure, such as K-225, K-250, and K-350, can be modified during the manufacturing process.

There are various factors that contribute to the global popularity of concrete as a raw material for building construction. To begin with, concrete has a high compressive strength. Compressive loads are applied to building structures such as columns, beams, and walls. Because concrete has a great strength when pressed vertically, it can handle this load well. This strength enables concrete to retain a building's structural integrity over time.

Second, concrete is pressure and wear resistant. Buildings must frequently withstand fluctuating loads such as weather fluctuations, earthquakes, and human activity. Concrete that is strong and durable can endure the stresses caused by these dynamic loads. Furthermore, concrete has a high resilience to wear and tear, allowing it to remain robust and undamaged even when subjected to harsh environmental impacts.

Third, concrete is resistant to fire. Fire resistance is an essential component of safe building design. Concrete is refractory in nature, which means it can tolerate high temperatures without collapsing or melting. Because of this property, concrete is an excellent material for shielding building structures from fire and delaying its spread in the case of a fire.

Fourth, concrete is easily deformed. Concrete is flexible and easy to mould into various shapes when newly mixed. This allows for greater versatility in designing complex architectural structures that are not bound to traditional designs. The capacity to precisely shape concrete allows for the creation of more efficient and visually beautiful structures.

Fifth, concrete is a substance that may withstand biological attack. Microorganisms such as fungi, bacteria, and insects can pose a threat to building structures. Concrete, on the other hand, has natural qualities that make it unsuitable for the growth of these organisms. This decreases the possibility of biological attack damage and ensures the building's physical strength in the long run.

E. CONCLUSION

Concrete's flexural strength can be improved by using Steel Slag Waste as a fine aggregate. Researchers have demonstrated the efficacy of using steel slag, a byproduct of the steelmaking process, to cleanse wastewater and strengthen concrete. Post-cured steel slag increases the strength of concrete by roughly 17% compared to that of concrete prepared with standard aggregates and by 8% compared to that of raw steel slag. The findings of the aforementioned studies show that the maximum concrete compressive strength is 22.63 MPa when 50% is added, and that it is only 20.27 MPa in regular concrete. The slump test results for standard concrete were measured at 7.5 centimeters, for concrete containing 20% asbestos waste at 5.5 centimeters, and for concrete containing 50% steel slag waste at 9.5 centimeters.

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