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Iron Casting Waste as a Coarse Aggregate of Strength Bending Concrete (Case Study: PT. Brawaja Makassar South Sulawesi)

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Abstract: The purpose of this research is to know the specification and character of iron casting waste as a substitute material of coarse aggregate on concrete and to know the value of bending strength of concrete in producing higher quality than regular concrete. This research method is the quantitative method through experimental empirical design. Research in the form of observation and sampling from iron casting waste in PT. Barawaja Makassar. This study was conducted at the laboratory of Universitas Hasanuddin (UNHAS) Makassar. Laboratory tests of aggregate characteristics consist of, specific gravity, absorption, filter analysis, moisture content, volume weight, mud content organic content and wear. Concrete mix design method in this research use DOE method. Tests were performed on the bending of concrete beams and data analysis of concrete test results in graphical form. Iron slag variation as a substitute for some aggregate with levels of 0, 25, 50, 75 and 100% of total aggregate weight. Test results and analysis have been made that iron slag as a substitute agent of coarse aggregate tends to meet all the standard specification requirements as a coarse aggregate. Bending strength of concrete, also increased of iron casting waste 25 and 50%. The highest flexural strength value occurred at 28 days with a value of 5.840 MPa. Added iron casting waste 50% increased 39.71% compared to regular concrete. However, there was a decrease in 75 and 100% iron foundry waste substitution. The use of iron waste as a rough aggregate added material can produce high concrete when compared to regular concrete.

Key words: Bending strength, concrete waste, iron casting, coarse aggregate, material, UNHAS

INTRODUCTION

The development of industry in Makassar is increasing, causing the occurrence of increased waste that impacts on environmental problems. One area of the industry at this time more advanced development is an iron casting industry. Increased production of iron casting industry resulted in increased waste also. Waste generated in the form of iron casting waste requires a lot of place and cost of management. The cost of handling waste is an obstacle for the industry in addition to the limited provision of land in urban areas.

Akhmadi (2009), explained that slag is the waste material from cast iron. The process of using the kitchen (furnace) with fuel from the air is blown (blast). Iron slag waste produced by PT. Barawaja Makassar is the result of reaction process at temperature 1600°C (wet scrubber).

Analysis of chemical sludge characteristics indicates that the mud steel industry is included in the category of hazardous toxic hazard waste and contains Ferro Silicate (FeSi), Ferro Mangn (FeMn) and Calcium Silicate (CaSi). This material required an early treatment of the industrial waste to prevent/reduce environmental impact. Besides, it can also add value to the waste of steel industry. One of the alternatives of added benefit, namely iron casting (iron slag) processing industry into structural components of the form making of concrete. The utilization of iron casting waste from PT. Barawaja Makassar as a substitute for some aggregate required research on the specification and character of the material. Analyzing the comparative ability of concrete bending strength using regular casting and concrete waste. In the study, concrete mixtures and K-500 quality concrete samples are needed.

Concrete as a mixture of portland cement or other hydraulic cement, fine aggregate, coarse aggregate and water with or without additional mixed materials forming a solid mass (Hidayat and Pustaka, 2009). High-quality concrete can be interpreted as high strength oriented concrete (high strength concrete) which considers the durability of concrete and the ease of concrete workmanship (Hama, 2017). According to Mulyono (2005) that in general the higher the value of cement water factor the lower the strength of concrete strength. Then to produce a high-quality concrete, the cement water factor in the concrete must be small.

The constituent material consists of Portland Cement (PC), coarse and fine aggregate and water. Portland Cement (PC) added to water produces a paste which if dried will have rock-like strength. The strength of cement is the result of the hydration process. This chemical process is recrystallized in the form of interlocking-crystals to form a cement gel which will have high compressive strength when hardened (Nawy, 2008). The coarse aggregate is when the size is already over a ¼ inch (6 mm). Its nature affects the hard end strength of concrete and its resistance to the disintegration of concrete weather and other destructive effects. The coarse aggregates of these minerals should be clean of organic materials and should have a good bond with the cement gel (Nawy and Suryoatmono, 2001).

The fine aggregate can be ash of stone, natural sand, processed sand or a combination of both sands. The size varies between No. 4 and 100 standard American filter. Fine aggregate must be free of organic material, clay, particles smaller than sieve No. 100 or other ingredients that may damage the concrete mix (Nawy, 2009). The fine aggregate is a natural sand as a result of physical disintegration of rocks or sand produced by the stone breaking industry and has the largest grain size of 50 mm (Purwanto and Priastiwi, 2012).

Water is required in the manufacture of concrete to allow chemical reactions with cement to moisten the aggregate and to lubricate the mixture for easy processing. Water containing harmful compounds, contaminated with salt, oil, sugar or other chemicals when applied to a concrete mixture will decrease its strength and may also alter the properties of cement (Nawy, 2008).

Concrete testing in the laboratory to determine the durability of a material or changes in shape that occur due to given forces. The shape changes that occur due to external load are strongly influenced by the compressive strength (Mulyono, 2005). Factors affecting the level of compressive strength as well as the flexural strength of the concrete are the size of fine aggregate (sand), coarse aggregate (crushed stone) and cement type. Coarse aggregates (rough stone) are the most important concrete materials in both compressive strength and flexural strength (Dhir and Jones, 1993).

On improving the quality of compressive strength, the small strength increases from the flexural strength. According to rough estimates, the flexural strength value ranges from 9-15% of the compressive strength. The calculation approach is usually done by using a modulus of rupture. According to Mulyono (2005), the value of concrete compressive strength with strong bending is not directly proportional.

MATERIALS AND METHODS

This research type is quantitative research with empirical design method through experiment. Sampling was conducted at PT. Barawaja Makassar and the research was conducted at the Test Materials Laboratory of Universitas Hasanuddin Makassar from January 1 March 2017. This study is done through experiment to get the data.

The test is performed on the value of strong bending concrete with a variation of iron casting waste (iron slag) as a substitute for some aggregate with 0, 25, 50, 75 and 100% aggregate total aggregate weight. The research procedure is carried out as follows: a laboratory test, performed on aggregate characteristics, namely, specific gravity and absorption, filter analysis, moisture content, volume weight, mud content organic content and wear. The design of the concrete mixture through the Department of Environment (DOE) method. Preparation of test specimens in the form of concrete test objects made through the stages, i.e:

- The composition of materials, i.e., portland cement, fine aggregate (sand) and coarse aggregate (crushed stone and iron slag), water by the composition and volume of the concrete of the specimen to be made
- Stirring of concrete with moulen (mixer)
- Condense with a compacting machine
- The test piece is left for 24 h and then the mold is opened and soaked in water

Concrete bending test: Data analysis of concrete test results in graphical form.

RESULTS AND DISCUSSION

Testing of aggregate characteristics: The examination of the concrete material produced the characteristics of fine aggregate (sand) and coarse aggregate (crushed stone and iron casting waste) as mentioned in Table 1.

Table 1 shows that there is an excess of iron casting waste when compared to crushed stone against use as a concrete material. The surplus is a small volume of heavyweight makes lightweight concrete, high absorption, so that, the tie between the existing concrete material to be strong. But there are also disadvantages when compared to crushed stone.

Table 1: Characteristics of fine aggregates and coarse aggregates

Description	Sand	Crushed stone	Iron casting waste
Water content	4.11%	0.89%	0.06%
Sludge levels	4.80%	0.96%	1.00%
Volume weight	1.51 kg/L	1.84 kg/L	1.43 kg/L
SSD type weight	2.54 g	2.87	3.14
Absorption	1.72%	0.76%	1.49%
Organic content	Clear	7.67	7.62
Modulus of subtlety	2.54	17.53%	31.77%
Filter analysis	Zone 2	0.89%	0.06%

Table 2: Concrete mix design

Volume (m^3)	Total weight (kg)	Water (L)	Cement (kg)	Sand (kg)	Crushed stone (kg)
1,00	2.400,00	200.27	566.00	517.90	1.061,83

Table 3: Slump condition of mixed proportions

Variation (%)	Number of samples	Slump (mm)
100	3	23
75	3	24
50	3	25
25	3	28
0	3	30

Aggregate merger: The proportion of fine aggregates 34.5% and coarse aggregate amount 65.5%.

Mix design: The result of concrete mix design with Department of Environment (DOE) method, obtained a result as in Table 2.

The design of the concrete mixture in Table 2 is a design for regular concrete. The addition of coarse aggregate will be adjusted to the percentage of variation of iron casting waste addition, i.e., 0, 25, 50, 75 and 100% of the total aggregate weight.

Testing of slump test: The workability of the concrete can be affected by the slump test value. The higher the slump test value, the easier it is to work the concrete (workable) but must be considered the amount of water given to the concrete because the slump test value determines the quality of the concrete. The results of slump test for various proportions of the mixture can be seen in Table 3.

In Table 3, the 100% variation of iron casting waste obtained the smallest slump value, then 0% variation obtained the highest slump value. To facilitate the reading for each variety of iron casting waste to slump value can be seen in the following graphic Fig. 1.

Bending strength testing: Gambhir (2013) states that pure bending is bending associated with the bending of a beam under a bending moment (bending moment) constant which means that the style of latitude equal to zero (because V = dM/dX). Conversely, unequal bending is associated with flexibility in the presence of latitudes which means that the bending moment will move along the beam.

Paul and Antoni, explain that strength bending is the value of the tensile stress produced by the bending moment (PL) divided by the object-sectional hold moment (bd^2) which is expressed in the modulus formula Rapture (R). The bending strength of the concrete is at 1/3 span (1/3 L) as shown in the following Fig. 2.

The result of the calculation of bending strength of concrete to the variation of iron casting waste can be seen in the following graphic Fig. 3.

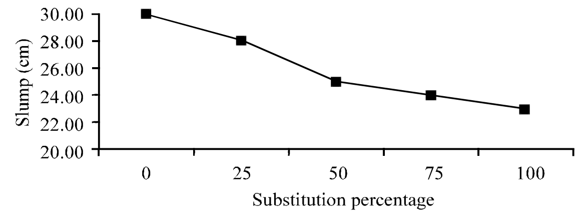

Fig. 1: Graph of variations in slump value

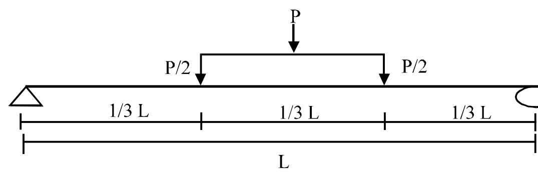

Fig. 2: The loading of 1/3 span

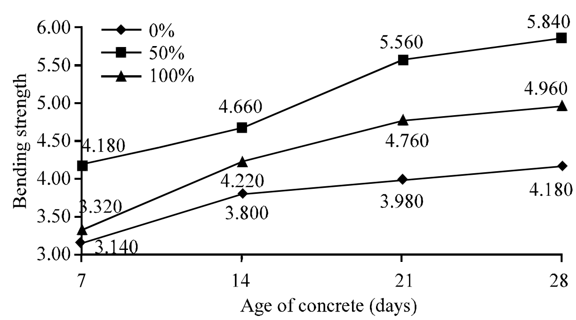

Fig. 3: Percentage of iron casting waste at various ages against strong bending

Figure 3 shows the addition of iron foundry waste as a partial replacement of 0% coarse aggregates (regular concrete) obtained a strength bending at 28 days of concrete of 4,180 MPa, smaller when compared to other variations of waste addition. Addition of iron casting waste of 50% obtained a strength bending of 5.840 MPa and 100% got 4.960 MPa. The 100% waste addition showed a decreased of strength bending. Of the three variations seen in the figure indicates that the addition of iron casting waste as a substitute of 50% rough aggregate obtained a stronger bending strength of 5.840 MPa.

Iron casting waste has a surface wear rate which is higher than the crushed stone causing the percentage of fine aggregate to increase. This shows that too many fine grains contained in the concrete mix, so that, the maximum density with a cavity between the minimum aggregate mineral hard compacted. Also, based on its physical characteristics, it has porous particles on its surface, resulting in low density. This is because the cavity is not properly filled with mortar. Lack of compaction can cause pores on the concrete resulting in a decrease in the value of strength bending of concrete (Hama, 2017). The

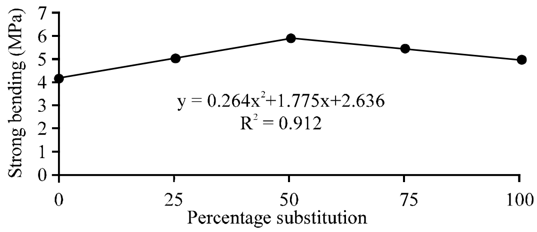

Fig. 4: Test result of bending strength object test based on character and effect casting process

relationship between the flexural strength of the concrete with the physical character and the result of the compaction process in the casting implementation will affect the value of the bending strength as shown in Fig. 4.

Figure 4 shows that out of the five variations of replacement of replacement iron casting parts in a coarse aggregate, the addition of 50% of the waste is still higher when compared to other varieties. However, when the selection of fine aggregate material with physical characteristics having particle grains is not porous on its surface and the process of extraction with good compacting, it will produce a higher bending strength value (Newman and Choo, 2003).

CONCLUSION

Based on testing and analysis and discussion that has been found then the conclusion of this research that is iron slag as a rough aggregate replacement material tends to meet all standard specifications, so that, it can be used as an aggregate additive material for concrete structures. Strong bending of concrete on a variation in the use of iron casting waste as a substitute for some aggregate coarse use of five variations of addition, i.e., 0, 25, 50, 75 and 100%. Addition of 50% obtained the highest result that is 5,840 MPa. The use of iron casting waste as a partial substitute of coarse aggregates obtained a higher bending strength of concrete than regular concrete.

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