EFFECT OF THE USE OF STEEL WASTE INTO MECHANICAL PROPERTIES OF CONCRETE

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Abstract— **Concrete is one option as a structural material in building construction. Improved climate change is happening requires an innovation in the world of construction. In order to create a concrete constituent materials are friendly to the environment, one way to use the waste production of steel called the PS Ball. This study aims to determine the effect of the use of PS Ball on concrete compressive strength and flexural strength of concrete. The method used in this study is replacing sand with PS Ball with the percentage of 0-50% and using the PS Ball as filler (filler) with the percentage of 0-50% is used in the concrete matrix, either for testing or testing press bending. Based on the results obtained by analysis concluded that PS Ball can be used as filler and sand replacement material in the concrete mixture. This can be seen in the concrete matrix obtained, that the use of PS Ball can enhance the compressive strength and flexural strength of the concrete**

Keywords— **Compressive strength, Precious Slag Ball, concrete, flexural strength, steel waste**

I. INTRODUCTION

Concrete is one option as a structural material in building construction. Concrete desirable because it has many advantages compared with other materials, among other things: the price is relatively inexpensive, has good strength, constituent raw materials readily available, durable, resistant to fire, do not decay, and so forth. Concrete technology innovation is always required in order to answer the challenge will be a requirement. The resulting concrete is expected to have high quality which includes strength and durability without neglecting its economic value. Moreover, with increasing climate change we need an innovation in the world of construction in order to create a concrete constituent materials are friendly to the environment. One way to use the waste production of steel called the PS Ball.

Improved quality of concrete can be done by adding or replacing the materials used. Substitutes has been done in previous studies. In this study, the replacement material used is PS Ball and is expected to replace the concrete sand with PS Ball can enhance the compressive strength of concrete. PS Ball is very superior to the sand in terms of compressive strength, hardness, and anti-weathering. The structure is very strong, weather resistant, and not easy to wear with a round shape shiny. PS Ball is suitable for various applications due to their physical and chemical properties. The most important is the fact that the PS Ball harmless and environmentally friendly technologies produced by independent negative influence on the environment. The aim of this study was to determine the effect of the use of steel waste PS Ball on the mechanical properties of concrete.

II. PS BALL

EAF slag is a by-product with a large volume formed in the steel-making process (15% to 20% of the capacity of liquid steel), and still contains the remnants of metal. This slag handling previously difficult and inefficient methods. Atomizing technology slag (slag atomizing Technology: SAT) is a new system to form a molten slag into small droplets (atomize) of Electric Arc Furnace (EAF) with high efficiency. Material results of the SAT spherical diameter and size are different, and so-called PS (Precious Slag).

SAT operates the first plant in 1997 in Korea, since the total installed capacity has increased to 1,12juta tons. Capacity under construction and projected to be realized in 2009 in South Korea, South Africa, Malaysia, Thailand, Taiwan, Indonesia, Iran, Vietnam, and the United States totaled 3,4juta ton. On December 1, 2008 SAT PT Full Steel Plant in Harsco (in the area of the factory of PT Krakatau Steel) started operating, with capacity 5.000ton per month.

SAT is the process of changing the liquid slag (1500 ° C-1550 ° C) into small balls with a diameter ranging from 0.1 mm to 4,5mm. The process in the form of high-speed wind system with catalyst and water to the flow of liquid slag is poured through the tundish toward the slag pitt. With the help of water, high-speed air flow generates heat exchange with the fast-changing stream of slag into balls (PS Ball) with a shiny surface.

PS Ball environmentally friendly products processed B3 waste material that can be used as a replacement for quartz sand blasting. In Figure 1 we can see the process of production of PS Ball.

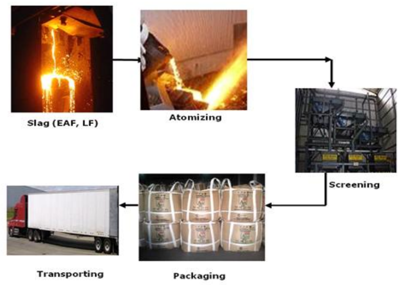

Fig. 1 Production Process PS Ball (Source: P.T.Purna Baja Harsco)

In the SAT process, molten slag is cooled quickly by air and water high speed. Various unstable elements form CaO-Fe2O3, SiO2-Fe2O3 and Mg-Fe2O3. There is no free CaO in the product and the surface will be shiny with spinel structure. Spinel structure is a combination of CaO-Fe2O3, CaO-SiO2. In Figure 2 can be seen in the form of granules of PS Ball.

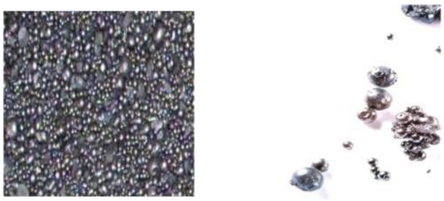

Fig. 2 Characteristics of PS Ball (Source: P.T.Purna Baja Harsco)

PS Ball stands for Precious Slag Ball, new materials resulting from EAF slag. PS Ball has a shiny surface with stable spinel structure. PS Ball is round with a diameter between 0.1 mm to 4,5mm, material with no free lime.

PS Ball is suitable for many applications, thanks to their physical and chemical properties. The most important is the fact that the PS Ball harmless and environmentally friendly technologies produced by independent negative influence on the environment. Chemical structure of PS Ball can be seen in Figure 3.

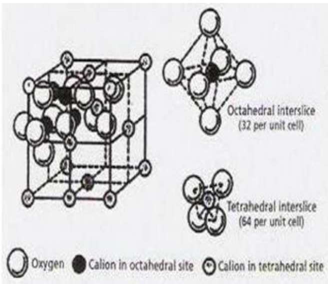

Fig 3 Structure of Spinel PS Ball (Source: P.T.Purna Baja Harsco)

Spinel structure is the main characteristic of this material, physical structure and clams stable eliminate pollution reasons. Characteristics of PS Ball material compared to other materials there can be diihat in Table I.

TABLE I
CHARACTERISTICS MATERIAL PS BALL

Classification	PS Ball	Sand	Garnet	Glass Bead	Steel Ball
Actual Specific Gravity	3,45	2,62	4,2	2,6	7,2
Mohs Hardness	7,5	5,5	7,5	5	8,5
Rockwell Hardness (HRC)	43	30	40	28	50
Brightness (quality grade)	Very good	Norm al	Good	Normal	Very good
Reusability	1-3 times	0ne time	1-3 times	One time	5-7 times

(Source: P.T.Purna Baja Harsco)

PS Ball is very superior to the sand in terms of compressive strength, hardness, and anti-weathering. The structure is very strong, weather resistant, and not easy to wear with a round shape shiny. As new materials, PS Ball has the advantage of physical properties and chemistry that provides the ability for a variety of wide applications, such as coatings precarious metal, manholes, sandpaper, road compaction, material ballast, silencers, protective radiation, a mixture of cement, floorings, soil compactor, piling, water treatment and waste water, filter materials, materials that are not slippery floors, brick, concrete and prefabricated materials, which are not easy to wear tiles, asphalt mixtures, and others.

Some other advantages in the use of PS Ball:

A. PS Ball is the kind of products that are environmentally friendly, safe, and free from toxic or crystalline silica
B. Low dust
C. High productivity. PS Ball is very quickly cut into the surface because of the character of the raw materials, the speed, force (7,5Mohs) and forms that have an impact on the surface.
D. Low Consumption of
   SSPC SP-6/Sa 2 : 18 kg/m^2
   SSPC SP-10/Sa 2,5 : 32 kg/m^2
   SSPC SP-5/Sa 3 : 52 kg/m^2
E. Recycling. PS Ball can be used 2 to 3 times

Usefulness of waste steel PS Ball can be used among others as abrasive blasting material, weight material, casting sand, water treatment, roofing granules, material non-slip, reinforcement materials, poly-concrete material, sand-pile material, road pavement material, and permeable reactive material.

III. RESEARCH METHOD

The method used is by using steel waste PS Ball as a substitute for sand and filler in the concrete matrix. The percentage of steel waste PS Ball using the percentage of 0-50%. Test specimen using the specimen cylinder with a diameter of 150mm and height of 300mm to determine the compressive strength of concrete. Test specimens were used to determine the flexural strength of concrete using a beam with dimensions of 150mm x150mm miners and beam length of 600mm. Set up the concrete flexural strength testing can be seen in Figure 4.

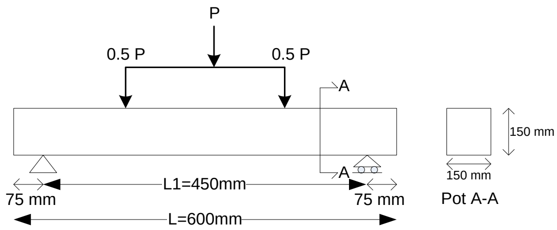

Fig. 4 Set Up Testing Bending Concrete

Stress of concrete in bending can be determined from the Equation (1), with M is the moment of the cross section, y is the distance from the outermost fiber concrete to the neutral axis and I is the moment of inertia of the cross section.

$$f_r = \frac{M.y}{I} \quad (1)$$

ACI regulations state that can be taken by 0,7dari f_r root fc 'for concrete in units of psi, or expressed in N / mm2 or MPa in SI units, then:

$$f_r = 0{,}7 \text{ x } \sqrt{f_c{'}} \quad (2)$$

Concrete compressive strength is determined by loading the concrete cylinder with a diameter of 150mm and height of 300mm. The amount of concrete compressive strength can be calculated using equation (3).

$$f_c{'} = \frac{P}{A} \quad (3)$$

Where :
fc ' = compressive strength (MPa)
P = Compression Load (N)
A = cross-sectional area of the cylinder (mm2)

IV. DATA ANALYSIS

The effect of the use of steel waste as a filler on a matrix of concrete to concrete compressive strength can be seen in Figure 5. The effect of the use of steel waste as a substitute for sand in concrete matrix of the concrete compressive strength can be seen in Figure 6. Comparison of the effect of the use of waste as a substitute for sand steel and as filler (filler) 28 days in the concrete matrix to the concrete compressive strength can be seen in Figure 7.

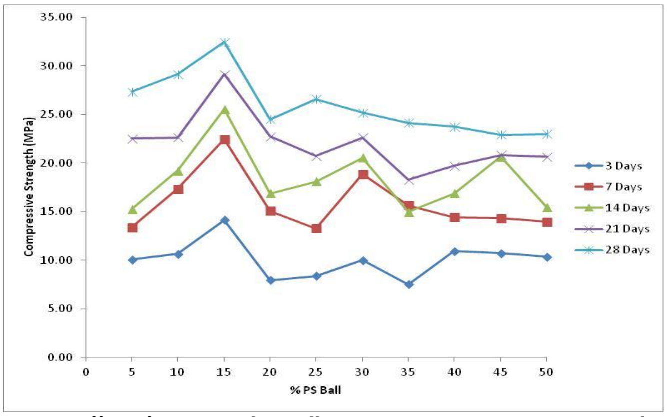

Figure 5 Effect of Waste Steel As Filler On Concrete Compressive Strength

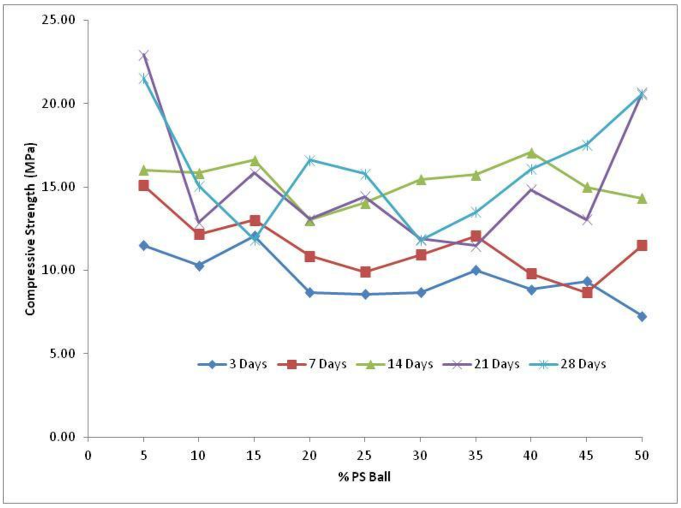

Fig 6 Effect of Waste Steel Instead of Sand Against Concrete Compressive Strength

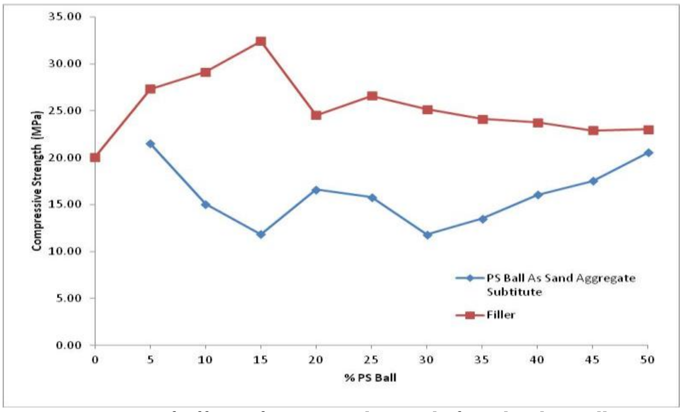

Fig 7 Comparison of Effects of Waste Steel Instead of Sand and as Filler On Concrete Compressive Strength

The effect of the use of steel waste as a filler (filler) on a matrix of concrete to the concrete flexural strength can be seen in Figure 8. The effect of the use of steel waste as a substitute for sand in concrete matrix to the concrete flexural strength can be seen in Figure 9. Comparison of the effect of the use of waste as a substitute for sand steel and as filler 28 days in the concrete matrix to the concrete flexural strength can be seen in Figure 10.

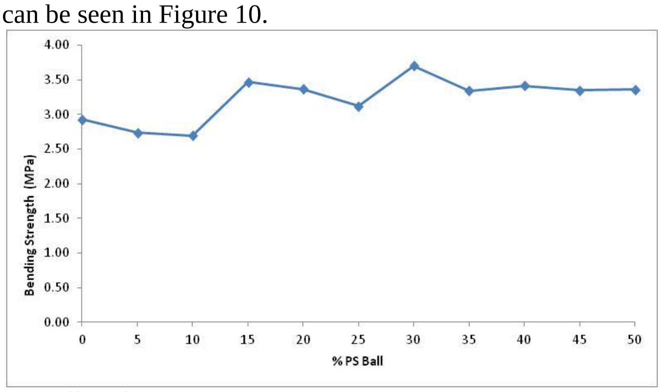

Fig 8 Effect of Waste Steel As Filler Against Bending Strength Concrete

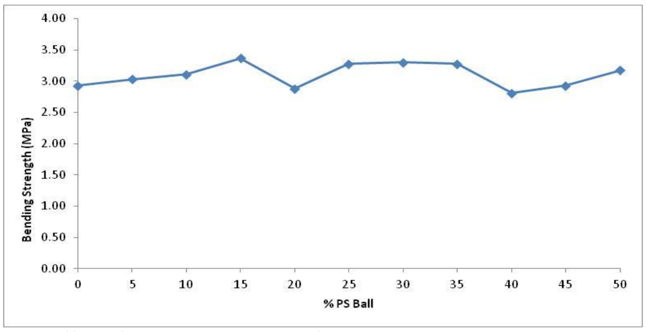

Fig 9 Effect of Waste Steel Instead of Sand Against Bending Strength Concrete

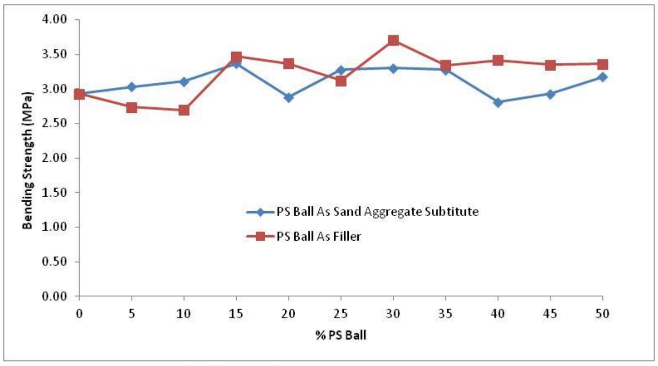

Fig 10 Comparison of Effects of Waste Steel As Substitute For Filler Against Sand and Bending Strength Concrete

Improvement of concrete compressive strength using PS Ball As filler into concrete matrix can been see in Table II

TABLE II
IMPROVEMENT CONCRETE COMPRESSION STRENGTH USING PS BALL AS FILLER

No	% PS ball	Improvement
1	0	-
2	5	1.36
3	10	1.45
4	15	1.62
5	20	1.22
6	25	1.32
7	30	1.25
8	35	1.20
9	40	1.18
10	45	1.14
11	50	1.15

Improvement of concrete compressive strength using PS Ball As sand aggregate subtitute into concrete matrix can been see in Table III

TABLE III
IMPROVEMENT CONCRETE COMPRESSION STRENGTH USING PS BALL AS SUBTITUTE SAND AGGREGATE

No	Kadar PS ball (%)	Improvement
1	5	1.07
2	10	0.75
3	15	0.59
4	20	0.83
5	25	0.79
6	30	0.59
7	35	0.67
8	40	0.80
9	45	0.87
10	50	1.02

Comparison of the increase in the compressive strength of concrete using as a filler PS and PS Ball Ball instead of sand can be seen in Figure 11.

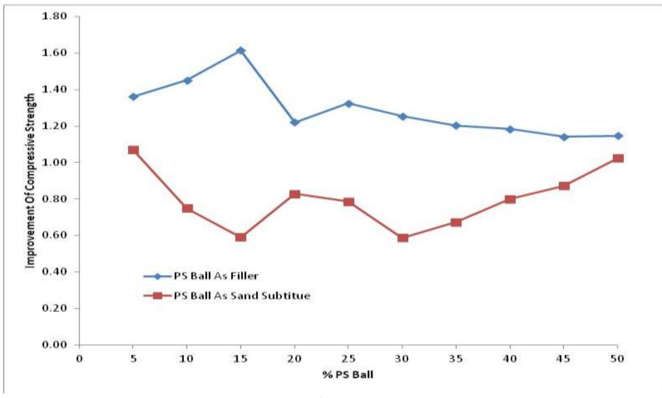

Fig. 11 Comparison Improvement of Compressive Concrete Strength using PS Ball As Filler And PS Ball As Sand Aggregate Subtitute

Improvement of concrete beding strength using PS Ball As filler into concrete matrix can been see in Table IV.

TABLE IV
IMPROVEMENT CONCRETE BENDING STRENGTH USING PS BALL AS FILLER

No	% PS Ball	Improvement Bending Strength (Mpa)
1	0	2.93
2	5	2.74
3	10	2.70
4	15	3.47
5	20	3.37
6	25	3.12
7	30	3.70
8	35	3.34
9	40	3.41
10	45	3.35

Improvement of concrete bending strength using PS Ball As sand aggregate subtitute into concrete matrix can been see in Table V

TABLE V
IMPROVEMENT CONCRETE COMPRESSION STRENGTH USING PS BALL AS SUBTITUTE SAND AGGREGATE

No	% PS Ball	Improvement Bending Strength (Mpa)
1	0	2.93
2	5	3.03
3	10	3.11
4	15	3.37
5	20	2.88
6	25	3.28
7	30	3.30
8	35	3.28
9	40	2.81
10	45	2.93
11	50	3.17

Comparison of the increase in the bending strength of concrete using as a filler PS and PS Ball Ball instead of sand can be seen in Figure 12.

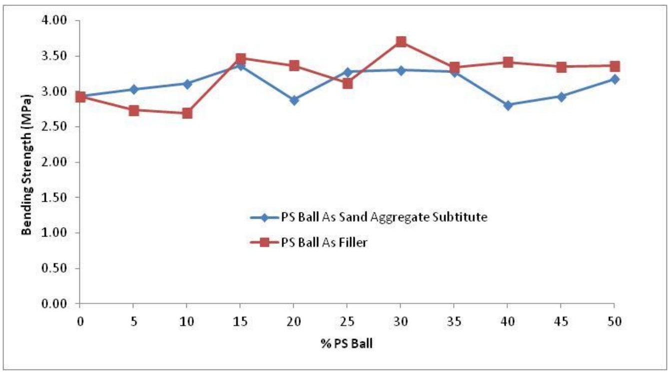

Fig 12 Comparison Improvement of Concrete Bending Strength using PS Ball As Filler And PS Ball As Sand Aggregate Subtitute

All crack pattern from the test using PS Ball as filler and PS Ball as sand aggregate subtitute indicate cracking that occurs is fexural cracked

V. CONCLUSIONS

1. The use of steel in the form of waste PS Ball can be used as the building blocks of concrete, either as asand replacement or as a filler in the concrete matrix.
2. The compressive strength of concrete is likely to increase as waste steel is used as filler in the concrete matrix.
3. The use of steel waste is better used as a fille for concrete compressive strength than used as a substitute for sand.
4. Strong bending concrete steel tends to increase when waste is used as filler (filler) in the concrete matrix
5. The use of steel waste is better used as a filler (filler) for flexural strength than the concrete used as a substitute for sand.
6. The use of steel in the form of waste PS Ball can enhance the mechanical properties of concrete, such as compressive strength and flexural strength of concrete. Improved mechanical properties of the concrete is increased when the waste steel is used as filler (filler) as well as waste steel is used as a substitute for sand

ACKNOWLEDGMENT

Acknowledgements to Higher Education for providing financial support DP2M-Higher Education Competitive Grant for Fiscal Year 2015 in this study with the title "Effect Using PS Ball Into Reinforced Concrete Beams under monotonic and cyclic loading".

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