Application of viscosity modifying admixture (VMA) in eco-friendly concrete

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Abstract. Utilization of waste as a material that is useful again becomes a concern for every industry player. The researchers are indirectly invited to innovate in order to preserve the environment. The use of slag as a recycled material in pervious concrete is one of the sustainable solutions for preserving the environment. The use of viscosity modifying admixture (VMA) is expected to provide good workability in eco-friendly concrete. In this study, the tests carried out on fresh concrete are the air content in the concrete and the weight volume, as well as hard concrete testing including compressive strength test and porosity test of concrete. Eco-friendly concrete uses slag with variations of 0%, 30%, 50% and 70% of the weight of coarse aggregate. In the result of volume weight test, there was a 30.8% increase in the level of 70% slag from 0% slag and air content of 47.7%. Concrete compressive strength test showed optimum results at 70% slag contain an increase of 271% from 0% slag specimens and void rate around 16.7%.

1. Introduction
The production of nickel from the nickel mine in Soroako, South Sulawesi can range from 70,000 to 72,000 tons in 2019. This indicates that the nickel material waste produced is not insignificant, therefore researchers from the company as well as academics are specifically challenged to be able to handle nickel production waste. The use of nickel slag as an eco-friendly concrete constituent is considered appropriate to reduce pollution and local environmental pollution. In addition, the use of nickel slag as coarse aggregate can reduce the use of natural coarse aggregate which will then affect the construction costs as well as energy savings. The use of nickel slag can be considered quite economical and environmentally friendly to the sustainability of materials in the construction industry.

The use of waste material is also carried out in research conducted by M.H. Andika, et al (2019) that is using slag and silica fume as cement substitution material in pervious concrete. Research shows that the use of 9.5 mm - 4.75 mm waste material produces the highest compressive strength, 13.25 MPa and the highest porosity with a value of 23.04%. This suggests that the use of slag and silica fume as pervious concrete substitution material can increase the compressive strength and reduce porosity. The use of recycled crude aggregate from construction waste (RCA) with some variations and local granite (2018) is a study conducted by Yap Soon Poh, et al. The material used is a composition of pervious non-structural concrete that was tested. The test results show that the lower strength is found in concrete with 100% RCA, but these results meet the BS EN 1338 standard. Research (2017) conducted by Ivana Barišić, et al. Conducted research using local materials with uniform and varied sizes and dolomites as a pervious concrete building material. This research shows that compressive strength can be achieved up to 25 MPa, flexural strength 4.31 MPa and porosity
value 21.66%. Herna Puji Astutik, et al (2014) conducted research on adding pottery waste into pervious concrete. The research conducted aims to determine the compressive strength, porosity and permeability of pervious concrete. Pottery waste used is burned clay (pottery waste) with variations of 0%, 44.6%, 50.9% and 100% of the weight of natural coarse aggregate. The results of the study indicate that earthenware fraction waste actually increases the porosity and permeability values of concrete but decreases the compressive strength of concrete.

2. Experimental Study
In this study, the coarse aggregates used were local aggregates and the nickel slag used came from PT. Vale Soroako. Viscosity modifying admixture used is viscocrete 8050 PT. Sika with the use of 1.5% by weight of cement. The aggregates used have been tested for characteristics such as volume weight (loose and solid), specific gravity and aggregate absorption and aggregate filter analysis test; all according to SNI (Indonesia Standard) provisions.

![Figure 1. Nickel slag](image1.png)

![Figure 2. Viscocrete](image2.png)

Mix design of pervious concrete is based on ACI 522R-10 with the calculation process in the following table 1:

| Description                                      | Value       |
|--------------------------------------------------|-------------|
| Void content                                     | 17.0 %      |
| Volume design                                    | 1 m³        |
| **Determine aggregate weight (see aggregate size)** |             |
| a. Weight of coarse aggregate in unit of coarse aggregate volume, (loose) (b) | 1347 kg/m³ |
| b. Weight of coarse aggregate in unit of concrete volume (compacted), (b₀) | 1460 kg/m³ |
| d. Ratio value b/b₀ based on table 6.1           | 0.99        |
| **Aggregate weight in saturated surface dry condition** |             |
| a. Absorption                                    | 2.9 %       |
| b. Weight of coarse aggregate in unit of concrete volume (SSD condition) | 1400 kg/m³ |
| **Determine paste volume**                       |             |
| Paste Content                                    | 25.00 %     |
| Paste volume in mix concrete (Vp)                | 0.250 m³    |
| **Determine eight of cement**                    |             |
| Water cement ratio (w/c)                         | 0.35        |
| c. Ratio value b/b₀                              | 0.92        |
The specimens used were cylinders with a diameter of 100 mm and a height of 200 mm, the life of the compressed strength and porosity specimens were 7, 14, 21 and 28 days. While the weight content and air content are carried out on fresh concrete test specimens. The composition of various variations is shown in the following table:

Table 2. Composition variation

| Materials          | 30% Nickel Slag (kg) | 50% Nickel Slag (kg) | 70% Nickel Slag (kg) |
|--------------------|----------------------|----------------------|----------------------|
| Cement             | 375.9                | 375.9                | 375.9                |
| Coarse aggregate   | 980.3                | 700.2                | 420.1                |
| Nickel Slag        | 420.1                | 700.2                | 980.3                |
| VMA                | 5.64                 | 5.64                 | 5.64                 |

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3. Results and Discussion

Based on the mix design of several variations that have been made, the following test results are obtained:

| Variation | Air content of fresh concrete (%) |
|-----------|-----------------------------------|
| 0%SN      | 12.8                              |
| 30%SN     | 25.7                              |
| 50%SN     | 36.7                              |
| 70%SN     | 47.7                              |

| Variation of composition | Weight volume (kg/m³) |
|--------------------------|-----------------------|
| 0%SN                    | 2153                  |
| 30%SN                   | 2398                  |
| 50%SN                   | 2608                  |
| 70%SN                   | 2817                  |

From the table and bar chart the test results above show that the greatest air content and volume weight are found in specimens with 70% nickel slag composition variation with values of 47.7% and 2817 kg / m³, respectively. For the largest volume weight increase occurred in the composition of 70% with a value of 30.8% of the composition of 0% nickel slag. Large air content in fresh concrete does not make the volume weight decreases, this is due to the specific gravity of the slag nickel which is quite large. Hard concrete and porosity test results are shown in the following tables and graphs:
Table 5. Result of compressive strength

| Age (days) | 0%SN | 30%SN | 50%SN | 70%SN |
|-----------|------|-------|-------|-------|
| 7         | 3.26 | 3.91  | 3.85  | 5.62  |
| 14        | 3.85 | 4.28  | 4.54  | 6.19  |
| 21        | 4.44 | 4.74  | 5.31  | 6.72  |
| 28        | 5.01 | 5.08  | 5.89  | 8.31  |

Figure 7. Graph for compressive strength for pervious concrete

Table 6. Result of void content in pervious concrete

| Variation of composition | Void content (%) |
|--------------------------|------------------|
| 0%SN                     | 15.9             |
| 30%SN                    | 16.5             |
| 50%SN                    | 15.8             |
| 70%SN                    | 16.7             |

Figure 8. Bar chart for void content test
Compressive strength test results showed a very significant increase in strength with each addition of nickel slag variations. In the 30% variation, there was an increase of 1.4%, a 50% variation had an increase of 17.6% and a 70% variation increased to 65.7%. The results of the void content show that the void content in pervious concrete for all variations ranges from 16-17%, which is the range of voids in the pervious concrete mix design.

4. Conclusion
   Eco-friendly concrete stated in pervious concrete with nickel slag content has been tested. Based on the results of laboratory tests it can be concluded that the use of viscosity modifying admixture can maintain the workability of pervious concrete with a usage range of 1-1.5% of the weight of cement. The use of nickel slag as a substitute material for coarse aggregate pervious concrete can increase the compressive strength up to 65% of pervious concrete without nickel slag. So it can be concluded that nickel slag can be used as a compiler material in pervious concrete that is environmentally friendly.

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