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EDITOR IN CHIEF
Prof. Dr. Ir. Enri Damanhuri

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Green Technology towards Sustainable Environment

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PREFACE

Green Technology that provides the basic needs of society in sustainable environment is essential for the survival, health and well-being of a society in developing countries. The engineers, scientists, policy makers, academics, environmental consultants, environmental contractors, industrial practitioners, businessmen, politicians, NGOs are at the epicenter in seeking means to enhance human life through modernization of technology and infrastructure. The current rate of urbanization, industrialization and environment mismanagement rise environmental issues. The problems are further aggravated with environmental degradation such as soil erosion, depletion of water resources, climate changes, and others. In order to seek answers for these multifaceted challenges, proper planning, implementation and verification exercises are required, via an integrated, multidisciplinary and holistic approach especially in the area of green infrastructure and green cities, development of eco-industry, environmental health and risk assessment, air quality, advanced technology, natural resources and mitigation of climate change. This international conference shall become a momentum for development of sustainable environment through green technology.

The 5th Environmental Technology and Management Conference (ETMC) was held on 23-24th November 2015, at *Sasana Budaya Ganesha, Institut Teknologi Bandung* (ITB). The ITB is located in Bandung, West Java. Bandung is the center of Sundanese culture and volcanoes surrounds city which make Bandung to be a delightful place to host this conference. More than 300 scientific participants (researcher, students, government officers and industries) had many fruitful discussions and exchange ideas that contribute to the success of the conference. Participants of the conference are coming from US, Australia, Nederland, Japan, Malaysia, Singapore and Indonesia, made the conference truly worthwhile globally. There are 4 speakers in plenary sessions covering different areas, and all the keynote speakers are well known and competent speakers; They are Ir. Mochamad Basoeki Hadimoeljono, M.Sc., Ph.D (Ministry of Public Works and Housing, Republic of Indonesia), Prof. Dr. AJM Smits (Director of Institute for Science, Innovation & Society, Radboud University Nijmegen), Albert Simanjuntak (President Director of Chevron Pacific Indonesia) and Ir. Edwan Kardena, PhD (Environmental Engineering, Institut Teknologi Bandung). There were also 5 parallel sessions with eight invited speakers : Prof. Satoshi Okabe; Prof. Ir. Mindriany Syafila, MS; Prof. Ir. Iwan Kridasantausa Hadihardaja, MSc, PhD; Prof. Dr. Takeshi Fujiwara; Rene van Berkel, PhD; Prof. dr. A.M.J. Ragas; Dr. Budi Haryanto, SKM, MKM, MSc; Dr. rer.nat Armi Susandi,MT.

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the conference. These proceedings divided into 6 sections of 110 abstracts as oral presentation and 23 abstracts as poster session with such topics as follows: Air Quality & Climate Change, Green Cities & Infrastructures, Eco-Industries, Appropriate & Advanced Environmental Technology, Natural Resource Management, and Environmental Health and Risk Assessment. Selected papers will be republished in the special issues of Journal of Technological and Engineering Sciences.

Generous support for the conference was provided by Chevron Pacific Indonesia, JICA, BNI, Vale, Sari Husada, Indocement, Holcim, Sabuga and Faculty of Civil and Environmental Engineering, ITB. The funds were sizeable, timely, and greatly appreciated, and allowed us to support a significant number of young scientists (students) and delegates from developing countries.

Finally, the 5th ETMC was a very successful conference. The plenary lectures, parallels session and special reports bridged the gap between the different fields of green technology, making it possible for non-experts in a given area to gain insight into new areas. Also, included among the speakers were several young scientists and students, who brought new perspectives to their fields. Given the rapid advancement of science in all areas that covered by ETMC, we expect that this ETMC was as stimulating as the previous one, as indicated by the papers contributions presented in this proceeding volume.

Bandung, 24 November 2015

Ir Agus Jatnika Effendi, PhD

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MECHANICAL PROPERTIES OF CONCRETE USING NICKEL SLAG AS COARSE AGGREGATE

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Abstract:*Experimental study on the use of nickel slag as coarse aggregate in concrete has been realizedconcerning compressive strength, splitting tensile strength and modulus of elasticity. The nickel slag was obtained from solid waste of the nickel ore processing in Southeast Sulawesi, Indonesia. Natural sand was used as fine aggregate, naturally weathered gravel as control coarse aggregate as well asordinary Portland cement as hydraulic binder. The aggregates grain distribution was designed to meet the mixture gradation of the granules with a maximum diameter of 40 mm according to Indonesian Standard SNI 03-2834-2000. The mix proportion of concrete, by weight, was 1.0 hydraulic binder: 2.0 fine aggregate: 3.0 coarse aggregate with the water-cement ratio was 0.5. Two mixtures were produced by varying the type of coarse aggregate used: one mixture using slag nickel and another mixture using naturally weathered gravel as a control. The test result, realized at 28 days, shows that the use of nickel slag in the mixture of concrete improves the mechanical properties of the concrete. In fact, the compressive strength, splitting tensile strength and modulus of elasticity of concrete using nickel slag increase, respectively, about 45%, 24% and 19% compared with the results given by control concrete. The interesting development of these mechanical properties can be relied by the rough-textured of nickel slag aggregate giving a stronger physical bond between the aggregate and the hydrated cement paste. This study reveals another possible way of the valorization of nickel slag, especially as coarse aggregate in concrete, in order to simultaneously conserve natural resource, reduce environmental problem and also production cost of concrete.*

Keywords: *nickel slag; compressive strength; splitting tensile strength; modulus of elasticity*

1. Introduction

Nickel slag is a solid waste product from nickel ore processing. A lot of nickel slag is generated for producing pure nickel. About 1.000.000 tons nickel slag are produced annually in Southeast Sulawesi, Indonesia [http://www.antam.com]. This by product, therefore, must be well managed in order to avoid environmental problem, because it is waste.

In Southeast Sulawesi, nickel slag is usually used as overburden backfilling material to fill in or extend usable land. Figure 1 shows an area in Southeast Sulawesi where nickel slag is disposed. From the ecological consideration, it seems that this strategy is not yet a "green" solution because slag could release toxic metals that are normally presents in small amounts. Therefore, it should find out a strategic way that can "consume" nickel slag in large quantities in order to reduce the future environmental problem.

Figure 1. Nickel slag disposal area in Southeast Sulawesi

In this research, concrete made by using nickel slag as coarse aggregate has been studied regarding its size and shape are similar to those of aggregates for normal concrete. The objective of this study is to evaluate the possibility of this kind of waste as a coarse aggregate in concrete production from the standpoint of compressive strength, splitting tensile strength and modulus of elasticity. As a control, it was also made concrete using naturally weathered gravel as coarse aggregate.

2. Materials and Methods

Natural sand was used as fine aggregate, naturally weathered gravel as control coarse aggregate as well as ordinary Portland cement as hydraulic binder. The nickel slag used in this study was obtained from Pomalaa in Southeast Sulawesi, Indonesia which was originally from the nickel smelting process at the electric furnace. Figure 2presents the shape and surface texture of this slag while Table 1gives some physical properties of natural sand, naturally weathered gravel and nickel slag.

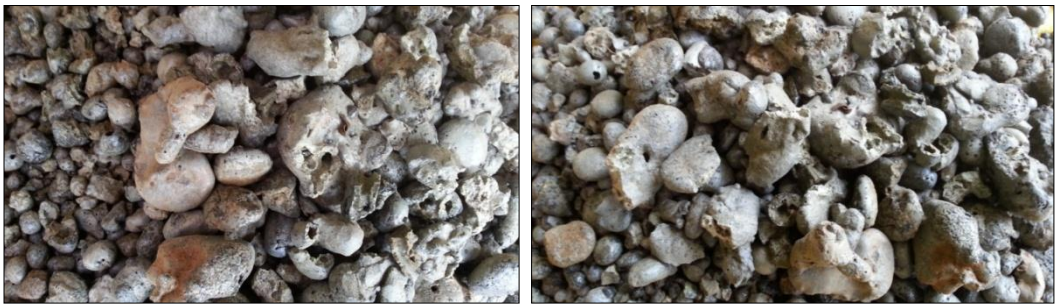

Figure 2. Shape and surface texture of nickel slag

Table 1. Physical properties of sand, gravel and nickel slag

Material	Unit weight (g/cm^3)	Specific gravity	Los Angeles Abrasion loss (%)	Absorption (%)
Natural sand	1.57	2.60	-	0.81
Weathered gravel	1.44	2.59	31.53	1.31
Nickel slag	1.57	2.90	40.92	0.88

The aggregates grain distribution was designed to meet the mixture gradation of the granules with a maximum diameter of 40 mm according to Indonesian Standard SNI 03-2834-2000.

Figure 3 shows the grain distribution of the aggregates used in this study.

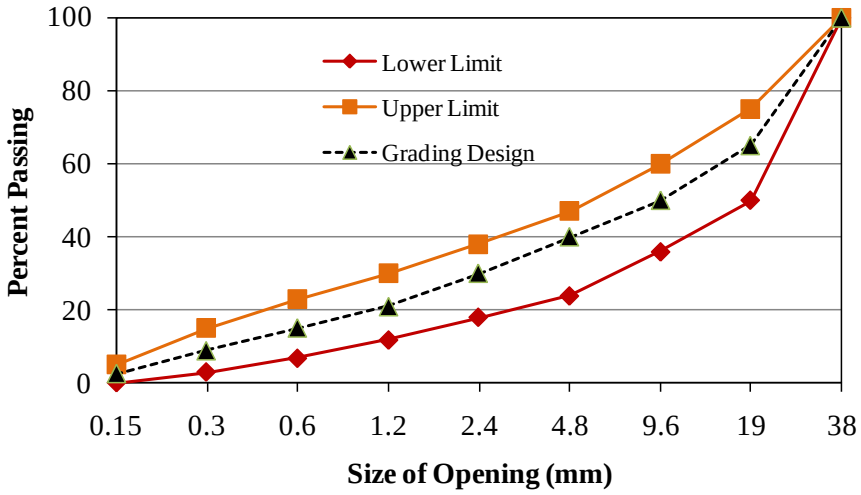

Figure 3. Grading curve for aggregate with SNI 03-2834-2000 grading limits

The mixture proportion of concrete, by weight, was 1.0 hydraulic binder: 2.0 fine aggregate: 3.0 coarse aggregate with the water-cement ratio was 0.5. Two mixtures
were produced by varying the coarse aggregate types used: one mixture using slag nickel and another mixture using naturally weathered gravel as a control. Each mixture was used to cast cylindrical specimens with a diameter of 150 mm and a height of 300 mm. These cylindrical specimens were kept in molds for 1 day and then cured in water until used for the mechanical properties test.

Tests of compressive strength, splitting tensile strength and modulus of elasticity were realized after 28 days of hydration by using 6 specimens for each test and conducted according to SNI 03-1974-1990, SNI 03-2491-2002 and ASTM C 469 respectively. Figure 4 shows the preparation and realization of the mechanical properties test.

Figure 4. Preparation and realization of mechanical properties test

3. Results and Discussion

3.1 Results

Results of the mechanical properties test, after 28 days hydration, are given in Figure 5, 6 and 7 for the compressive strength, splitting tensile strength and modulus of elasticity respectively. It can be clearly observed that the use of nickel slag as coarse aggregate in the mixture increases the compressive strength of the concrete. This result is in accordance with other research results [Sugiri, 2005; Tanijayaand Hardjito, 2007].This phenomenon can also be clearly observed for the splitting tensile strength and modulus of elasticity.

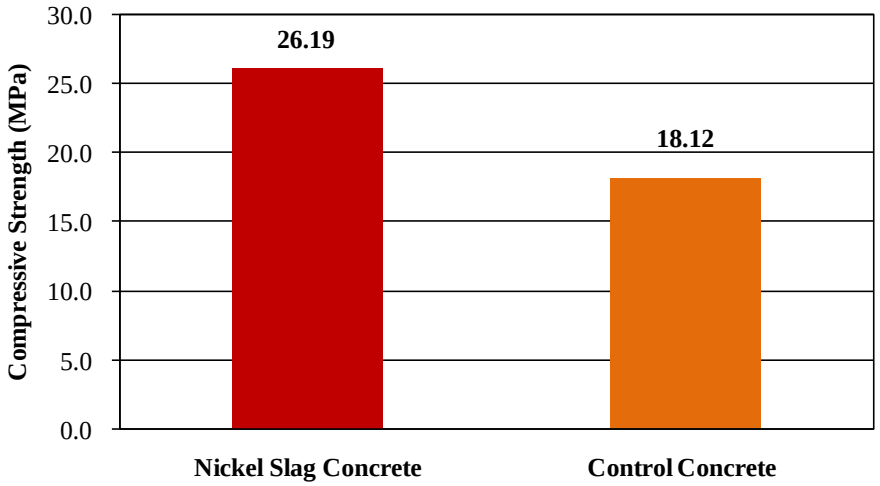

Figure 5. Compressive strength of nickel slag concrete and control concrete

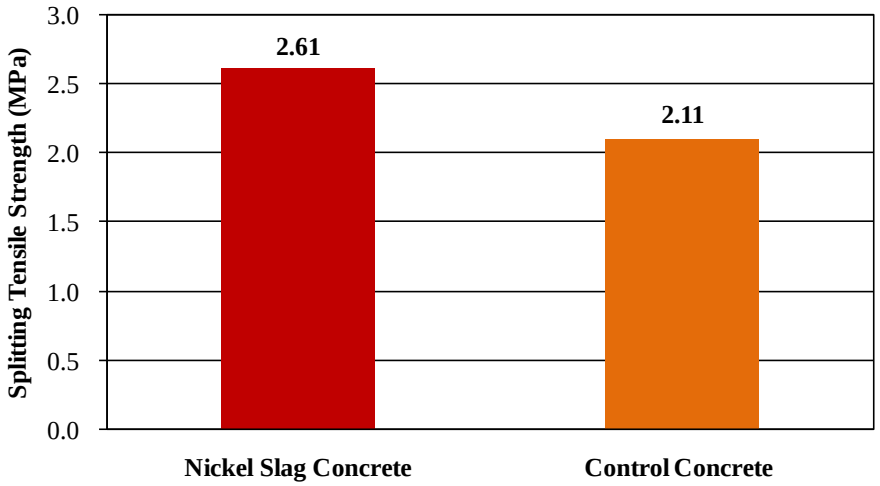

Figure 6. Splitting tensile strength of nickel slag concrete and control concrete

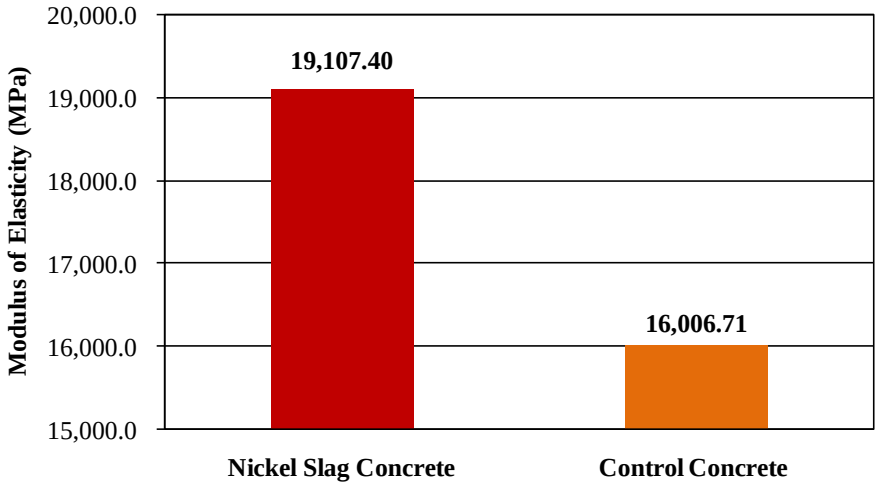

Figure 7. Modulus of elasticity of nickel slag concrete and control concrete

By using nickel slag as coarse aggregate in the mixture, the compressive strength, splitting tensile strength and modulus of elasticity concrete increase respectively about 45 %, 24 % and 19 % compared with the results given by control concrete which use naturally weathered gravel as coarse aggregate. It is clearly noted that the improvement is more pronounced for the compressive strength.

3.2 Discussion

It is clearly observed that the use of nickel slag in the mixture improves the mechanical properties of concrete, especially its compressive strength. The magnitude improvement can reach about 45 %, 24 % and 19 %, respectively, for the compressive strength, splitting tensile strength and modulus of elasticity.
This interesting improvement can be obviously related to the physical form of nickel slag aggregate. A more rough surface texture of the nickel slag aggregate compared with that of naturally weathered gravel produces a stronger physical bond between the aggregate and the hydrated cement paste [Mehta, 1986; Neville and Brooks, 1998]. In fact, this stronger physical bond helps to increase the capacity of nickel slag concrete to carry load, especially compressive load. Thus the presence of rough-textured aggregate in a concrete mixture gives an advantage for the development of the compressive strength, splitting tensile strength and modulus of elasticity of concrete although not to the same degree.
From the result of this study it can be showed that nickel slagcan be used as coarse aggregate in concrete mixture. The massive use of this waste in concrete technology in the future could help simultaneously to conserve naturally weathered gravel as natural resource, reduce environmental problem and also production cost of concrete.

4. Conclusions

- The use of nickel slag as coarse aggregate in concrete mixture can improve the mechanical properties of the concrete.
- The compressive strength, splitting tensile strength and modulus of elasticity of nickel slag concrete increase, respectively, about 45 %, 24 % and 19 % compared with the result given by concrete using naturally weathered coarse aggregate.

- The massive use of this waste could help simultaneously to conserve the natural resource, reduce environmental problem and also production cost of concrete.

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