# SOCIAL GREEN BEHAVIOUR, ARTIFICIAL INTELLIGENCE AND BUSINESS STRATEGIES & PERSPECTIVES IN GLOBAL DIGITAL SOCIETY

Editors


***Assoc. Prof. Dr. Muhammad Ali Tarar***
***Dr. Muhammad Saghir Ahmad***
***Lawrence Walambuka***


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## PREFACE

How well people work together is a crucial factor in the success of any business & organization. Social behavior and good leadership play important role in adoption of new innovations, technologies, and skills that ultimate change the pattern of communication to promote business, enhance sales and strengthen organization and industry in present era. The development of the Industrial Revolution brought changes to the adjustment of work in humans, machines, technology and processes in various professional fields, including the accounting profession. The Industrial Revolution requires the accounting profession to adapt to the development of information technology and big data. Facing today's latest industrial era, the development of the digital economy has opened new possibilities while simultaneously increasing risk. These changes have a significant impact on the development of accounting. In this era, technological developments and innovations seem to keep pace with time. New innovations encourage the creation of new markets and shift the existence of old markets. Smart machines and robots are now taking on many roles and seem to rule the world. In the Industrial Revolution 4.0 there was an extraordinary shift in various fields of science and profession, therefore the way accountants work, and practice needs to be changed to improve service quality and global expansion through online communication and the use of cloud computing and artificial intelligence.

Thank you for the hard work of the Steering Committee who has assessed the articles to be published in Social Behaviour, Leadership, Sales, Communication, Organization, Branding, Feasibility Analysis for Business Management: Inquiries with New Approaches in the Post-Pandemic Era.

This publication is dedicated to the world of science in the field of Accounting which is currently growing so rapidly. The development of Cloud Computing and Artificial Intelligence has played a role in changing the work order of Accountants.

**Assoc. Prof. Dr. Muhammad Ali Tarar;**
**Bursa – January 2024**

# CONTENTS

# CHAPTER 6

# Investigation of Cement Substitution with Industrial Solid Waste as an Alternative Material in Construction: A Review

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## ABSTRACT

As the growth of infrastructure in Indonesia increases, the need for concrete rises. The reduction of environmental, energy, and $CO_2$ impact resulting from the use of concrete for construction is crucial as it is directly associated with the depletion of natural resources and the increasing severity of the greenhouse gases effect. Cement is a fundamental material utilized in the construction industry, working as a major component for ordinary concrete, an essential material for construction for society. This research investigates the possibility of utilization of industrial waste as an additional cementitious ingredient in the manufacturing of concrete. The objective is to emphasize a method of utilizing these waste materials by providing comprehensive details related to their technology, physical, and chemical properties. This is an overview of the present knowledge regarding the effective utilization of industrial waste materials, such as fly ash, ground granulated blast furnace slag, silica fume, and nickel slag, within the building materials sector. An innovative approach that might be adopted is minimizing the utilization of cement by employing eco-friendly alternative materials.

**Keywords:** Cement, Cementitious, Construction, Fly Ash, Greenhouse gases

## A. Introduction

Along with the acceleration of infrastructure development in Indonesia, the demand for concrete is increasing. Minimizing environmental, energy, and CO2 impacts is crucial. The intensity of concrete used for construction plays a pivotal role, as it is directly proportional to the decline in natural material resources and the increasing greenhouse effect. Cement, a primary material in conventional concrete essential for the community and the construction industry, is obtained through mining natural minerals. The availability of these minerals is dwindling due to production processes that emit greenhouse gases, including carbon dioxide (CO2), contributing to global warming. An innovative approach to address this is to reduce cement use by incorporating environmentally friendly substitute materials. According to literature (McLellan et al., 2011), global cement production contributes about 5-7% of total carbon dioxide gas (CO2) emissions to the Earth's atmosphere. Therefore, Ordinary Portland Cement (OPC) can be replaced with more environmentally friendly materials.

Advancements in science and technology have led to the discovery of materials that can substitute cement in making concrete. Geopolymer concrete, also known as Geopolymer Concrete, is one such innovation resulting from research proving that cement can be replaced with industrial solid waste materials. Industrial waste, including fly ash, slag, rice husk ash, and metakaolin, serves as alternatives that can replace the role of cement (Wallah & Rangan, 2006).

Utilizing industrial and agricultural solid waste with the concept of Supplementary Cementitious Materials (SCMs) can act as partial replacements for cement. These materials enhance concrete durability, reduce the risk of thermal cracking, and further minimize CO2 emissions compared to traditional cement (Berndt, 2009). Previous studies have shown that alternative materials like SCMs can significantly reduce the amount of CO2 produced by concrete (Flower & Sanjayan, 2007).

Creating environmentally friendly construction involves considering factors that affect the mechanical characteristics and microstructure of concrete, including compressive strength tests, tensile strength tests, and Scanning Electron Microscopy (SEM) tests. In the following sections of this book, the author will discuss the results of several studies on the use of industrial solid waste as an advanced material in environmentally friendly concrete fabrication to promote sustainable development.

## B. Literature Review

The previous research journals that became references in this study were with SCMs criteria (*Supplementary cementitious materials*) and the application of different research. The lack of SCMs research using industrial solid waste is a limitation in this study. Usually, industrial solid waste is used as a substitute for aggregate and asphalt mixture in road pavements, because the size and texture of the base material are more in the gradation in aggregate form. To be substituted with cement, the industrial solid waste must go through several processes to form a fine powder /*Powder*. Previous research that became a reference in this study can be seen at

Table 1.

Table 1. Previous Research

| No. | Reference | SCMs | Application | Country |
|---|---|---|---|---|
| 1 | (Oksri-Nelfia et al., 2016) | Waste recycled concrete | Concrete | French |
| 2 | (Karwur et al., 2013) | Glass Powder | Concrete | Indonesian |
| 3 | (Raharja, 2013) | Rice Husk Ash | Concrete | Indonesian |
| 4 | (Bahedh &; Jaafar, 2018) | *Fly Ash* | Concrete | Malaysia |
| 5 | (Berndt, 2009) | *Fly Ash* | Concrete | Australia |
| 6 | (Danasi &; Lisantono, 2015) | *Fly Ash* with *Silica Fume* and *Quartz Sand* Filler | Concrete | Indonesian |
| 7 | (Saha &; Sarker, 2018) | *Fly Ash* and GGBFS | Concrete | Australia |
| 8 | (Kadhafi, 2015) | *Copper Slag* | Concrete | Indonesian |
| 9 | (Moura et al., 2007) | *Copper Slag* | Concrete | Brazil |
| 10 | (Edwin et al., 2016) | *Copper Slag* | Concrete | Belgium |
| 11 | (Afshoon &; Sharifi, 2014) | *Copper Slag* | *Concrete Workability* | Iran |
| 12 | (Sugiri, 2005) | *Nickel Slag* | Concrete | Indonesian |
| 13 | (Oksri-Nelfia et al., 2020) | *Nickel Slag* | Concrete | Indonesian |
| 14 | (Nabiilah et al., 2019) | *Nickel Slag* | Concrete | Indonesian |
| 15 | (Wu et al., 2018) | *Nickel Slag* | Road | China |
| 16 | (Wu et al., 2019) | *Nickel Slag* | Cement Paste | China |

Based on the results of previous research, industrial solid waste can be categorized as SCMs that have the potential to be utilized more optimally.

### B.1. Effect of Cement Substitution with Substitute Material

Cement plays an important role in construction materials, both in building structures and road construction. On the other hand, cement has a bad impact on the environment. World cement production of 1.6 billion tons contributes 7% of CO2 to the atmosphere annually. Every 1 ton of cement production requires about 4 GJ of energy and the manufacture of cement releases 1 ton of CO2 into the atmosphere (Edser, 2005).

From year to year, the use of cement material in the construction industry is increasing and this increase has an impact on increasing the production of exhaust gas, CO2 in nature which results in the formation of the greenhouse effect. With the aim of minimizing adverse effects on the environment caused by technology and the use of materials that are not environmentally friendly, experts in the field of construction engineering continue to strive to find alternative technologies and materials that can produce environmentally friendly construction materials without reducing structural performance (Waani et al., 2017).

## C. Methodology

The research method used in this study is a literature study method from previous studies that discuss the use of industrial waste such as *fly ash, copper slag, steel slag, nickel* slag, and others as *Supplementary Cementitious Materials* (SCMs). The data and results of the study are expected to provide information to find out how much influence SCMs have on construction materials, and can also be used as a reference for further research so that it can continue to be developed.

## D. The Effect of SCMs on Construction Materials

### D.1. Procedure for Using SCMs for Construction Materials

Some previous studies refer to SNI-03-6468-2000(SNI 03-6468-2000, 2000) and ASTM International & Statements in 2003, due to the absence of regulations regarding the composition of designs using SCMs in concrete, especially in nickel slag, concrete recycling waste, metakaolin and others. For road construction, research (Wu et al., 2018) Refer to the provisions in GB13693-2005 for mineral clinker. To make cement paste with SCMs, research (Wu et al., 2019) do *dry mixed* at *nickel slag* and $Ca(OH)_2$ with a mass ratio of 1:1 for 5 minutes, then mixed with water to form *binders* nickel slag. The water/binders ratio is 0.42. To *binders* with *nickel slag*, *nickel slag* mixed with water so that a ratio is obtained *water/binders* the same.

### D.2. Construction Material Composition in Previous Research

Previous research used different SCMs, as well as different construction applications. Therefore, the composition of the material mixture in each study is certainly different. Variations in the composition of concrete mixtures are not only carried out with SCMs, some studies make substitutions on coarse aggregates and fine aggregates, mixing two types of industrial waste, with variations in cement water factor (w / c), and the presence or absence of fine aggregates, as well as the number and type of *superplasticizer use*. The many variations carried out will certainly affect the characteristics of concrete.

There is a slight drawback in previous studies that do not include the composition of the concrete mixture completely and in detail, as well as the different ways of calculating the composition of the mixture so that there are some incomplete data and must be explored further. The composition of the material mixture is divided into three tables, where

Table 2 is a composition of construction materials that use SCMs in previous research with concrete applications, Table 3 is the composition of previous research with road applications, and Table 4 is the composition of previous research with the application of cement paste.

Table 2. Composition of Previous Research with Concrete Application

| Reference | Coarse Aggregate | Fine Aggregate | *SP** | Water | Cement | *W/C* | Waste recycled concrete | Glass Powder | Rice Husk Ash | *Fly Ash* | *Silica Fume* | Quartz Sand | GGBFS | *Copper Slag* | *Nickel Slag* | *Steel Slag* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 |
| (Oksri-Nelfia et al., 2016) | | 1431 | | 299 | 499 | 0.6 | 0 | – | – | – | – | – | – | – | – | – |
| | | 1431 | | 299 | 374 | 0.8 | 99 | – | – | – | – | – | – | – | – | – |
| | | 1431 | | 299 | 249 | 1.2 | 197 | – | – | – | – | – | – | – | – | – |
| | | 1431 | | 299 | 125 | 2.4 | 296 | – | – | – | – | – | – | – | – | – |
| (Karwur et al., 2013) | 848 | 735 | – | 203 | 388 | 0.5 | – | 0 | – | – | – | – | – | – | – | – |
| | 848 | 735 | – | 203 | 365 | 0.6 | – | 23 | – | – | – | – | – | – | – | – |
| | 848 | 735 | – | 203 | 357 | 0.6 | – | 31 | – | – | – | – | – | – | – | – |
| | 848 | 735 | – | 203 | 349 | 0.6 | – | 39 | – | – | – | – | – | – | – | – |
| | 848 | 735 | – | 203 | 341 | 0.6 | – | 47 | – | – | – | – | – | – | – | – |
| | 848 | 735 | – | 203 | 330 | 0.6 | – | 58 | – | – | – | – | – | – | – | – |
| (Raharja, 2013) | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 0% | – | – | – | – | – | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 2.5% | – | – | – | – | – | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 5% | – | – | – | – | – | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 7.5% | – | – | – | – | – | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 10% | – | – | – | – | – | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | 15% | – | – | – | – | – | – | – |
| (Bahedh &; Jaafar, 2018) | – | 1050 | 40 | 160 | 657 | 0.2 | – | – | – | 0 | – | – | – | – | – | – |
| | – | 1050 | 40 | 160 | 591.3 | 0.3 | – | – | – | 65.7 | – | – | – | – | – | – |
| | – | 1050 | 40 | 160 | 525.6 | 0.3 | – | – | – | 131.4 | – | – | – | – | – | – |
| | – | 1050 | 40 | 160 | 459.9 | 0.3 | – | – | – | 197.1 | – | – | – | – | – | – |
| | – | 1050 | 40 | 160 | 394.2 | 0.4 | – | – | – | 262.8 | – | – | – | – | – | – |

| Reference | Coarse Aggregate | Fine Aggregate | *SP** | Water | Cement | *W/C* | Waste recycled concrete | Glass Powder | Rice Husk Ash | *Fly Ash* | *Silica Fume* | Quartz Sand | GGBFS | *Copper Slag* | *Nickel Slag* | *Steel Slag* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 |
| (Berndt, 2009) | 1118.2 | 739.1 | 3.90 | 156.3 | 390.4 | 0.4 | – | – | – | 0 | | – | 0 | – | – | – |
| | 1090.3 | 720.7 | 3.81 | 152.4 | 190.3 | 0.8 | – | – | – | 190.3 | | – | 0 | – | – | – |
| | 1119.1 | 739.7 | 3.91 | 156.5 | 195.4 | 0.8 | – | – | – | 0 | | – | 195.4 | – | – | – |
| | 1117.9 | 738.0 | 3.91 | 156.4 | 117.3 | 1.3 | – | – | – | 0 | | – | 273.6 | – | – | – |
| | 1094.0 | 723.1 | 3.82 | 153.0 | 191.0 | 0.8 | – | – | – | 95.5 | | – | 95.5 | – | – | – |
| (Danasi &; Lisantono, 2015) | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 0% | 10% | 10% | – | – | – | – |
| | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 5% | 10% | 10% | – | – | – | – |
| | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 10% | 10% | 10% | – | – | – | – |
| | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 15% | 10% | 10% | – | – | – | – |
| | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 20% | 10% | 10% | – | – | – | – |
| | N/a* | N/a* | 2% | N/a* | N/a* | N/a* | – | – | – | 25% | 10% | 10% | – | – | – | – |
| (Saha &; Sarker, 2018) | 0 | 1355 | – | 197.87 | 421 | 0.47 | – | – | – | 181 | – | – | – | – | – | – |
| | 435 | 1015 | – | 197.87 | 421 | 0.47 | – | – | – | 181 | – | – | – | – | – | – |
| | 873 | 678 | – | 197.87 | 421 | 0.47 | – | – | – | 181 | – | – | – | – | – | – |
| | 1306 | 338 | – | 197.87 | 421 | 0.47 | – | – | – | 181 | – | – | – | – | – | – |
| | 1744 | 0 | – | 197.87 | 421 | 0.47 | – | – | – | 181 | – | – | – | – | – | – |
| | 0 | 1355 | – | 197.87 | 421 | 0.47 | – | – | – | – | – | – | 181 | – | – | – |
| | 435 | 1015 | – | 197.87 | 421 | 0.47 | – | – | – | – | – | – | 181 | – | – | – |
| | 873 | 678 | – | 197.87 | 421 | 0.47 | – | – | – | – | – | – | 181 | – | – | – |
| | 1306 | 338 | – | 197.87 | 421 | 0.47 | – | – | – | – | – | – | 181 | – | – | – |
| | 1744 | 0 | – | 197.87 | 421 | 0.47 | – | – | – | – | – | – | 181 | – | – | – |
| (Kadhafi, 2015) | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | – | – | – | – | – | 0% | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | – | – | – | – | – | 10% | – | – |

| Reference | Coarse Aggregate | Fine Aggregate | *SP** | Water | Cement | *W/C* | Waste recycled concrete | Glass Powder | Rice Husk Ash | *Fly Ash* | *Silica Fume* | Quartz Sand | GGBFS | *Copper Slag* | *Nickel Slag* | *Steel Slag* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | – | – | – | – | – | 15% | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | – | – | – | – | – | 20% | – | – |
| | N/a* | N/a* | N/a* | N/a* | N/a* | N/a* | – | – | – | – | – | – | – | 30% | – | – |
| (Moura et al., 2007) | 1.46* | 1.36* | – | – | – | 0.4* | – | – | – | – | – | – | – | – | – | – |
| | 3.16* | 2.04* | – | – | – | 0.5* | – | – | – | – | – | – | – | – | – | – |
| | 3.87* | 2.72* | – | – | – | 0.6* | – | – | – | – | – | – | – | – | – | – |
| | 1.46* | 1.36* | – | – | – | 0.4* | – | – | – | – | – | – | – | 0.2* | – | – |
| | 3.16* | 2.04* | – | – | – | 0.5* | – | – | – | – | – | – | – | 0.2* | – | – |
| | 3.87* | 2.72* | – | – | – | 0.6* | – | – | – | – | – | – | – | 0.2* | – | – |
| (Edwin et al., 2016) | – | 962.5 | 40 | 163.9 | 875 | 0.2 | – | – | – | – | 218.8 | – | – | 0 | – | – |
| | – | 962.5 | 40 | 163.9 | 831.3 | 0.2 | – | – | – | – | 218.8 | – | – | 43.8 | – | – |
| | – | 962.5 | 40 | 163.9 | 787.5 | 0.2 | – | – | – | – | 218.8 | – | – | 87.5 | – | – |
| | – | 962.5 | 40 | 163.9 | 743.8 | 0.2 | – | – | – | – | 218.8 | – | – | 131.3 | – | – |
| | – | 962.5 | 40 | 163.9 | 700 | 0.2 | – | – | – | – | 218.8 | – | – | 175 | – | – |
| (Afshoon &; Sharifi, 2014) | 700 | 950 | 1.4* | – | 400 | 0.51* | – | – | – | – | – | – | – | 0 | – | – |
| | 700 | 950 | 1.4* | – | 380 | 0.51* | – | – | – | – | – | – | – | 20 | – | – |
| | 700 | 950 | 1.2* | – | 360 | 0.51* | – | – | – | – | – | – | – | 40 | – | – |
| | 700 | 950 | 1.2* | – | 340 | 0.51* | – | – | – | – | – | – | – | 60 | – | – |
| | 700 | 950 | 1.1* | – | 320 | 0.51* | – | – | – | – | – | – | – | 80 | – | – |
| | 700 | 950 | 1.1* | – | 300 | 0.51* | – | – | – | – | – | – | – | 100 | – | – |
| | 700 | 950 | 1.1* | – | 280 | 0.51* | – | – | – | – | – | – | – | 120 | – | – |
| (Sugiri, 2005) | N/a* | N/a* | N/a* | N/a* | 100% | N/a* | – | – | – | – | – | – | – | – | 0% | – |
| | N/a* | N/a* | N/a* | N/a* | 90% | N/a* | – | – | – | – | – | – | – | – | 10% | – |

| Reference | Coarse Aggregate | Fine Aggregate | *SP** | Water | Cement | *W/C* | Waste recycled concrete | Glass Powder | Rice Husk Ash | *Fly Ash* | *Silica Fume* | Quartz Sand | GGBFS | *Copper Slag* | *Nickel Slag* | *Steel Slag* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 |
| | N/a* | N/a* | N/a* | N/a* | 80% | N/a* | – | – | – | – | – | – | – | – | 20% | – |
| | N/a* | N/a* | N/a* | N/a* | 70% | N/a* | – | – | – | – | – | – | – | – | 30% | – |
| | N/a* | N/a* | N/a* | N/a* | 60% | N/a* | – | – | – | – | – | – | – | – | 40% | – |
| | N/a* | N/a* | N/a* | N/a* | 50% | N/a* | – | – | – | – | – | – | – | – | 50% | – |
| | N/a* | N/a* | N/a* | N/a* | 40% | N/a* | – | – | – | – | – | – | – | – | 60% | – |
| | N/a* | N/a* | N/a* | N/a* | 100% | N/a* | – | – | – | – | – | – | – | – | 0% | – |
| | N/a* | N/a* | N/a* | N/a* | 90% | N/a* | – | – | – | – | – | – | – | – | 10% | – |
| | N/a* | N/a* | N/a* | N/a* | 80% | N/a* | – | – | – | – | – | – | – | – | 20% | – |
| | N/a* | N/a* | N/a* | N/a* | 70% | N/a* | – | – | – | – | – | – | – | – | 30% | – |
| | N/a* | N/a* | N/a* | N/a* | 60% | N/a* | – | – | – | – | – | – | – | – | 40% | – |
| | N/a* | N/a* | N/a* | N/a* | 50% | N/a* | – | – | – | – | – | – | – | – | 50% | – |
| | N/a* | N/a* | N/a* | N/a* | 40% | N/a* | – | – | – | – | – | – | – | – | 60% | – |
| (Oksri-Nelfia et al., 2020) | 1030 | 662 | – | 195 | 400 | 0.47 | – | – | – | – | – | – | – | – | 0 | – |
| | 1030 | 662 | – | 195 | 380 | 0.47 | – | – | – | – | – | – | – | – | 20 | – |
| | 1030 | 662 | – | 195 | 360 | 0.47 | – | – | – | – | – | – | – | – | 40 | – |
| | 1030 | 662 | – | 195 | 340 | 0.47 | – | – | – | – | – | – | – | – | 60 | – |
| | 1030 | 662 | – | 195 | 320 | 0.47 | – | – | – | – | – | – | – | – | 80 | – |
| | 1030 | 662 | – | 195 | 300 | 0.47 | – | – | – | – | – | – | – | – | 100 | – |
| (Nabiilah et al., 2019) | 1109.38 | 590.85 | 5.92 | 96.32 | 591.94 | 0.16 | – | – | – | – | – | – | – | – | 0 | – |
| | 1109.38 | 587.54 | 5.62 | 84.86 | 562.34 | 0.15 | – | – | – | – | – | – | – | – | 29.60 | – |
| | 1109.38 | 584.22 | 5.33 | 85.14 | 532.74 | 0.16 | – | – | – | – | – | – | – | – | 59.19 | – |
| | 1109.38 | 580.90 | 5.03 | 85.42 | 503.15 | 0.17 | – | – | – | – | – | – | – | – | 88.79 | – |
| | 1109.38 | 577.58 | 4.74 | 85.70 | 473.55 | 0.18 | – | – | – | – | – | – | – | – | 118.39 | – |

| Reference | Coarse Aggregate | Fine Aggregate | *SP** | Water | Cement | *W/C* | Waste recycled concrete | Glass Powder | Rice Husk Ash | *Fly Ash* | *Silica Fume* | Quartz Sand | GGBFS | *Copper Slag* | *Nickel Slag* | *Steel Slag* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 | kg/m3 |
| | 1109.38 | 574.26 | 4.44 | 85.98 | 443.95 | 0.19 | – | – | – | – | – | – | – | – | 147.98 | – |
| | 1109.38 | 570.94 | 4.14 | 86.26 | 414.35 | 0.21 | – | – | – | – | – | – | – | – | 177.58 | – |

Information:* : the calculation of the composition of the mixture is carried out by means of *by weight*

*SP** : *Superplasticizer*

N/a*: *not available* (no use listed in the literature)

% : the calculation of the composition of the mixture refers to the proportion of cement

On research (Saha &; Sarker, 2018), substitutions are made on SCMs and their coarse aggregates and fine aggregates. In addition, research (Sugiri, 2005) perform fineness comparisons of SCMs *nickel slag* with cement. The fineness of the cement used = 312 m2 / kg, while the fineness *nickel slag powder* type A is coarser than cement at 284 m2/kg, and fineness *nickel slag powder* type B is 306 m2 / kg which is closer to the fineness of cement.

Table 3. Composition of Previous Research with Road Application

| Reference | Sample | *Limestone* | *Fly Ash* | *Nickel Slag* | *Clay* | *Steel Slag* | Gypsum | $CaF_2$ | KH | BC | IM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Wu et al., 2018) | A | 74 | 4 | 14 | – | 7 | 0.6 | 0.4 | 0.90 | 1.31 | 0.67 |
| | B | 73 | 2 | 20 | 4 | – | 0.6 | 0.4 | 0.80 | 1.91 | 0.64 |
| | C | 75 | 2 | 18 | 4 | – | 0.6 | 0.4 | 0.88 | 1.90 | 0.66 |
| | D | 70 | 3 | 15 | 4 | – | 8 | 1 | 0.87 | 1.88 | 0.77 |

Description: KH : *Lime Saturation Factor*
BC : silica modulus
IM : alumina modulus

Table 4. Composition of Previous Research with Cement Paste Application

| Reference | Sample | Cement | Gypsum | *Nickel Slag* |
|---|---|---|---|---|
| (Wu et al., 2019) | 0 | 95 | 5 | 0 |
| | 1 | 85 | 5 | 10 |
| | 2 | 75 | 5 | 20 |
| | 3 | 65 | 5 | 30 |
| | 4 | 55 | 5 | 40 |
| | 5 | 45 | 5 | 50 |

Description: the calculation of the composition of the mixture is carried out by the method by *weight*

**D.3. Characteristics of Test Objects in Previous Research**

The characteristics of construction materials can be seen in the results of compressive strength, tensile strength, and *Scanning Electron Microscopy* (SEM). *Workability or* slump flow testing *is also carried out to determine the consistency (workability or not) of fresh concrete mixture to determine the workability level* of the *influence of SCMs material with cement and the effect of adding* admixture *to the test specimen mixture.*

**D.3.1. Mechanical Characteristics of Test Specimens**

The mechanical characteristics analyzed are *workability* test, compressive strength test, and tensile strength test. Treatment methods (curing) carried out in previous studies also vary, some use water curing *and* water *curing*. The test result observed was a 28-day-old specimen.

Table 5. Mechanical Characteristics of Test Specimens in Previous Research

| Reference | *Slump* | *Flow Table* | *Curing* | *Temperature* | Compressive Strength | Strong Tensile |
|---|---|---|---|---|---|---|
| | Mm | Mm | *water* | °C | Mpa | Mpa |
| (Oksri-Nelfia et al., 2016) | 45.8 ± 1.45 | – | *Water curing* | – | | – |
| | 38.4 ± 0.46 | – | | – | | – |
| | 16.4 ± 0.19 | – | | – | | – |
| | 4.2 ± 0.19 | – | | – | | – |
| (Karwur et al., 2013) | 77 | – | *Water curing* | – | 26.23 | – |
| | 81 | – | | – | 27.69 | – |
| | 85 | – | | – | 29.15 | – |
| | 85 | – | | – | 31.07 | – |
| | 80 | – | | – | 27.12 | – |
| | 80 | – | | – | 24.13 | – |
| (Raharja, 2013) | – | 18.25 | *Water curing* | – | 87.96 | – |
| | – | 17.25 | | – | 92.1 | – |
| | – | 16.6 | | – | 90.03 | – |
| | – | 16.15 | | – | 97.28 | – |
| | – | 15.55 | | – | 100.38 | – |
| | – | 14.85 | | – | 80.72 | – |
| (Bahedh &; Jaafar, 2018) | – | 50 | *Water curing* | – | 78 | – |
| | – | 120 | | – | 90 | – |
| | – | 170 | | – | 105 | – |
| | – | 215 | | – | 118 | – |
| | – | 240 | | – | 122 | – |
| (Berndt, 2009) | 75 | – | *Water curing* | 23°C | 42 | 2.5 |
| | 170 | – | | | 24 | – |
| | 65 | – | | | 46 | 2.7 |
| | 60 | – | | | 44 | 2.2 |
| | 130 | – | | | 38 | – |
| (Danasi &; | 175 | – | *Water curing* | – | 38.07 | – |
| | 197 | – | | – | 74.04 | – |
| | 204 | – | | – | 66.44 | – |

| Reference | *Slump* | *Flow Table* | *Curing* | *Temperature* | Compressive Strength | Strong Tensile |
|---|---|---|---|---|---|---|
| | Mm | Mm | *water* | °C | Mpa | Mpa |
| Lisantono, 2015) | 188 | – | | – | 58.86 | – |
| | 203 | – | | – | 58.93 | – |
| | 195 | – | | – | 66.26 | – |
| (Saha &; Sarker, 2018) | N/a* | | *Water curing* | – | 18 | – |
| | | | | – | 18.5 | – |
| | | | | – | 19 | – |
| | | | | – | 17 | – |
| | | | | – | 15 | – |
| | | | | – | 19 | – |
| | | | | – | 19.5 | – |
| | | | | – | 20 | – |
| | | | | – | 19.5 | – |
| | | | | – | 18 | – |
| (Kadhafi, 2015) | N/a* | | *Water curing* | – | 19.249 | – |
| | | | | – | 21.798 | – |
| | | | | – | 23.496 | – |
| | | | | – | 20.76 | – |
| | | | | – | 17.174 | – |
| (Moura et al., 2007) | 70 ± 10 | – | *Water curing* | – | 38.7 | 3.9 |
| | | – | | – | 28.1 | 3.23 |
| | | – | | – | 22 | 2.95 |
| | | – | | – | 39.6 | 4.4 |
| | | – | | – | 34.8 | 3.8 |
| | | – | | – | 28.7 | 3.2 |
| (Edwin et al., 2016) | – | 185 | *Fountaining* | 20 ± 2 | 155 | |
| | – | 188 | | | 128 | |
| | – | 193 | | | 135 | |
| | – | 215 | | | 121 | |
| | – | 218 | | | 125 | |
| (Afshoon &; Sharifi, 2014) | – | 670 | – | – | – | – |
| | – | 695 | – | – | – | – |
| | – | 655 | – | – | – | – |
| | – | 670 | – | – | – | – |
| | – | 655 | – | – | – | – |
| | – | 660 | – | – | – | – |
| | – | 675 | – | – | – | – |
| | N/a* | | N/a* | – | 65.92 | – |

| Reference | *Slump* | *Flow Table* | *Curing* | *Temperature* | Compressive Strength | Strong Tensile |
|---|---|---|---|---|---|---|
| | Mm | Mm | *water* | °C | Mpa | Mpa |
| (Sugiri, 2005) | | | | – | 66.71 | – |
| | | | | – | 62.21 | – |
| | | | | – | 56.47 | – |
| | | | | – | 54.8 | – |
| | | | | – | 42.1 | – |
| | | | | – | 40.81 | – |
| | | | | – | 65.92 | – |
| | | | | – | 67.13 | – |
| | | | | – | 68.75 | – |
| | | | | – | 57.59 | – |
| | | | | – | 53.22 | – |
| | | | | – | 43.31 | – |
| | | | | – | 41.77 | – |
| (Oksri-Nelfia et al., 2020) | 20 ± 0 | – | – | – | 41.7 | – |
| | 20 ± 6 | – | – | – | 39.8 | – |
| | 40 ± 8 | – | – | – | 36.1 | – |
| | 40 ± 8 | – | – | – | 34.2 | – |
| | 60 ± 10 | – | – | – | 30.2 | – |
| | 60 ± 10 | – | – | – | 28.4 | – |
| (Nabiilah et al., 2019) | 210 | – | *Water curing* | – | – | 6.2 |
| | 230 | – | | – | – | 6.4 |
| | 230 | – | | – | – | 6.3 |
| | 240 | – | | – | – | 5.8 |
| | 250 | – | | – | – | 5.3 |
| | 250 | – | | – | – | 4.9 |
| | 250 | – | | – | – | 4.8 |
| (Wu et al., 2018) | – | – | – | 1350 | 52.5 | 14.5 |
| | – | – | – | | 50 | 10 |
| | – | – | – | | 40 | 13.5 |
| | – | – | – | | 35 | 6 |

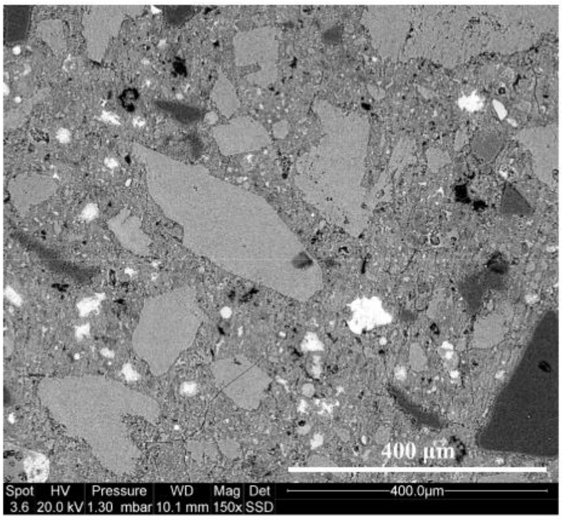
Description: n/a* : *not available* (not listed in literature)

At Table 5 It can be concluded that the composition of the mixture of test specimens and methods *Curing* The specimen affects the results of the compressive strength and tensile strength of the specimen. The use of SCMs can increase compressive strength and tensile strength at the right proportions, if the proportions used excessively will decrease the strength.

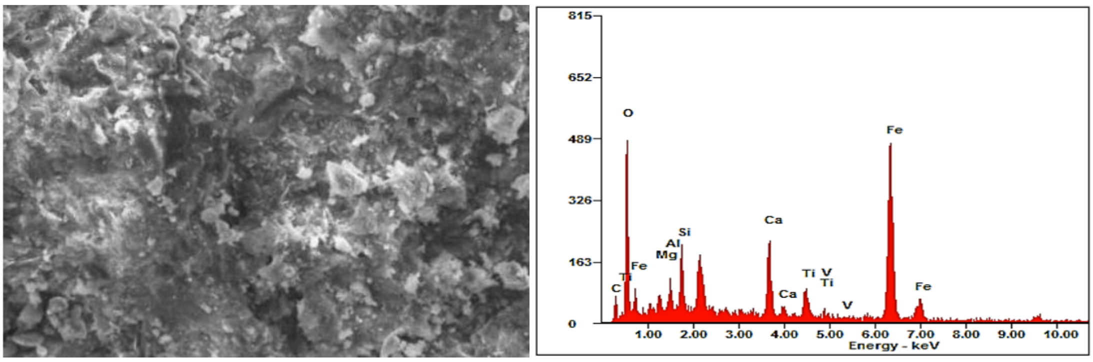
In some studies, the compressive strength achieved exceeds fc' ≥ 41.4 MPa. Where it can be categorized as high quality concrete (SNI 03-6468-2000, 2000).

### D.3.2. Microstructural characteristics in concrete

The characteristics of the analyzed minerals are: *Scanning electron microscopy* (SEM). SEM observations were made on concrete with recycled concrete waste SCMs, concrete with SCMs *nickel slag powder* 28 days lifespan, road construction with SCMs *nickel slag*, and cement paste with 30% SCMs *nickel slag* age 7 days and 120 days. From the results of the SEM image with recycled concrete waste (Picture 1) shows that there are still parts of cement that have not been hydrated even with a low percentage of 4% shown in white. These results provide *impact* which is good in the possibility of rehydration process the use of such concrete waste as a cement substitute. While on Picture 2 It is shown that in concrete containing nickel composition there is a content of Magnesium, alumina, and calcia which is shown from the results of SEM with EDS analysis where the mineral content contained in the concrete has similarities with conventional concrete that uses 100% cement in the mixture.

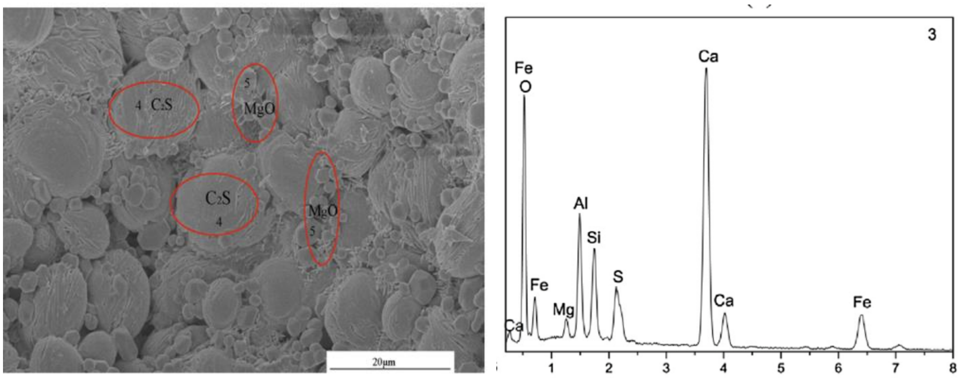



Picture 1. Results of Concrete SEM with SCMs of Recycled Concrete Waste (Oksri-Nelfia et al., 2016)



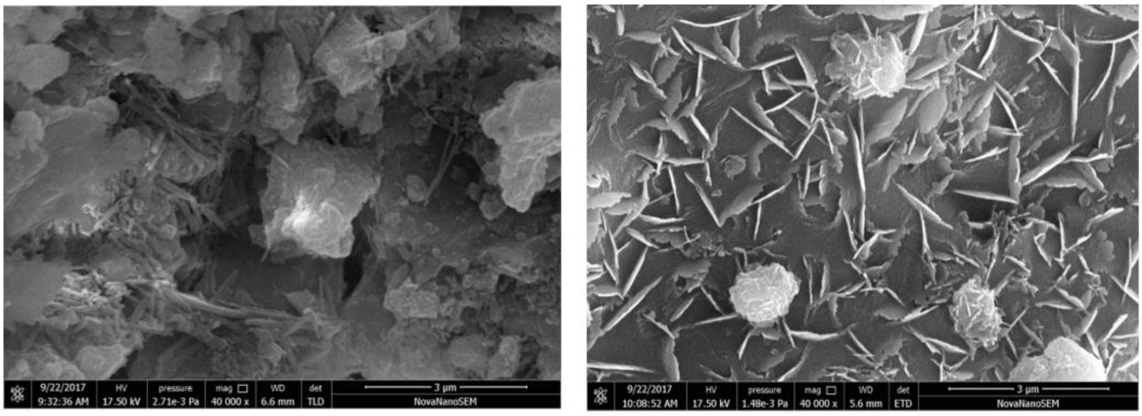

(a) (b)

Picture 2. (a) Concrete SEM Results with SCMs Nickel Slag Powder, (b) EDS Analysis (Oksri-Nelfia et al., 2020)




(a) (b)

Picture 3. (a) SEM Results of Road Construction with SCMs Nickel slag, (b) EDS Analysis (Wu et al., 2018)




(a) (b)

Picture 4. SEM yield of cement paste with SCMs 30% *nickel slag*
(a) age 7 days ; (b) age 120 days (Wu et al., 2019)

## E. Conclusions and Recommendation

### E.1. Conclusions

From the results of research based on literature studies, research (Raharja, 2013) with rice husk ash SCMs, research (Edwin et al., 2016) with SCMs copper slag, and research (Sugiri, 2005) with SCMs *nickel slag powder* is able to reach FC' ≥ 41.4 Mpa so it can be categorized as high quality concrete. This proves that industrial solid waste is very competent if used in the right proportion.

### E.2. Recommendation

For future research, testing can be done over the age of 28 days to see the effect of pozzolan from industrial solid waste. The type of *admixture* can also be varied because it affects the strength of the test object.

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Tomato grows in Hydroponic system and achieve 25-30 kg per plant in three months and set hydroponic fertilizer solutions formula and set formula according to plant growth, flowing time and harvesting time. Changing household bulk to energy saving LEDs for two years, House roof Installation for saving energy heat and cooling of the house.

-

Coupar Angus Institute of Technology, Pioneer College, McCarthy Learning, Angel Institute, Linx Institute (Empower College), PSL Group, VCTD, International Institute for Professional Development, iVET Australia, Australian Tourism college, as assessor and trainer

Skilled Migration Services
Connect small Business, Analysis their Financials, establish their new branches in Regional Area, Recruit suitable employee, Establish 11 Salons, Six Restaurants, Three Bakeries, Three Auto Repairer Shops, Two Printing Press within a year

The Corporate Financial Centre Pty Ltd
Find International Project for international funding & onshore client with onshore funding, Govt. of Sri Lanka's Health project valued US$80 Millions, Complete Feasibility study of the information technology, Requirements and efficient courier mailing system, Design and implement the setup of mailing database for Education Board, Implementation of mail system in Bank Customer Confirmation Statements, Pak Telecom, Pak Northern Sui Gas

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**Department of Higher Education and Training (DHET) SA**

Public Management N6 Diploma (2014 – 2016)

**Southern Africa Association of Accountants (SAAA)**

Higher National Diploma in Accounting (2000 – 2003)

**RESEARCH I N T E R E S T S**

- International political economy
- Global governance and security
- Conflict and conflict resolution
- International political theory
- Democracy and other forms of regimes
- Decoloniality
- International Organizations

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T.C.
KÜLTÜR VE TURİZM BAKANLIĞI

## SERTİFİKA

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