

The Acceptance of Utilizing Steel Slag in Concrete Among Construction Stakeholders

Hamidun Mohd Noh^{1,*}, Siti Nursyafiqah Sukadis Samsu Djatmiko¹, Nur'ain Idris², Narimah Kasim¹, Rozlin Zainal¹, Syarifah Meryam Shareh Musa¹

¹Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, 86400, MALAYSIA

²Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Muar, 84600, MALAYSIA.

*Corresponding Author

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Abstract: In construction industry, cement is important for the production of concrete. It is also a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Unfortunately, manufacturing process of cement contributes the greenhouse gases which harmful the environment. On the other hand, steel slag which has a huge potential to be utilize in concrete as replacement material could be used as an alternative material in concrete. The needed to improve the use of steel slag is an effective way to solve these problems. The objectives of this study are to determine the factors that influence the concrete production, to observe the future acceptance to produce concrete using the steel slag among concrete manufacturer, to identify the initiative in managing by product of steel and improving the product in the market. The methodology of this research uses consistency approaches by interviewing a concrete supplier from Inno Concrete Technologies Sdn. Bhd, Seng Foong Concrete Sdn. Bhd and Renggam Concrete. The finding show that all factors stated influence the choice of materials in concrete manufacturing. From the qualitative analysis, respondents agreed that the use of steel slag could be an alternative material in concrete but required a lot of improvement to be accepted in the industry besides aiming to reduce the environment impact from production of cement. Thus, it is anticipated that the objective of this analysis will have a possible to contribute as an alternative material and also towards better future in this field.

Keywords: Cement, Steel Slag, Concrete Manufacturer

1. Introduction

Cement is one of the key materials used in the manufacture of concrete. The worldwide production of concrete is 10 times that of steel. Even worse, cement manufacturing requires the release of significant volumes of carbon dioxide gas into the atmosphere, which is a major contributor to the greenhouse effect and global warming, and so it is likely either to look for another material or to partly replace it with some other material. The hunt for any such content that can be used as a substitute or as a replacement to cement could contribute to global sustainable growth and the lowest possible environmental effects. It is also the important materials in the construction of a structure in the civil engineering sector (Shahidan *et al.*, 2018). In construction sector, there are many issues that related environment impact and construction industries. Due to minimize cement dependency, the use of steel slag material from by-products is proposed as a partial cement substitute material because it includes silica that can react chemically with calcium hydroxide from the cement hydration process. It is supported by Chi (2004) says the use of steel slag in these cementing systems results in some advantages over conventional cements.

One of the replacement materials such as steel slag can be used as replacement of cement in producing concrete. In addition, portland cement manufacturing is an energy intensive process which produces a significant amount of greenhouse gases, so the use of steel slag should first be considered as a cementing part on the basis of technological, economic and environmental considerations.

1.1 Research Background

Past few years, the building industry in Malaysia is one of the first industries of the national economy. During the period of accelerated economic growth in Malaysia, its contribution to the gross domestic product (GDP) is 3-6 percent per year. Besides, concrete is also a common material for many building applications and is commonly used for its strength, resilience, reflectivity and flexibility. These properties make it a robust and long-lasting choice for many domestic and commercial environments. Environmental protection is an essential concern for developed and developing countries (Tse, 2001). Construction is by itself not an environmentally friendly operation (Li *et al.*, 2010). Levin (1997) suggested that design and operation of buildings have a substantial direct and indirect effects on the environment. Ijiga *et al.* (2013) claimed that the identification of the environmental effects of the building project is an activity that needs to be carried out in order to ensure an appropriate environmental impact.

The concept of using steel is not new in the construction industry. Steel slag is a waste material manufactured during the steel making process. A significant quantities of steel slag was stored in slag storage yards, invaded farmland, silted waterways and contaminated the atmosphere for several years. Steel slag is a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling.

Compressive strength of steel slag concrete with different dosage of slag was studied as a partial replacement of cement (Palanisami *et al.*, 2015). From the experimental investigations, it has been observed that the optimum percentage of steel slag for high strength concrete. In addition, waste materials are a major environmental problem, which is a threat to the environment. It is also can be harmful to the environment. So, it is important to reuse the materials and dispose of them.

However, cement processing is a very energy consuming process which results in the production of significant volumes of carbon dioxide. Carbon dioxide is primarily generated when the calcareous raw material is calcined to produce calcium oxide. Generally, approximately 0.5 tonnes of carbon dioxide is released for each tonne of cement made. Despite that, there is a few alternative and more environmentally sustainable concrete are required to minimize carbon emissions from Ordinary Portland Cement (OPC) manufacturing and to conserve the natural resources of the nation. One of the

possibilities is by using a by-product of steel making which is steel slag as a partial substitute of cement.

Steel slag is incredibly useful because it increases the original concrete performance. The steel slag contains around 15.04% silica that helps to react with cement. According to İsa Yüksel (2017) the use of iron and steel industry slags as mineral admixture or partial replacement of cement improves the microstructure of the concrete as well as its mechanical and durability characteristic. In addition, it would contribute to environmental protection by using stainless steel slag as a substitute tool. If high volumes of cement are substituted with steel slag, it can decrease ambient greenhouse gas pollution in cement manufacturing and reduce the cost of cement production with the usual demand for Portland cement for building materials declining.

The replacement for cement in concrete could also demonstrate that they have various advantages compared with traditional cements. The use of recycled building materials in order to increase recycling and reduce the carbon footprint was made compulsory by some agencies.

1.2 Problem Statements

Concrete is the world's most commonly used building material. Concrete is a blend of different materials rather than a substance which is independent. These products are cement, water, fine compounds and stones or gravel crushed. However, the materials been extensively used in all construction industries. Due to the emission of carbon dioxide pollutants into the atmosphere, the processing of cement is one of the environmentally unfriendly processes. One tonne of Portland cement clinker processing is believed to contain around one tonne of carbon dioxide and other greenhouse gases (Hailu *et al.*, 2016). Raw materials are widely used in all fields of construction. Approximately 5% of global man-made carbon emissions are produced by the concrete industry for a 1000 kg cement output.

Moreover, Yildirim and Prezzi (2011) state that 15-40% of the 10-15 million tonnes of steel produced is wasted. This large amount of waste is initially stored and then disposed of at a landfill. Because of this huge amount of waste, the costs of handling and disposal are high considering the cost of transportation and the salaries of workers. Other than that, the increasing demand of cement encourages the mining for raw materials, hence cement replacement is needed to sustain the country's resources and to help protecting the environment.

Other than that, the increasing demand of cement encourages the mining for raw materials, hence cement replacement is needed to sustain the country's resources and to help protecting the environment. Another obvious impact from the increasing demands of cement is its contribution towards global climate change. Devi *et.al.* (2018) pointed out that the major environmental health and safety issues associated with cement production is the emissions to air and energy use. The gas released from a cement kiln contains organic compounds and heavy metal that could cause degradation towards human health. These emissions also could cause global warming, ozone depletion, acid rain and reduced crop productivity. The highest the quantity of cement used in building, the highest releases carbon dioxide that will impact air emissions. Despite the fact that Malaysia still does not conduct the substitution of steel slag with cement in this manner, but it is not impossible for Malaysia to follow this approach some day because the current situation shows a spike in steel waste around the world.

1.3 Research Questions

- (i) What are the factors that influence the choice of materials in concrete manufacturing?

- (ii) What is the potential acceptance of concrete mixture by using steel slag among concrete manufacturer?
- (iii) How can the initiatives in managing by product of steel help to improve the product in the market?

1.4 Research Objectives

- (i) To identify the factors that influence the choice of materials in concrete manufacturing.
- (ii) To investigate the potential acceptance of concrete mixture by using steel slag among concrete manufacturer.
- (iii) To identify the initiative in managing by product of steel and improving the product in the market.

1.5 Significance of the Study

The study will contribute towards concrete manufacturers that will get the greatest benefits because this study can be used as a guide in the problems that are often faced in this industry. In addition, this study will also benefit agencies involved in the construction industry as well as academics can improve their knowledge while contributing ideas to improve the quality of the construction sector.

1.6 Scope of the Study

In this inquiry, this study is focused on registered civil engineer that majoring in concrete manufacturing. It was conducted on three different company that located in Malaysia.

2. Literature Review

2.1 Steel Slag

Steel slag is an industrial by-product of steel industry. The use of iron and steel slags as mineral admixture or partial cement substitution increases the concrete's tensile strength as well as its mechanical and strength properties. Many of the strength properties of hardened concrete are strengthened by slag cement. Slag cement is a hydraulic binder that reacts with water, like Portland cement, to form cement material (calcium-silicate hydrate or CSH). It also absorbs calcium hydroxide by-products, close to pozzolan, from the hydration of Portland cement to form additional CSH. The subsequent cement paste is thicker and denser and the concrete therefore is strengthened. High-grade standard steel production requires the elimination by oxidation of iron that has a significant volume of carbon content. This requires a larger quantity of oxygen to reduce carbon and a higher rate of lime to eliminate impurities, thus enhancing the production of slag.

However, production of cement is quite harmful for our environment. Hence, recycling the wastes in the concrete production appears to be viable solution not only to environmental pollution but also economical option to design of green building. So, recycling the process is one of the many ways that can help reduce pollution, reduction in disposal cost, and also gives benefit to landfills.

Slag cement processing produces a value-added commodity from a material, blast furnace slag, that may otherwise be meant for disposal. The manufacture of slag cement not only reduces the dependency on landfills, but also reduces air pollution through the granulation process at steel plants. Reducing greenhouse gas emissions by eliminating approximately one ton of carbon dioxide for each

ton of Portland cement replaced. (Slag Cement Association, 2020). In addition, it is also helps reducing the volume of extracted raw material to produce concrete.

2.2 Glass waste

Glass is generally used in every country including in Malaysia. Glass powder obtained from grinding of crushed containers and building demolition to produce glass powder blended cement as concrete additives. Million tons of waste glass is being generated annually all over the world (Islam *et al.*, 2017). Once the glass becomes a waste it is disposed as landfills, which is unsustainable as this does not decompose in the environment.

2.3 Sugarcane Bagasse Ash

Sugarcane are several species and hybrids of tall perennial grasses in the genus *Saccharum*, tribe *Andropogoneae*, that are used to get the juice from which sugar is processed. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominated by silicon dioxide (SiO₂). However, there are many types of sugarcane and in Asia based on the the species and the area of the plant. According to (Hailu *et al.*, 2016) sugarcane bagasse ash contains around 68.28% of silica which helps to reduce carbon emission after reacting with cement and it also contains sugar in some amount that can increase the strengthens of the concrete.

3 Research Methodology

Research methodology is important for researchers to achieve the goals and objectives of the study that have been set. To achieve this goal, the researcher will list and discuss some aspects of the methodology in detail.

3.1 Research Design

According to Ruhizan et.al (2010), good data can be obtained from carefully planned research based on appropriate design that used in the process of obtaining research data. The study design is a plan that acts to determine the methods and procedures for collecting and analyzing the necessary information, which aims to achieve the objectives of the study as well as find solutions to the study. This study will use qualitative methods by using interview methods with company managers as well as concrete production management staff to obtain data on appropriate methods in increasing the potential of the concrete market in the construction industry.

3.2 Data Collection

In this study, researchers chose to use the interview method to obtain primary data information, while the literature review method was used to obtain secondary data.

(a) *Primer Data*

In this study, researchers chose the interview method to obtain primary data because it will provide a more in-depth picture of the research problems compared to quantitative methods such as surveys and questionnaires.

(b) *Secondary Data*

Data used by researchers from past studies and from other databases were supplementary data. Kabir (2016) lists many ways in which secondary data can be obtained. Books, histories, biographies, journals, written census or statistical reports, data files, internet articles, other research papers and libraries are among them.

3.3 Data Analysis

The researchers have chosen to use content analysis approaches to analysis the data collected from the interview process in order to provide a consistent knowledge and general description of this study.

4 Data Analysis and Results

This research using qualitative approaches and survey methods have been used by researchers to gather data, then analyze the data using content analysis methods. During the interview period, the researchers gathered voices using a smartphone and reported important information in writing. Researchers use these methods to ensure that the collected data is more accurate and consistent.

4.1 Background of Respondents

The researchers decided three respondents in this study who needed to be interviewed. To meet all the goals, the study focused on the important person in production of concrete. The backgrounds of the respondents participating in the interview process are given in Table 1:

Table 1: Background of Respondents Involved in the Study

Respondent	Age	Position	Company Name	Type of Concrete
R1	36	Production Technician	Inno Concrete Technologies Sdn. Bhd.	Ordinary Concrete
R2	55	Contractor	Seng Foong Concrete Sdn. Bhd.	Ready-mixed Concrete
R3	34	Civil Engineer	Renggam Concrete	Ordinary Concrete

All respondents are active in manufacturing process. In addition, the respondents interviewed were active in the field of production. This data collection is from three respondents in concrete manufacturers as a case study is an activity that uses Ordinary Portland Cement as ingredients in concrete production. The data obtained from well-experienced in the making of concrete. Researchers have constraints interview from other states because the Covid-19 outbreak makes it difficult for researchers to cross the state.

4.2 Analysis Data

4.3 At this stage, the data received by each respondent will be analyzed in particulars to get a clear explanation. Meanwhile, data analysis methods have been used in this process. The result of data which are the factors that influence the selection of concrete making in Table 2:

Table 2: The Factors That Influence The Choice of Materials In Concrete Manufacturing

Factors	R1	R2	R3
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Expertise	Yes	Yes	Yes
Material availability	Yes	Yes	Yes
Price	Yes	Yes	Yes
Machinery	Yes	Yes	Yes
Location	Yes	No	Yes
Technology	Yes	Yes	Yes

Among the above, almost all the factors that influence the choice of materials in concrete manufacturer. In this case, three respondents agree that all the factors mentioned are very important in producing concrete. The most factors that influencing in manufacturing are technology and expertise because it can help for maximizing the effective manufacture and distribution of goods.

To achieve the second objectives, the researcher focused on the potential to be acceptance of the product using steel slag as cement replacement in concrete manufacturing. The findings of this objective study are described in Table 3:

Table 3: The Potential of Product Acceptance

Category	R1	R2	R3
Comment based on the result	7 and 28 days, only 5% the highest compressive strength	The use of steel slag is effective in terms of its compressive strength	Highest strength to compare with 0% replacement
Product knowledge	Yes	Yes	No
The potential product to be marketed in the industry in the future	Yes, because the raw materials in Malaysia depleted. Thus, it is necessary to find a recycled material that can replace cement	Yes, this product is potential because the result of compressive strength clearly shows this material is stronger than the ordinary concrete	Yes, but for certain project only.
Product accepted in the industry	Yes, because it is suitable for cement replacement and can help to reduce environment impact	Yes, this product can be accepted	No, the industry already familiar with ordinary concrete.
Factors that influence market acceptances	Customer will decide to buy a product based on the quality of the product itself.	Price and quality of the product	Price, location and expertise

Based on the result, two respondents agree that the product has potential to be acceptance in the industry. However, respondent 3 disagree that the product can be accepted in the industry because of based on respondent's experience, the industry only familiar with the ordinary concrete. This could happen because consumers are not going to purchase products that they are not aware of.

Table 4: The Initiative In Managing By Product of Steel and Improving The Product In The Market

Category	R1	R2	R3
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How to improve the product?	Market research will help to understand the demand for and acceptance of the product	More information about the product to the industry	Improve the awareness of the product
Product quality is important in long-term revenue and profitability	This establishes confidence in the clients	Quality goods add greatly to long-term profits and sustainability	Yes
How did you market your product? Advertisement? Which platform? Government should provide subsidy in order to improve the quality of concrete in Malaysia	Guest posting on industry-related sites Government incentives benefit a company by providing tax credits or reimbursements or covering some of the cost of manufacturing a product or service	Advertising and social media is the platform that can help to spread the information of the product. However, mouth advertising also help to work well. This is because customers will tend to tell others about the company and the perfect work that you do. Yes, when government subsidies are implemented to the supplier, an industry is able to allow its producers to produce more goods and services	Advertisement and social media platform Yes
Reusing waste material contribute to protect the environment?	Waste materials can help to reduce environmental impact	Can protect the environment as well and save existing concrete materials	Better to use waste goods than to harm somebody else's community or property
How could we improve this product to better meet respondents needs?	Save budget, reduce cost production	Make it more convenience for concrete production	Cut cost materials with high quality item
In your opinion, can all the features help to improve the products?	Yes	Yes	Yes

According to the result above, if the product has the quality but the product is still not recognized to customers, customers reluctant to buy items of which they are not conscious. Also, to satisfy clients

and sustain their confidence, consistency is crucial such that they want to buy in the future from quality goods that add greatly to long-term profits and sustainability. Not only quality, but through word of mouth advertising. Once customers know the quality of work and product, they will be inclined to tell others about your company and the great work that you do.

For the next question, all of the respondents agree that government subsidy could help the producers to produce more goods and services. Furthermore, because of high competition and globalisation, manufacturing firms especially the small ones, fail to increase their earnings. Further measures are also aimed at reducing production expenses. It is also might help the small companies to increase their production until they reached the target.

Next, the respondents agree with the initiative by reusing waste materials could reduce environmental effects itself. Currently, recycling is used by using existing items that can be reused and repurposed as a means to keep the world safe for humans and animals, eliminating waste sent to landfills, reducing energy consumption and mitigating the environmental effects of manufacturing consumer goods.

Moreover, another important aspect of the production costs involved in manufacturing is materials. It makes sense to look at ways to reduce this burden because more of the production expense is due to raw material costs. In addition, when a product is nice, buyers still come back even though the price is high. A premium product provides unshakeable loyalty to consumers that yields improved leads. They return, make regular transactions, and promote the item or service to others when consumers find a product they trust.

4.3 Discussion

In order to identify the factors that influence the choice of materials in concrete manufacturing among the concrete stakeholders, individual contractors should still be mindful of new and evolving developments in the area of cement work. With the pace at which technology is evolving, contractors of cement specialties should still have a finger on the industry's pulse. Much is happening right now in the concrete building space that has the ability to increase profit margins, and certain examples of innovative features are sure to disrupt things in a positive way.

By achieving the second objectives, it is important to know the potential of the product to be marketed in the industry. It must be considered from all aspects before the product launched. Furthermore, the result of compressive strength clearly shows this material is stronger than the ordinary concrete. Besides, the raw materials in Malaysia is depleted. Thus, it is necessary to recycled material that can use a cement replacement. However, if the product is still not recognized to customers, customers will reluctant to buy items of which they are not conscious. So, it is necessary to improve the awareness of the products in the industry.

To achieve the third objective, it is important to identify the initiative in managing by product of steel slag and improving the product in the market. In manufacturing, distribution processes and in raw materials to the production process, there is constant development and creativity. In general, this would suggest introducing additional product functionality and benefits.

5 Conclusion

The study that has been implemented in this chapter is based on qualitative research methods. Through the interview process all data and information has been collected and analyzed in more depth through this chapter. The interview method was chosen to follow the suitability of the data to be

obtained based on the objectives to be achieved and based on the data from the literature review that has been done. In this chapter also describes the findings of the study through feedback and information from respondents. Respondents who have been selected to obtain information is a group that is knowledgeable about the manufacture of concrete. All the factors are crucial in producing concrete. It is use for maximizing the effective manufacture and distribution of goods. Besides, manufacturing companies are becoming more information intensive, highly flexible, and immediately responsive to the customer expectations. Recycling is used by using existing items that can be reused and repurposed It reduces waste sent to landfills, reduces energy consumption and mitigating the environmental effects of manufacturing consumer goods. The ability to recycle waste helps to distinguish cities, cultures, and nations.

Quality is one of the factors which consumers take into account when making their choice of brand. Besides, quality is an integrals part of brand identity. In addition, advertisement is to create awareness. Advertising is a noticeable means of contact. The interview sessions that were conducted also aimed to obtain authentic information and subsequently can be analyzed so that each objective of this study can be achieved. In summary, the analysis carried out has succeeded in achieving the targets set. The important factors for future product adoption of steel slag and product development measures to be sold in concrete production in Malaysia. It has been established from the research that has been performed. Thus, respondents give opinions to boost the quality of the commodity as well as to reduce the issue of pollution in Malaysia by reusing waste content. Respondents give a positive answer to the researchers' idea of market the product so it is not unlikely for the product to be appropriate and relevant in the Malaysian construction industry in the future.

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