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Review

Effects of adding brass byproduct on the basic properties of concrete

Radhi Al Zubaidi *, Samer Barakat, Salah Altoubat

Department of Civil and Environmental Engineering, University of Sharjah, Sharjah, United Arab Emirates

HIGHLIGHTS

- Partial replacements of cement with brass filings increased the concrete strength properties.
- The use of 15% brass filings resulted in a better enhancement of the concrete strength values.
- The use of brass waste reduced the need for landfill capacity both on-site and off-site.
- With the use of brass byproduct waste, sustainable concrete construction can be optimized.

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ABSTRACT

The use of industrial byproducts in the concrete industry has become a common and attractive practice in recent years. It offers alternative materials for making concrete and reduces the environmental risk associated with these industrial byproducts. One industrial byproduct is that associated with the production of brass. Brass byproduct (BBP) typically comes in the form of thin, flexible strips which can be cut down into small fibers and used in concrete. The brass waste represents an environmental issue, and its management by recycling in the concrete industry could be a considerable achievement. This paper discusses the feasibility of adding BBP to normal concrete. The effects of the incorporation of BBP on the basic properties of fresh and hardened concrete were experimentally investigated. Three control mixtures (strong, regular, and lean) were designed with w/c of 0.45, 0.5, and 0.6, respectively. The BBP was added to these mixes at variable dosages ranging from 5% to 30% by weight of the cement. A total of 21 mixes (3 control and 18 with BBP) were designed and tested in this study. The effects of adding BBP on the concrete workability, compressive strength, flexural strength, and Ultrasonic Pulse Velocity (USPV, as a measure of strength) were investigated.

Several concrete cubes and flexural beams specimens were cast from each concrete mix and were moist-cured until the day of testing. The workability of fresh concrete was also measured for all mixes using a standard slump test. Compressive strength and flexural strength were measured at two ages (28 days and 90 days). The USPV was also recorded at these testing ages on the cube samples. The results obtained showed that mechanical properties (compressive and flexural strength) and USPV increased with increasing brass byproducts less than 10–15%, but, significantly decreased when the content exceeded 15%. The results also showed that workability properties decreased as brass byproducts content increased. These results suggest an optimum rate of addition of the BBP in the range of 10–15% by weight of cement.

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* Corresponding author. Mobile: +971 505377020.
E-mail address: ralzubaidi@sharjah.ac.ae (R.A. Zubaidi).

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1. Introduction

Millions of tons of industrial waste or byproducts are produced and stored or landfilled every year in the world. Heavy weight raw materials that contain steel, like steel shots such as cast iron and steel, aluminum, copper, brass, and bronze are the major byproducts of the metal industries. With the increasing awareness about the environment, high consumption of natural resources, limitations on landfill space, and rapid increase in disposal cost, the use or recycling of waste materials and byproducts has become of increasing interest worldwide. According to the concept of industrial ecology, the detrimental effects of industries on the environment can be considerably reduced if a byproduct of one industry can be used as a raw material by others [1,2].

The use of industrial byproducts in concrete industries is becoming common due to the economic, environmental, and technical advantages. Utilization of waste materials and byproducts is considered as a sustainable construction development since it helps provide a partial solution to the environmental and ecological problems. The use of these materials helps to optimize the cement, concrete, and other construction materials with satisfactory performance, in terms of both safety and serviceability, at lower direct and indirect costs and with environmental advantages over ordinary materials. The direct costs include the cost of manufacturing cement and concrete, and the indirect costs include the cost of the landfill, energy, and cleaning possible pollution from the environment.

Examples of industrial wastes and byproducts used as replacements or supplements for Portland cement or aggregate in making cement-based materials include fly ash [3], coal ash [4,5], silica fume [6,7], recycled concrete [8], waste/recycled plastics [9], scrap tyres [10], waste glass [11,12], rice husk ash, municipal solid waste ash, wood ash, volcanic ash, cement kiln dust, and foundry sand [13–16]. Many studies have been carried out to investigate the possibility of utilizing large volumes of the waste materials and byproducts in civil engineering construction include retaining structures, road reconstruction, landfill liners, asphalt concrete, concrete barriers, and pavement bases [17–21].

A gap in the knowledge about the variations in the performance of concrete containing brass byproducts has triggered this research. Therefore, this research evaluates the behavior of fresh and hardened concrete made by adding industrial byproduct waste (brass byproducts) in different proportions. Brass byproducts were chosen for three main reasons: they are (1) a strong metallic material that has material properties similar to those of concrete, (2) an available byproduct and cheap industrial waste material, and (3) a daily industrial waste that represents an environmental issue which needs management and recycling. These properties need to be considered in terms of both their suitability for use in concrete and their potential impact on human health and the environment in different concrete applications.

Three classes of concrete (strong, regular, and lean) with w/c of 0.45, 0.5, and 0.6 were considered in this study. A total of 21 concrete mixes were tested of which three control mixtures without brass and 18 with brass byproducts were designed and tested in this study. The workability of fresh concrete and the compressive strength, flexural strength, and USPV of the hardened concrete were evaluated. The results showed that the addition of brass waste into the plain concrete mixture enhanced its compressive and flexural strengths while decreasing the workability of the fresh concrete, but to acceptable levels.

2. Experimental program

The effect of using brass byproducts in various percentages by weight of the cement on the basic properties of fresh and hardened concrete was investigated. The concrete mechanical properties such as compressive and flexural strengths, Ultrasonic Pulse Velocity (USPV) and workability of the fresh concrete were evaluated.

2.1. Material used

2.1.1. Cement

Ordinary Portland cement (type I) conforming to ASTM C150/C150M-09 was used. The chemical composition and physical properties of the cement are presented in Table 1.

2.1.2. Aggregate

Normal weight natural sand having a maximum particle size of 4.75 mm and specific gravity of 2.6 was used as a fine aggregate. Properties of the sand are reported in Table 2 and its size distribution is conformed to the requirements of ASTM

Table 1
The chemical analysis and physical properties of the cement.

Oxide composition	Percentage by weight	Limits of specifications ASTM C150/C150M-09
Chemical properties		
Silica (SiO_2)	20.5	–
Lime (CaO)	61.3	–
Iron oxide (Fe_2O_3)	3.10	⩽6.0
Alumina (Al_2O_3)	5.8	⩽6.0
Magnesium oxide (MgO)	3.65	⩽6.0
Sulfate (SO_3)	2.32	⩽3.0
Tricalcium aluminate (C_3A)	7.38	⩽8.0
Ignition loss	2.75	⩽3.0
Insoluble residue	0.63	⩽0.75
Physical property	Test result	Limits of specifications
Physical properties		
Specific surface area (Blaine), (m^2/kg)	310	⩾260
Setting time (Vicat)		
Initial (min)	105	⩾45
Final (min)	235	⩽375
Compressive strength (MPa)		
Strength at: 3 days	19.50	⩾7.0
7 days	28.70	⩾12.0