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The Mechanical Properties of Concrete Incorporating Steel Slag as Supplementary Cementitious Material

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Abstract. Steel slag (SS) is a kind of industrial solid waste usually been dumped at landfills and causes environmental pollution. Previous studies have demonstrated that SS can be an alternative material to be used for making concrete and could achieve good mechanical properties, which not only reduce natural resources depletion but also improve environmental quality. This study aims to evaluate the effectiveness of SS as supplementary cementitious material (SCM) partially replacing cement on workability and mechanical properties of fresh and hardened concrete. X-ray fluorescence test, slump test, compressive strength test and ultra-pulse velocity test have been conducted. Mix designs are determined with replacement proportion of cement by SS of 0, 10%, 20%, 30%, 40% and 50%. Results show that replacement of cement by SS up to 50% increase the workability of concrete. The density of concrete ranges from 2083 to 2373 kg/m^3, with and without replacement of SS at curing age of 1-day, 3-day and 28-day. Compressive strength of concretes incorporating SS is lower than that of plain concrete. 1-day and 3-day compressive strength of concrete incorporating SS decrease with the increase in replacement of SS while 28-day compressive strength reach peak at 30% replacement and further replacement of SS reduce 28-day compressive strength. The ultra-pulse velocity (UPV) values of concrete have good relationship with compressive strength with the correlation coefficient of 0.92, 0.87 and 0.70 of 1-day, 3-day and 28-day experiment data, respectively. This study indicates the SS can be used for making concrete.

1 Introduction

Concrete plays an important role in construction development which used to construct building, bridges and highways. Therefore, more cement is needed to be manufactured to cater the concrete consumption of the market since cement is one of the components of concrete production. The cement manufacturing industry has contributed severe impacts to the environment such as depletion of non-renewable resources, emission of carbon dioxide and human health issue. In 2019, Malaysia was produced 16.1 million metric tons of cement which means same amount of carbon dioxide was emitted from the cement industry since one tons of cement generate approximately one tons of carbon dioxide to the atmosphere [1]. In order to reduce the cement consumption, some potential waste material such as fly ash (FA), silica fume (SF), metakaolin (MK) and steel slag (SS) are used as a supplementary cementitious material in concrete production. SS is the by-product of steel and iron industry which produced by quenching the molten iron slag from blast furnace in water. A