The Use of Copper Tailing of Mineral Processing Plant in the Preparation of Concrete in order to Prevent Environmental Pollution

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ABSTRACT

Copper tailing is the by-product of copper processing plants, and due to their large volume and physical and chemical characteristics, they bring many environmental and economic problems. The recent research examines the effect of using mineral processing tailings of copper as a substitute for cement on the mechanical properties and durability of concrete. For this purpose, five mixing plans with different percentages of copper tailings from Chehel-Koreh mine were used in concrete production. This tail contains Si, Fe, Mg and Al. 105 samples including 75 cubic samples with dimensions of 10×10×10 cm and 30 cylindrical samples with dimensions of 15×30 cm were prepared. The results showed that using 5% copper tail improve the compressive strength compared to the control sample. If the copper tail increased to 10%, a decrease in the compressive strength was observed, and despite this decrease, the compressive strength was still higher than the control sample. By using copper tailings, there was a slight decrease in tensile strength. Electrical resistance and water absorption tests at the age of 28 days showed that using copper tail cause a slight decrease in electrical resistance and water absorption. In addition, adding 5 to 10 percent of copper tailings instead of cement will reduce concrete production costs and energy consumption with less cement consumption, reduce damage to the environment with less cement production and optimal use of copper tailings. Therefore, copper tailings can be used as a suitable alternative for partial replacement of cement in concrete.

KEYWORDS

Mineral tailings, Chehel-Koreh copper mine, construction materials, environment, concrete.

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Introduction

One of the methods of the management of mineral tailings is their reuse [1]. This matter, in addition to reducing the consumption of natural resources and construction materials, can also improve the mechanical properties and durability of concrete. In addition, this method can create a new market for the mining industry and increase the economic value of mine tailings [2].

In this research, the tailings from the copper processing plant of Chehel-Koreh have been used. This tailings mainly contains elements of silicon, magnesium, iron, aluminum, calcium and sulfur. These tailings are the final tailings of the processing plant. The ore containing copper, after crushing and flotation process, is filtered and the solid part is stored behind the tailings dams as tailings. At present, the final concentrate (product) of this factory is sent to Sarcheshmeh copper complex processing plant to produce pure copper and process valuable elements such as zinc and lead.

Chehel-Koreh mine is one of the active mines in Sistan and Baluchestan, so far no scientific work has been done on the tailings of this mine. By using these tailing as raw materials for building materials, in addition to considering environmental aspects, energy and other costs can be significantly reduced.

Methodology

In this research, five mixing designs with a ratio of water to cement materials of 0.43 were considered [3, 4].

Table 1 shows the amount of each material used in 5 concrete mix design. In this table, T represents copper tailings and M represents microsilica. The control mixing design without the use of copper tailings and microsilica and with 400 kg of cement has been evaluated.

Table 1. Concrete mix design examined in this research (Kg/m^3)

Design code	ID	Fine-grained	coarse grain	Cement	Copper tailing	Microsilica	Water	super-lubricant
1	T0M0	750	850	400	0	0	172	1.6
2	T5M0	750	850	380	20	0	172	1.6
3	T10M0	750	850	360	40	0	172	1.6
4	T0M5	750	850	380	0	20	172	1.6
5	T0M10	750	850	360	0	40	172	1.6

The BS 1881 standard was used to test the compressive strength of concrete [5], Bisection method or Brazilian test to determine the tensile strength of concrete (ASTM C496 [6] and BS 1881 [7] standards). The electrical resistance of concrete (indicator of the permeability and durability of concrete against aggressive factors) was be measured by applying a current and using two or four electrodes attached to the end of a sample with a uniform cross-section. Concrete water absorption test was done to determine the durability and quality of concrete.

Results and Discussion

The results of the compressive strength test is shown in Figure 1. The results shows at the age of 7 and 28 days, the replacement of 5 and 10% of copper tailing instead of cement increased the compressive strength of these samples compared to the control sample (the compressive strength of the control sample, at the age of 7 and 28 days, was 22.5 and 32.4 MPa, respectively). The increase in compressive strength using copper tailing in cement can be related to the pozzolanic state and the fineness of the copper tailing. So, a significant amount of the weight of concrete (10%) can be replaced with copper tailing.

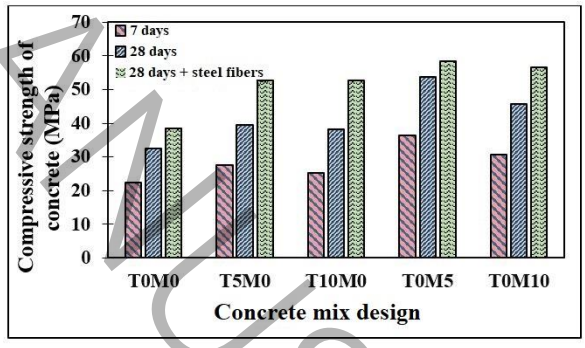

Figure 1. The results of compressive strength test of concrete at the ages of 7 and 28 days

As can be seen in Figure 1, copper tailing has a better pozzolanic property than cement, but comparing copper tailing with microsilica, a lower compressive strength was measured for copper tailing. In this condition, steel fibers were used to increase the compressive strength of concrete up to its compressive strength by using microsilica. By using 10% copper tailing instead of cement along with 0.06% steel fibers, the 28-day compressive strength of concrete reached 52.8 MPa, which is 37.86% higher than the case without fibers (38.3 MPa). In general, regarding the compressive strength, the effect of using steel fibers together with these tailings is almost similar to the effect of using microsilica in

concrete (52.7 MPa for the simultaneous use of steel fibers and tailing, in contrast to 53.8 MPa for the use of microsilica). Therefore, it is possible to replace microsilica with copper tailing along with steel fibers with a similar effect.

Figure 2 shows that replacing 5% and 10% of copper tailings in the concrete caused a decrease in tensile strength compared to the control sample (the 7 and 28 day tensile strength for the control sample was 3.57 and 4.5 MPa, respectively). The reason for this can be related to the lack of cement materials that play the role of adhesive in the mixture and the increase of pores along the length of the cylinder, so that more pores reduce adhesion. By replacing 10% of copper tailing in the concrete, a greater decrease in tensile strength was observed compared to the control sample, so that the tensile strength decreased by 16.58% compared to 5% replacement with concrete. It should be noted that even if 10% of copper tailing is used in the concrete, the tensile strength of the resulting concrete is still acceptable.

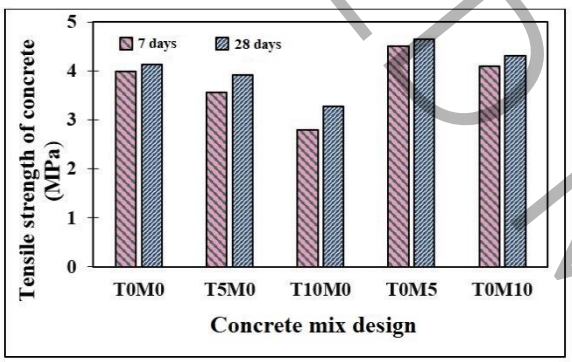

Figure 2. The results of the tensile strength test at the ages of 7 and 28 days

According to Figure 3, the lowest value of electrical resistance was related to the sample containing 10% of copper tailing, and the highest value of electrical resistance was related to the sample containing 10% of microsilica, which showed a 10% decrease and a 396% increase in electrical resistance, respectively, compared to the control sample. Of course, it should be noted that even if 10% of copper tailing is used in the concrete, the electrical resistance of concrete is still an acceptable number. By replacing 5% of microsilica in the concrete (compared to the control sample), the electrical resistance increased by 193%, and by adding 10% of microsilica to the cement mixture (compared to the control sample), it increased by 396%. The concrete with the addition of microsilica will have less porosity than copper tailing. Anyway, the use of copper tailing, while reducing the consumption of cement, does not have a significant effect on the electrical resistance of concrete and the mechanical properties related to it.

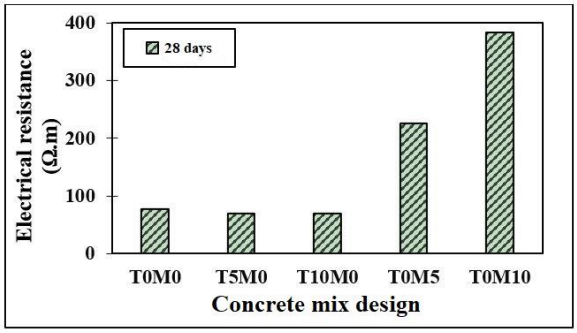

Figure 3. The results of the electrical resistance test on the samples obtained from different mixing designs

In Figure 4, the lowest percentage of water absorption (1.3 percent) was observed in the sample containing 5% of copper tailing, and the highest amount of water absorption (1.7 percent) was observed in the sample containing 10% of copper tailing, compared to the control sample (the amount of water absorption for the control sample was 1.4%). Therefore, in terms of water absorption, the use of 5% of copper tailing as a substitute in the concrete is similar to the use of microsilica (1.3 MPa for both numbers).

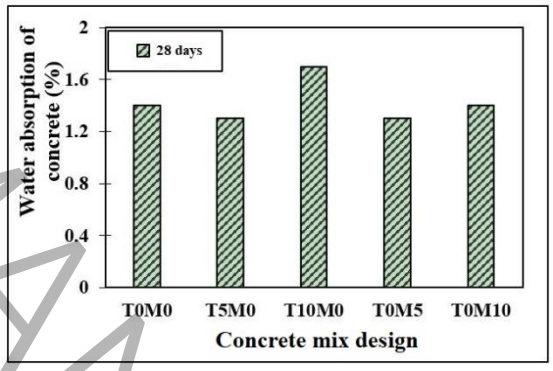

Figure 4. The results of concrete water absorption test on the samples obtained from different mixing designs

Conclusions

In this research, to help sustainable development and reduce cement pollution, copper tailing was used as a partial substitute for cement. To determine the mechanical properties of concrete, tests of compressive strength and tensile strength were conducted, and to check its durability, tests of electrical resistance and water absorption of concrete were investigated.

The results showed that by adding copper tailing to the concrete mixture, its compressive strength improved compared to the control sample. In addition, the combination of steel fibers with copper tailing caused a further increase in compressive strength. As the percentage of copper tailing increased, the tensile strength of the samples decreased; Of course, even if 10% of copper tailing is used in the concrete mixture, the tensile strength of concrete is still an acceptable number. Electrical resistance reduced by adding copper tailing to

the concrete mixture. Of course, even if 10% of copper tailing is used in the concrete mixture, the electrical resistance of concrete is still an acceptable number.

Therefore, the results showed that copper tailing can be used as a suitable and stable substitute for partial replacement of cement in concrete. This is an important step towards the sustainable development of the construction industry.

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