Laboratory investigation of the effect of plastic packaging belt fibers and iron oxide on the mechanical properties of self-compacting concrete

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ABSTRACT

Self-compacting concrete is one of the newest types of concrete due to its durability, efficiency, viscosity, stability, flowability and resistance. Nowadays, one of the most important concerns in the environment is solid waste disposal. Plastic packaging belts are one of the plastic materials that are thrown away after use and are known as waste, also iron smelting factories are the main source of iron oxide waste production. In this research, based on the idea of using plastic packing belts and iron oxide waste in the design of self-compacting concrete mix with different percentages (0, 0.5, 1, 1.5, 2 percent compared to the weight of cement) and (0, 5, 10, 15, 20% relative to the weight of sand) was added as an additive. For fresh and hardened properties of self-compacting concrete tests with and without fibers and iron oxide, slump flow tests, V funnel, L box, J ring, U box and compressive strength, tensile strength, ultrasonic pulse speed, Schmidt hammer, temperature effect They were evaluated on compressive strength and permeability. The results of the tests showed that with the increase in the percentage of fibers and iron oxide waste in self-compacting concrete for cubic samples, respectively, the compressive strength, ultrasonic pulse speed, Schmidt hammer and the effect of temperature on the 1-day compressive strength in 28-day processing from the range of 1.61% - 72.57%, 10% - 57.5%, 3.27% - 9.27% and 5.22 – 20.64% increased compared to self-compacting concrete (control) and also the tensile strength of cylindrical samples in 28 days processing. It increased from the range of 21.09%-72.57% compared to self-density (control).

KEYWORDS

Self-compacting concrete, iron oxide, plastic belt fibers, compressive strength, tensile strength

1. Introduction

Self-compacting concrete is known as one of the biggest advances in the concrete industry. Self-compacting concrete can easily flow from all kinds of complex shapes or shapes that have many reinforcing bars, and due to its malleability, it does not leave any empty space [2]. This type of concrete has low yield stress, high deformability, separation resistance and medium viscosity [3]. Self-compacting concrete is also better than ordinary concrete in terms of time, workability and durability. As a result, the use of self-compacting concrete is better and more efficient compared to conventional concrete, and it can be considered as a cost-effective material to reduce costs in implementation, time and vibration due to compression under its own weight [4]. The amount of solid waste produced, including the waste from mineral processing activities, industries, iron smelting, plastic material manufacturing companies, etc., is one of the main and important concerns in the pollution of the environment and natural resources. One of the industrial wastes produced from steel and ingots in iron smelters is iron oxide (Fe_2O_3), which appears during the cooling and hardening of steel ingots from the molten state, moisture and cooling in the dehumidifier. The main cause of this issue is the amount of moisture in the steel and its evaporation from the steel surface. It is also created due to the expansion and contraction of the steel surface and after cleaning from the steel surface, it is considered as waste. The size of iron oxide particles is smaller than cement. Iron oxide has impressive physical and mechanical properties due to its chemical composition. Due to the low pozzolanic reactivity of iron oxide, it affects the mechanical properties of cement in self-compacting concrete. The use of iron oxide is also used to improve homogeneity, compressibility, reduce porosity, concrete density and strength in order to achieve mechanical properties and durability of concrete. Today, plastics play an important role in almost every aspect of life. The largest percentage of plastic waste is packaging waste. Plastic packaging wastes are considered as one of the sources of pollution in the environment. Plastic packaging bags can be an effective solution to solve environmental problems as a replacement of part of cement in concrete mix design. Due to its mechanical properties, low density, chemical resistance, high modulus of elasticity, tensile properties and thermal insulation compared to other recycled materials, it leads to the improvement of the mechanical properties of concrete. The use of plastic packaging belts in the form of fibers in concrete is one of the best solutions for their disposal and improves the strength, ductility and durability of concrete.

2. Mixed design

5 designs of self-compacting concrete mixes with and without the effects of plastic packaging belt fibers and iron oxide were investigated in this research. The percentage of plastic packing belt fibers and iron oxide with different ratios (0%, 0.5%, 1%, 1.5%, 2% relative to the weight of cement and 0%, 5%, 15%, 20% compared to the weight of sand). In all 5 mixed designs, the amount of materials is fixed and the percentage of plastic packing belt fibers and iron oxide varies, because the results of the tests are more accurate and transparent (according to Table 1).

Table 1. Mixing design of self-compacting concrete with and without plastic packing belt fibers and iron oxide (The unit of values is in kg/m³)

iron oxide	Plastic packing belt fibers	VMA	Stone powder	Super lubricant - nano silica super gel	Water	sand	Almond sand	pea gravel	Cement
Self-compacting concrete without plastic packing belt fibers (0%) and iron oxide (0%) (SCC)									
-	-	0.167	207	12-7	154	1067	240	350	400
Self-compacting concrete with plastic packing belt fibers (0.5%) and iron oxide (5%) (SCC FO1)									
24.5	2.5	0.167	207	12-7	154	1067	240	350	400
Self-compacting concrete with plastic packaging belt fibers (1%) and iron oxide (10%) (SCC FO2)									
49	5	0.167	207	12-7	154	1067	240	350	400
Self-compacting concrete with plastic packing belt fibers (1.5%) and iron oxide (15%) (SCC FO3)									
73.5	7.5	0.167	207	12-7	154	1067	240	350	400
Self-compacting concrete with plastic packaging belt fibers (2%) and iron oxide (20%) (SCC FO4)									
98	10	0.167	207	12-7	154	1067	240	350	400

3. Results and interpretation

3.1. Slump flow test

The results of the slump flow test showed that with the increase in the percentage of plastic packaging belt fibers and iron oxide, the slump diameter (flowability) decreased compared to self-compacting concrete (standard) and the slump flow time increased compared to self-compacting concrete (standard) (According to figure 1).

Figure 1. Slump flow test

3.2. V- Funnel test

The results of instantaneous test and 5-minute V-funnel test showed that with the increase in the percentage of plastic packaging belt fibers and iron oxide, the time also increased compared to self-compacting concrete (standard) (According to figure 2).

Figure 2. V-funnel test

3.3. Ultrasonic pulse speed test

The results of the ultrasonic pulse velocity test on cubic and cylindrical specimens showed that the ultrasonic pulse velocity increased with the addition of plastic packing belt fibers and iron oxide to self-compacting concrete (According to figure 3).

Figure 3. Testing the ultrasonic pulse speed on the test piece.

3.4. Testing the compressive strength of cubic specimens

The test results on cubic specimens based on the ISIRI 3206 standard showed that the compressive strength increases with the addition of plastic packing belt fibers and iron oxide to self-compacting concrete (According to figure 4).

Figure 4. Compressive strength fracture test of cubic specimen with concrete breaker jack, Broken specimen of self-compacting concrete with fiber and iron oxide.

3.5. Testing the tensile strength of cylindrical samples

The results of tests on cylindrical specimens based on the ASTM C496 standard showed that the tensile strength increases with the addition of fibers and iron oxide to self-compacting concrete.

4. Conclusion

According to the main achievement of this article, the following results can be achieved:

1) The average compressive strength test results of self-compacting concrete cube samples with plastic packing belt fibers and iron oxide during 7 and 28 days of processing showed that with the increase of fibers and iron oxide, it increased by 3.2, 3.79, 6.87, and 68. 9 and 1.61, 3.28, 4.34, 7.44% increase in strength compared to the self-compacting concrete sample (control).

2) The average tensile strength test results of cylindrical samples of self-compacting concrete with plastic packing belt fibers and iron oxide during 7 and 28 days of processing showed that with the increase of fibers and iron oxide, 14.37, 26.81, 44.61 and 58.36 respectively 21.09, 35.57, 57.95, 72.57% increased strength compared to the self-compacting concrete sample (control).

3) The average results of the ultrasonic pulse velocity test of cubic samples on self-compacting concrete with plastic packing belt fibers and iron oxide during 28 days of processing showed that with the increase of fibers and iron oxide by 10%, 25%, 32.5%, and 57.5% respectively. An increase in the pulse speed compared to the self-compacting concrete sample (control) was found.

4) The average results of the ultrasonic pulse speed test of cylindrical samples on self-compacting concrete with plastic packing belt fibers and iron oxide during 28 days processing showed that with the increase of fibers and iron oxide, 14.28, 19.04, 23.80 and 33.33 respectively percent increased pulse speed compared to the self-compacting concrete sample (control).

5. References

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