Study on Preparation and Properties of Modified Functional Mortar Mixed with Reduced Iron Powder

Yingjian Lu[1,2], Jing Huang[2] and Yi Gao[2*]

1 Naval University of Engineering, Wuhan 430000, China
2 Naval Logistics Academy, Tianjin 300450, China
Corresponding author e-mail: gaoyi5777@163.com
Corresponding author: Yi Gao

Abstract. The effect of reduced iron powder on the performance of functional mortar was studied. Aimed at the construction performance, the experiments of consistency and water retention were carried out. Aimed at the mechanical properties, tensile bond strength, compressive strength and flexural strength experiment were carried out. The results show that the content of powder has little effect on mortar consistency. It can improve water retention. The 14d tensile bond strength is 36.2% higher than the reference mortar, which can meet the requirements of plaster-mortar. The compressive strength of 7d mortar was 24.2% higher than that of reference mortar. Compared with the reference mortar, the 28d compressive strength increased 13.6%, the 7d flexural strength increased 36.6%, and the 28d increased 25.8%.

1. Introduction

Cement-based materials have the advantages of low price and strong applicability. In the face of increasingly complex space requirements, materials prepared by adding special components have been studied a lot. Some scholars have prepared cement-based materials by adding metal powder, and concluded that the materials have good electrical conductivity [1]. Taking graphite powder and carbonyl iron powder as admixtures, the absorption effect of materials in high frequency band was studied [2]. A cement-based material was prepared with carbon nanotubes, and its astuteness of the structure was tested [3]. Aluminate cement matrix composite was prepared with iron powder as admixture, and its thermal properties at high temperature were investigated [4]. Some studies have prepared concrete slab with reduced iron powder and conducted relevant studies on its mechanical properties [5]. As a kind of ultrafine metal powder, reduced iron powder has good electrical conductivity [6]. The plastering mortar prepared by adding reducing iron powder in cement mortar can provide a choice for reconstruction of old engineering with special needs. Mechanical properties, as the most obvious performance of cement-based materials in engineering applications. The thesis studies the effect of reduced iron powder on the properties of mortar, which lays a foundation for the study of its construction and application.

2. Experiment

2.1. Raw Materials

Reduced iron powder: 200 mesh secondary reduced iron powder; Cement: grade 42.5 ordinary Portland cement; Sand: medium river sand; 1250 mesh fly ash: first class fly ash.

2.2. Mix Proportion

According to the proper standard, the proportion of plastered mortar is selected and the strength grade of test match is adjusted appropriately. The content of reduced iron powder is respectively 0kg/m^3, 100kg/m^3, 200kg/m^3, 300kg/m^3, 400kg/m^3 and 500kg/m^3. The specific proportion is shown in table 1.

Table 1. Mix proportion

Specimen number	Content (kg/m^3)				
	Reduced iron powder	Cement	Sand	Fly ash	Water
1	0	450	1498	50	300
2	100	450	1473	50	300
3	200	450	1448	50	300
4	300	450	1423	50	300
5	400	450	1398	50	300
6	500	450	1373	50	300

2.3. Preparation Methods

According to the selected mix proportion, weigh the quality of each group. The cement and reduced iron powder were put into the mixer for 60s dry mixing at a slow speed, followed by 60s dry mixing at a fast speed, so that they were fully mixed. Sand and fly ash were added at a uniform velocity, and water was added at the same time. The time was no less than 180s.

2.4. Method of Experiment

The consistency and water retention of functional mortar were tested. The specimens were cured to 28d under the specified environment, and the cube compressive strength was tested. The specimens were cured to 14d under the specified environment, and the tensile bond strength was tested. The specimens were cured to 7d and 28d respectively under the specified environment, and the compressive and flexural strength were tested.

3. Experimental Results

3.1. Effect of Reduced Iron Powder on Consistency of Mortar

With the continuous increase of reduced iron powder, the consistency shows the law of decreasing, and the fluidity becomes worse. At this time, the consistency of mortar can meet the basic requirements of plastered mortar. When the content is 400kg/m^3 and 500kg/m^3, the consistency decreases obviously, which cannot meet the requirements of plastering mortar. The effect is shown in figure 1.

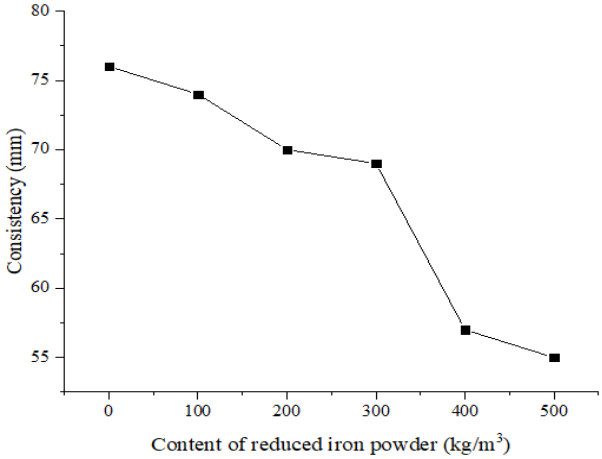

Figure 1. Effect of Reduced Iron Powder on the Consistency of Functional Mortar

Through analysis, the main reasons for the above phenomenon has the following two aspects: on the one hand, the reduced iron powder has a larger specific surface area, also, there are bulk powder particles adhered to the surface, which can make it combined with water molecules easily, the powder can reduce the water which is to participate in the hydration reaction, which cause mortar to thicken. On the other hand, the powder belongs to super fine powder, there are more contact surfaces between particles, and the relative friction force increases, which reduces the fluidity of mortar.

3.2. Effect of Reducing Iron Powder on Water Retention of Mortar

When the content is less than 400kg/m^3, with the increase of the content, the water retention rate shows a linear trend of increase. When the content is 400kg/m^3, the rate reaches a peak of 95.8%. Compared with the reference mortar, the rate increases by 1.7%. When the content was increased to 500kg/m^3, the rate decreased significantly. The effect is shown in figure 2.

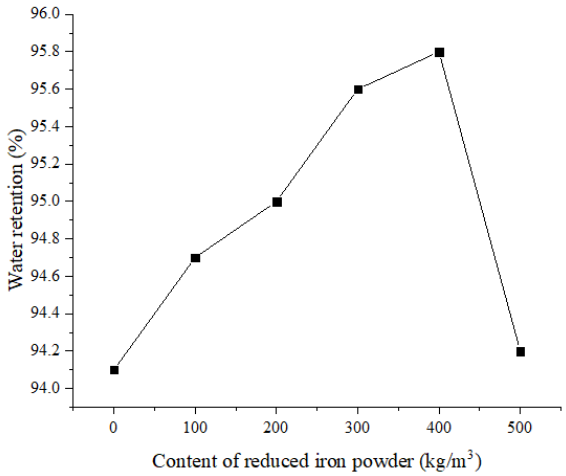

Figure 2. Effect of Reduced Iron Powder on the Water Retention of Functional Mortar

Through the analysis, the reduced iron powder has a porous sponge structure, which is easy to combine with the free water in the mortar, making it difficult to separate out. When the right amount of reducing iron powder is added, it can improve the water-retention performance of the mortar .When the content of reduced iron powder increases to 500kg/m^3, because the density of reduced iron powder is larger, when the content is too much, settlement will occur in the mortar, the rate decreases obviously.

3.3. Effect of Reduced Iron Powder on Tensile Bond Strength

According to the experiment, when the content of reduced iron powder is less than 300kg/m^3, the tensile bond strength shows an increasing trend. When the content is 300kg/m^3, the strength reaches the peak value of 0.79MPa, which is 36.2% higher than the reference mortar. When added to 500kg/m^3, the tensile bond strength of mortar specimens decreases gradually. The effect is shown in figure 3.

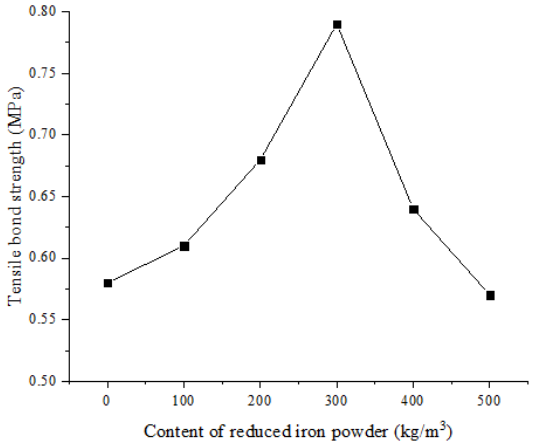

Figure 3. Effect of Reduced Iron Powder on the Tensile Bond Strength of Functional Mortar

Through the analysis, reduced iron powder belongs to super fine powder, when mixed with mortar, it has a physical filling effect [7], the interface between the cement particles is more compact, the workability has improved, which can improve the bonding strength. When the content added to 500 kg/m^3, the strength decreases, on the one hand, the powder has a large density, when the content is too much, it will subside, the physical filling effect decrease, causing strength reduced; On the other hand, the powder has a large specific surface area, when the content is too much, it will lead to the increase of the porosity, and the insufficient cement slurry used to bond decrease, thus reducing the strength.

3.4. Effect of Reduced Iron Powder on Compressive Strength

According to the experiment, when the content of reduced iron powder is less than 300kg/m^3, the compressive strength of the specimens increases gradually with the increase of the content. The 7d strength reaches the peak strength when the content is 300kg/m^3. When the content of powder increases to 400kg/m^3, the 28d strength reaches its peak. The strength of the cube reached a peak of 34.2MPa, 13.6% higher than that of the reference, and the strength of the prismatic specimen reached a peak of 31.3MPa, 7.2% higher than that of the reference. When the content of powder increased to 500kg/m^3, the strength decreased significantly. The effect is shown in figure 4.

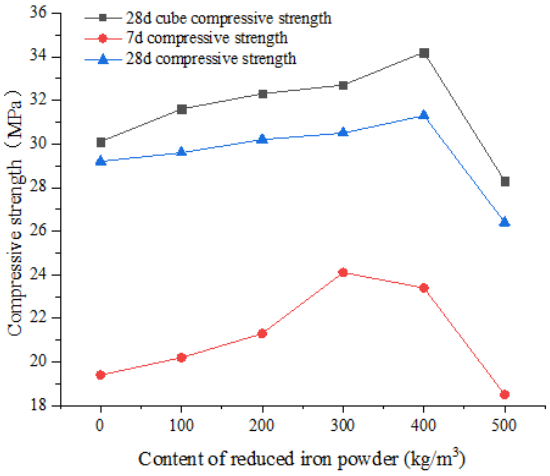

Figure 4. Effect of Reduced Iron Powder on the Compressive Strength of Functional Mortar

Through the analysis, reduced iron powder has a great effect on the early strength of specimen. On the one hand, the powder has a degree of water absorption, which can reduce the free water in the

mortar, and the internal foam is more likely to burst, so that the pores are reduced, the structure is more compact, and the strength is increased. On the other hand, the powder belongs to super fine powder. When it is mixed with mortar, it will play a physical filling role between cement and aggregate, improve the pore structure and particle gradation inside mortar specimen, making the interior structure more compact.

The main reasons that the strength reduced are as follows: on the one hand, the hydration reaction is an important factor of strength increasing, the powder has a certain water absorption [8], when the content is too much, it will make a water shortage, leading to the decrease of strength of cement hydration reaction, the filling effect of powder have been unable to offset the lack of hydration reaction. On the other hand, the density of powder is large, and it will subside when the content is too much, and it cannot be evenly dispersed in mortar, leading to the increase of the weak points of specimens. By comparing the two groups of 28d specimens, it can be seen that the strength of the cube is relatively high. When the powder is not added, the compressive strength has a small difference. When the content of powder is 400kg/m^3, the difference is 2.9MPa. The cube compressive strength specimen is prepared by manual tamping, while the prism one is formed by mechanical vibration. Due to the large density of reduced iron powder, mechanical vibration is more likely to cause the settlement than manual vibration, which leads to the reduction of its filling effect. This indicates that choosing proper mixing and vibrating methods is beneficial to reduce the settlement of powder in mortar and make the best use of it.

3.5. Effect of Reduced Iron Powder on Flexural Strength

It was founded that when the content of reduced iron powder was less than 400kg/m^3, the flexural strength of the two groups gradually increased with the increase of the content. When the content was 400kg/m^3, the specimen reached the peak strength, the 7d specimen reaches the peak strength of 5.6MPa, which was 36.6% higher than that of the reference mortar. The 28d specimen reached the peak strength of 7.8MPa, which was 25.8% higher than the reference mortar. When the content increased to 500kg/m^3, the flexural strength decreased obviously. The effect is shown in figure 5.

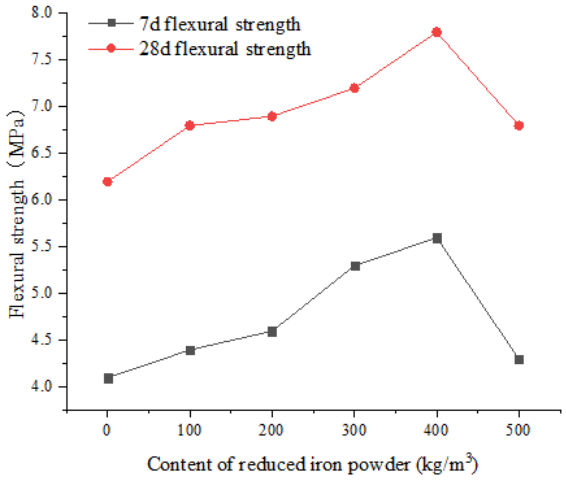

Figure 5. Effect of Reduced Iron Powder on the Flexural Strength of Functional Mortar

Through the analysis, the main reasons for the above phenomenon are as follows: on the one hand, the interface area between cement slurry and aggregate is the weak point, and a good interface area structure can effectively improve the flexural strength. When proper amount of reduced iron powder is added, its good physical filling effect can significantly improve the interface structure and improve the flexural strength. On the other hand, as a super fine powder, the reduced iron powder has a high strength and elastic modulus. When the specimen is subjected to flexural failure, the powder can buffer the stress with its bending deformation [9], delaying the cracking, so as to improve the strength. When the content powder is increased to 500kg/m^3, the strength decreases, when adding reduced iron

powder. When the content is too large, on the one hand, it is easy to cause the settlement phenomenon in mortar, which leads to the increase of the weakness of specimen and the decrease the bending strength. On the other hand, it will also lead to a decrease of sand that plays the role of "skeleton", which will increase the brittleness of mortar specimens and reduce the flexural strength.

4. Conclusion

(1) Reduced iron powder will reduce the consistency of mortar. When the content is less than 300kg/m^3, the mortar consistency can meet the basic requirements of plastered mortar construction.

(2) An appropriate content of reduced iron powder can improve the water retention of mortar and meet the construction requirements of plastered mortar. When the content is less than 400kg/m^3, with the increase of content, the rate gradually increases, and reaches the peak when the content is 400kg/m^3.

(3) An appropriate content of reduced iron powder can effectively improve the tensile bond strength and meet the construction requirements of plastered mortar. When the content is less than 300kg/m^3, the strength gradually increases with the increase of the content. When the content is 300kg/m^3, the strength reaches the peak.

(4) An appropriate content of reduced iron powder can improve the compressive strength of mortar specimens. The powder has a great effect on the early strength of the specimen. When the content was 300kg/m^3, the strength of the specimen on 7d reached its peak. When the content increased to 400kg/m^3, the compressive strength of 28d specimens reached the peak. By comparing the compressive strength of the two groups of 28d specimens, it can be seen that the selection of appropriate mixing and vibrating methods is conducive to preventing excessive settlement.

(5) An appropriate content of reduced iron powder can improve the flexural strength of functional mortar specimens. When the content is 400kg/m^3, it reaches the peak strength.

5. References

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