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Correlation Analysis on Impermeability of Concrete between Magnesium Oxide and Magnetized Water

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Adding magnesia can compensate shrinkage of concrete and prevent crack of concrete, and this technique is applied widely. However, if magnitude of expansive stress caused by adscititious magnesia is too large, it trends to damage the structure of cement concrete. Substantial research results show that the magnetized water can make the cement hydration reaction more completely. The magnetic water can increase the strength of concrete, which can infer that the impermeability of concrete has been improved. So, the physical and chemical properties of magnetized water in different degrees and the compactness and impermeability of the magnesium oxide micro-expanded concrete mixed with magnetized water in different degrees are studied in the thesis. The research starts with the physical and chemical properties of magnetized water such as the conductivity, viscosity, PH value and surface tension. 14 samples with the intensity levels C25 and C30 MgO concrete are chosen in the impermeability test. The test indicates the difference of impermeability between magnetized water MgO concrete and ordinary water MgO concrete at the condition of same strength. The effects such as hypothesis of the mechanism, action of the cement hydration, concrete workability, water ratio of the concrete of MgO concrete mixed with magnetic water was studied in this issue. And the mechanism of impermeability of magnetic water MgO concrete is also analysed.

1. Introduction

Adding magnesia can compensate shrinkage of concrete and prevent crack of concrete, and this technique is applied widely. However, if magnitude of expansive stress caused by adscititious magnesia is too large, or its distribution is not uniform, it tends to damage the structure of cement concrete, and then affect seriously dam durability.

Substantial research results show that the magnetic water can make the cement hydration reaction more completely, which can increase the cohesion of concrete mixture and enhance the strength of concrete (Porteneuve et al., 2001; Boguszynska et al., 2005; Sklar, 1959; Beyea et al., 1998). So, it can infer that the impermeability of magnesium oxide micro-expanded concrete has been improved.

Besides, in the circumstances of either no need changing or influencing the normal production process of the concrete, using the method of using magnetic water, to improve the performance of magnesium oxide micro-expanded concrete, so as to improve the impermeability of concrete.

The purpose of this paper is to investigate the mechanism of impermeability of magnetic water magnesium oxide micro-expanded concrete by the study of the effects such as action for the cement hydration, concrete workability, and water ratio of the concrete. And the mechanism of impermeability of magnetic water MgO concrete is also analyzed. Also, conclusions are given in the last of this paper (Su et al., 2000; Lilliefors, 1967; Gao et al., 2008; Wang and Yao, 2014).

2. Experimental

2.1 Physical and chemical properties of magnetized water

Conductivity of water decreased after it was magnetized which can be shown as Table 1.

Reason of measurement of the PH value of the difference between magnetized water and ordinary water at the same condition was shown in Table 2.

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Table 1: Magnetized water conductivity

Sample	1	2	3	4	5	6	7	8	9
Double distilled water	1.676	1.692	7.555	2.110	1.975	1.596	3.063	2.961	2.529
Magnetize	1.564	1.521	3.150	1.963	1.805	1.478	2.508	2.386	1.852

Table 2: Reason of measurement of the PH value

Magnetic field intensity (mT)	Ordinary water	230	280	330	230	280	330
Water flow rate (m/s)		2.0	2.0	2.0	1.0	1.0	1.0
PH value	7.52	7.52	7.53	7.54	7.52	7.55	7.61

Among the range of test parameters, when water is magnetized, PH value was indeed increased. Especially PH value of the magnetized water with the magnetic parameters (magnetic field intensity is 330mT, water flow rate is 1m/s) increased the most significant (Sneyers, 1977; Gattuso et al., 2016; Mo et al., 2012).

Viscosity can be indicated by dynamic viscosity and motorial viscosity, and the relationship between them can be shown as Equation (1):

$$\nu = \eta / \rho \tag{1}$$

Where ν is the motorial viscosity, η is the dynamic viscosity, and ρ is the density of liquid. Motorial viscosities of ordinary water and magnetized water can be tested by viscometer (Table 3).

Table 3: The relation of viscosity and the magnetic field strength

Magnetic field intensity (A/m)	0	250	300	350	400	450
Motorial viscosity (m2/s)	1.114	1.109	1.103	1.096	1.081	1.083
Dynamic viscosity (Pa·s)	1.113	1.108	1.102	1.096	1.089	1.082

It is indicated that the viscosity reduces when water is magnetized, and they show a negative linear correlation. Touch surface of cement particles and magnetized water is increased because of reduced viscosity. It increases the level of hydration reaction of cement.

Some research showed that surface tension of water would change when it was magnetized. In order to find the relationship between surface tension of water and magnetization, pull-out method is adopted to test the surface tension of water in different magnetic field intensity. When the metal ring is pulled out of the water, the θ becomes zero. The surface tension can be shown as Equation (2):

$$F' = mg + F \tag{2}$$

Where F' is the tension when the metal is pulled out of water, mg is the gravity of metal ring and the water attaching ring, F is the surface tension. The results of test are shown in Table 4, among the range of test parameters, when water was magnetized, the surface tension was indeed decreased (Wang and Yao, 2014).

Table 4: Reason of measurement of surface tension

Magnetic field intensity (mT)	0	230	280	330	230	280	330
Water flow rate (m/s)	0	2.0	2.0	2.0	1.0	1.0	1.0
Surface tension (mN/m)	74.14	74.08	73.79	73.59	73.66	72.45	71.44

2.2 Test methods on impermeability of magnetic water concrete

At the present time, the methods of impermeability test used in the study of concrete are constant flow method, chloridion penetration method, gas permeation method and so on. Constant pressure method is used on this test about impermeability of concrete. Groups of concrete samples are sealed by a set of impermeability test dies (circular truncated cone test dies: diameter of upper surface is 175mm, diameter of lower surface is 185mm, and altitude is 150mm. Each group contains 6 concrete samples). Then, 6 concrete samples are installed on the concrete penetrometer and put on pressure to 2.5MPa one by one. After keeping this constant pressure 24 hours, shut down the concrete penetrometer and discharge 6 concrete samples. Each concrete sample will be broken into two by pressure machine. Average value of 10 equal-spaced measurements and the maximum value of depth of penetration of each concrete sample are recorded. Then compute the average of depth of penetration of 6 concrete samples. If the maximum and minimum value of depth of penetration stray 20% from the middle value, the maximum and minimum value should be taken off

and the average value of another 4 middle value is taken as the depth of penetration of this group of concrete samples.

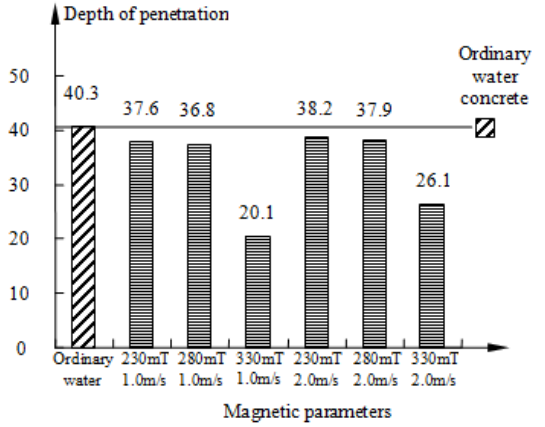
2.3 Test materials and Scheme design

Cement: 32.5MPa ordinary Portland cement.
Sand: medium sand of 2.6 fineness modulus.
Aggregate diameter: 0.5~2.5cm, fine grading.
Water: ordinary water and magnetic water with different magnetic parameters.
Magnetic water MgO concrete and ordinary water MgO concrete with different intensity levels C25 and C30 are contrasted by the test mixing with 6%(by mass) MgO. Under the same mix proportion of concrete, each strength class of concrete will make a group of ordinary water MgO concrete and 6 groups of magnetic water MgO concrete. According to the principle of cross-test, 6 groups of magnetic water MgO concrete adopt different magnetic field intensity (230mT, 280mT, 330mT) and different water flow rate (1m/s, 2m/s) in the comparison test under the same condition of agitation, material, curing (28 days standard curing periods).

3. RESULTS AND DISCUSSION

3.1 Analysis of impermeability of MgO concrete

At the condition of same strength C25, depth of penetrations of 6 groups of magnetic water MgO concrete are less than the group of ordinary water MgO concrete and reduce with the degree of magnetic water increase among the range of test parameters. Especially depth of penetration of the group of magnetic water MgO concrete under the condition of magnetic field intensity: 330mT and water flow rate: 1m/s is the minimum of all 7 groups of concrete, and it is 50.1% of depth of penetration of ordinary water MgO concrete (Figure 1).



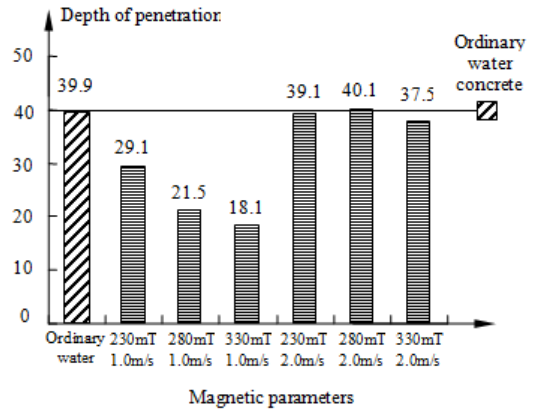


Figure 1: Depth of penetration of C25 MgO concrete Figure 2: Depth of penetration of C30 MgO concrete

At the condition of same strength C30, not all the 6 groups of magnetic water MgO concrete's depth of penetrations are less than the group of ordinary water MgO concrete and even under the magnetic field intensity of 230mT and water flow rate of 2m/s, depth of penetration of magnetic water MgO concrete is greater than ordinary water MgO concrete. Thus it can be seen that, when water flow rate is quite great and magnetic field intensity is quite small, depth of penetration of magnetic water MgO concrete is less decreased than ordinary water MgO concrete (Figure 2).
But, depth of penetration of the group of magnetic water MgO concrete under the condition of magnetic field intensity: 330mT and water flow rate: 1m/s is still the minimum of all 7 groups of concrete, and it is 46.0% of depth of penetration of ordinary water MgO concrete.

3.2 Cement hydration reaction of concrete

Action of cement hydration firstly took place on the surface of cement particles, and the layer of gel film can be formed on the surface of the cement, which can reduce surface tension of the magnetic water and increase the activity of the cement 15-18. Therefore, magnetic water can make the cement hydration more completely and the structure more compactly. The process of Cement hydration reaction of magnetic water can be shown as follows.

$$\begin{cases} 2(3CaO \cdot SiO_2) + 6H_2O = 3CaO \cdot 2SiO_2 \cdot 3H_2O + 3Ca(OH)_2 \cdot \\ 2(2CaO \cdot SiO_2) + 4H_2O = 3CaO \cdot 2SiO_2 \cdot 3H_2O + Ca(OH)_2 \\ 3CaO \cdot Al_2O_3 + 6H_2O = 3CaO \cdot Al_2O_3 \cdot 6H_2O \\ 4CaO \cdot Al_2O_3 \cdot Fe_3O_4 + 7H_2O = 3CaO \cdot Al_2O_3 \cdot 6H_2O + CaO \cdot Fe_2O_3 \cdot H_2O \\ 3CaO \cdot Al_2O_3 \cdot 6H_2O + 3(CaSO_4 \cdot 2H_2O) + 19H_2O = 3CaO \cdot Al_2O_3 \cdot 3CaSO_4 \cdot 31H_2O \end{cases} \quad (3)$$

3.3 Improvement Mechanism of Magnetized Water MgO Concrete

Up to now, by most accepted hypothesis is that under the action of Lorentz force, chain molecules group of ordinary water, which has been linked together with hydrogen bonds, will be cut or damaged. Consequently, it will crack into group of small molecules or individual water molecules (Gattuso et al., 2016; Mo et al., 2012; Temiz et al., 2015; Wang et al., 2014; Mirandola and Lorenzini, 2016).

Changes in the connection between molecules of magnetic water can lead to physical and chemical properties change of magnetic water, such as surface tension, PH value, density and volatile changes and the ability to change of oxygen or other substances dissolved and so on.

Among the range of test parameters, when water is magnetized, the surface tension is indeed decreased. Especially surface tension of the magnetized water with the magnetic parameters (magnetic field intensity is 330mT, water flow rate is 1m/s) decline the most significant.

Action of cement hydration firstly took place on the surface of cement particles, and the layer of gel film can be formed on the surface of the cement, which can reduce surface tension of the magnetic water and increase the activity of the cement. Therefore, magnetic water can make the cement hydration more completely and the structure more compactly (Figure 3).

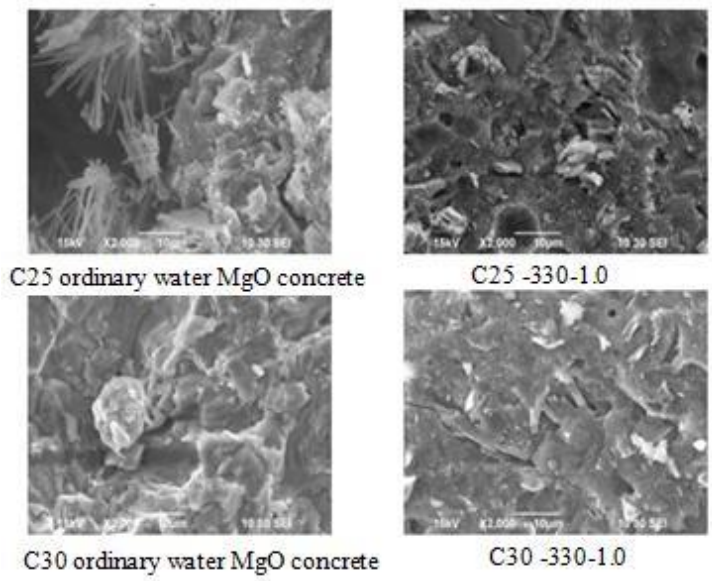


Figure 3: 2000×observation

As we all know, there is not much strong physical and chemical activity single water molecule in ordinary water and the activity of water is not enough, which can affect the cement hydration. Through the magnetic field, the water flow may be affected by Lorentz force, resulting changes in the orbital motion of electrons around the nucleus in water molecules and the spin motion, thereby the state of charge of water was changed. Single polar water molecules ($O^{2-}$and H^{+}) will be partly separate from water molecules. The number of this strong activity single water molecules will be increased which can greatly enhance the activity of the magnetic water. Therefore, magnetic water molecules can easily enter the cement grains and make the cement hydration more completely (Wang et al., 2011).

When the cement mixing with water, due to the action of molecular cohesion between cement particles, the cement could be formed of flocculation structure (Figure 4). Under the action of the electric repulsive, the cement particles can be separated. And it can make the flow ability of the concrete mixture increased without increasing the water consumption (Wang et al., 2011; Huang et al., 2016; Kaliakatsos et al., 2016; Cho et al., 2015; Liu et al., 2015; Li, 2000).

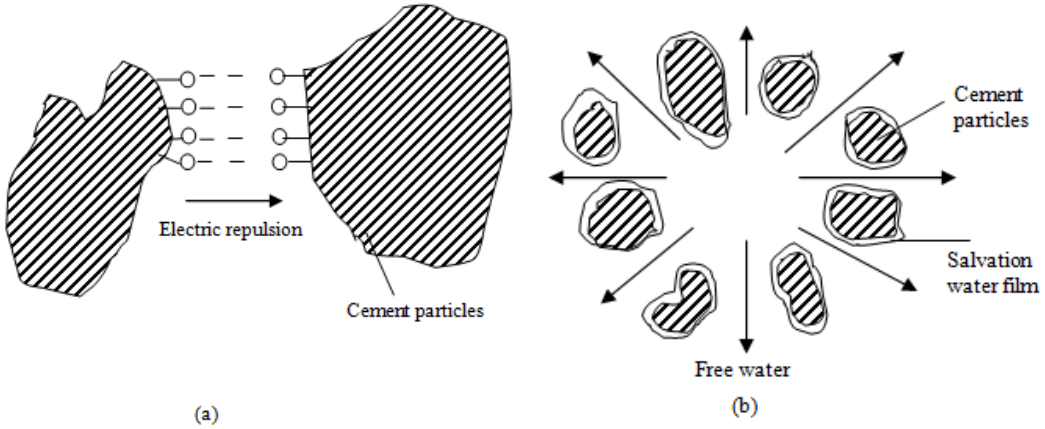


Figure 4: Effection of magnetized water

4. CONCLUSIONS

The water system is a complex object, which is difficult to study. The structure of molecules of magnetized water has indeed occurred the minor changes. So, the magnetic water can make the cement hydration reaction more completely, which can increase the cohesion of MgO concrete mixture.

Magnetic water molecules can easily enter into the cement grains. Therefore, magnetic water can increase the workability of concrete mixture, which can reduce the inhomogeneity degree of mixture. Under the action of the electric repulsive, the cement particles can be separated. This can make the flowability of the concrete mixture increased without increasing the water consumption. As the magnetic field changes the morphology and water impurities in the water molecules, so that the physical and chemical properties of magnetized water, some changes have taken place.

Concrete samples with different intensity levels C25 and C30 are chosen in the test of impermeability. Each strength class of all the 7 groups of MgO concrete are made under the same mix proportion of concrete. According to the principle of cross-test, 6 groups of magnetic water MgO concrete adopt different magnetic field intensity (230mT, 280mT, 330mT) and different water flow rate (1m/s, 2m/s) in the comparison test under the same condition of agitation, material, curing (28 days standard curing periods). Almost all the depth of penetration of magnetic water MgO concretes are less than ordinary water MgO concrete. Only when the magnetic field intensity is 230mT and water flow rate is 2m/s, depth of penetration of C30 magnetic water MgO concrete is greater than C30 ordinary water concrete. Under the magnetic field intensity of 230mT and 280mT and water flow rate of 2m/s, depth of penetration of magnetic water MgO concrete is close to ordinary water MgO concrete. Thus it can be seen that depth of penetration of magnetic water MgO concrete is less decreased than ordinary water MgO concrete when water flow rate is quite great and magnetic field intensity is quite small. It is discovered by test that, among the range of test parameters, depth of penetrations of magnetic water MgO concrete reduce with the degree of magnetic water increase among the range of test parameters. That is to say, the impermeability of MgO concrete can improve with the increase of the degree of magnetic water.

This paper demonstrates that magnetic water can improve the impermeability of MgO concrete and a more detailed analysis and discussion need to be undertaken. Moreover, combining the impact of admixture and durability of concrete will be the topic of future research.

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