RESEARCH ARTICLE OPEN ACCESS

The Magnetization of Water Arising From a Magnetic-Field and Its Applications in Concrete Industry

Pang Xiao-Feng and Zhu Xing-Chun

Institute of Life Science and Technology, University of Electronic Science and Technology of Chengdu 610054， China.

Abstract

The magnetization of water arising from a magnetic-field and its applications of magnetized water in concrete industry are investigated. In this study we introduce firstly that correct method of magnetization of water. In order to elucidate clearly its applications in the concrete industry we studies and inspect in detail the influences of magnetized water on the mechanical and optic properties of concrete, including mass density tensile strength, tensile strength, compressive strengths, deformation modulus and Poisson's ratio, shear strength of broken (cohesive force internal friction angle) as well as the infrared spectrum of absorption and fluorescence spectrum by different methods involving synthetic method including the ultrasonic and rebounded techniques as well as infrared and fluorescence spectra, respectively. The results obtained from these investigations indicate that the mass density tensile strength, tensile strength, compressive strengths, deformation modulus and Poisson's ratio of the concretes increase, but its cohesive force internal friction angle decrease as well as some new peaks in the concrete occur under influences of magnetized water relative to those of pure water. These show clearly that the magnetized water enhance the combined force among the molecules or corpuscles or components and lifts its mass density. Thus the changes of mechanical and optic properties of the concrete under influence of magnetized water.

Keywords: magnetic-field, magnetized water, concrete, mechanical properties optic feature

PACS numbers: 51.10.+y, 51.90.+r, 61.20.Ne.

I. INTRODUCTION

As it is known, water is a most familiar matter in nature, but its molecular structures and physical properties as well as its changes of property under actions of external factors, for example, electromagnetic-fields are not quite clear as yet, although these problems were widely studied about several hundreds of year. Experiments demonstrate that water can be magnetized in a magnetic-field only if the method of magnetization is correctly used. In the magnetization a standard pure water must be used[1-16] . Practice manifested we cannot use any water, can only use standard pure water to research the magnetized phenomenon of water, or else, the results obtained are incorrect or unreliable. The purified water we use here is prepared using the Simplicity 185 Water System (Millipore) made by USA. After this we measured seriously properties of purified water and the elementary elements contained in it using some instruments including the mass and color spectrometers at 25℃. Its pH value is 7.1-7.2 , electric resistivity is 1 MΩ.cm, absorption ratio of light (254nm, 1cm light path) is ≤0.01; Ca, Si, Na, K, nitrate, oxide (or O) and soluble silicon (i.e., SiO_2) involved in the purified water are 0.01mg/L, 0.005mg /L, 0.007mg/L, 0.002mg/L, 1mg /L, ≤0.08 mg / L and ≤0.02 mg / L, respectively. Therefore, there are not metallic and magnetic elements in the purified water. In the experiments the magnetized water is obtained and extracted from a glass container of pure water.

In this experiment. a standard magnetized device must be used. What are the requests of standard magnetized device? A standard magnetized device is required to product enough strong strength of magnetic field, which can guarantee that the magnetic lines of force of the magnet can penetrate over total water through wise arrangement. This is very important, or else, the water cannot be magnetized. Therefore, the magnetized device is, in general, made by NdFeB or superconductivity magnets. The pure water is lightly placed into an appropriate position in this device to guarantee that its magnetic lines of force can penetrate over total water and that its magnetized effect is not destructed in this case. This means that the weight or mass of pure water should be suitable, or speaking, cannot be too many to magnetize.

At the same time, after pure water is magnetized, we should inject immediately the magnetized water into the sample baths of the instrument to measure their properties because the time, in which the magnetization effect can be retained, is finite. The experiments should be repeated about 2-3 times for their credibility.

In general, the properties of magnetized water be considerably changed relative to those of pure water, for instance, the electromagnetic and optic features and molecular structure [1-16]. Just so, the magnetized water can be extensively utilized in industry, agriculture and medicine, for example, it is useful to aid the digestion of food and to eliminate the dirty in industrial boilers, etc.. However, what are the concrete characteristics of these changes? What are the reasons arising from the changes? and so on. Therefore, it is very necessary to investigate deeply and in detail the changes of macroscopically physical properties of water under action of magnetic-field as well as the influences of magnetized water on the mechanical and optic properties of the concretes. Through these investigations we can both know the features of macroscopic behaviors of magnetized water and extend its applications in industry and building of home. Therefore , this investigation has an important significance.

II. Preparation of the concrete containing magnetized water

II.1.Preparation of the concrete containing magnetized water.

The magnetized water we here use is extracted from a beaker of purified water at 25^0C exposed in the magnetic field of 4400G for 25 minutes., where the purified water we use here is prepared using the Simplicity 185 Water System (Millipore) made by USA. We measured properties of purified water and the elementary elements contained in it using the instruments including the mass and color spectrometers at 25℃ Its pH value is 7.1-7.2 , electric resistivity is about 1 MΩ.cm, absorption ratio of light (254nm, 1cm light path) is ≤0.01; Ca, Si, Na, K, nitrate, oxide (or O) and soluble silicon (i.e., SiO_2) involved in the purified water are 0.01mg/L, 0.005mg /L, 0.007mg/L, 0.002mg/L, 1mg /L, ≤0.08 mg / L and ≤0.02 mg / L, respectively.

II.2.Preparation of the concretes

According to the criterions and requests of the concretes drawn up by Chinese government we prepared the concrete, which is composed of the cement, fine sand, small stones and water, where the diameters of stone are about 7-20mm and cement is No:425 and has the feature of 32.5 Mpa, in which the proportions of cement, fine sand, small stones and water are 1：0.87：2.32：0.47. we prepared two concretes as shown in Fig.1, one concrete is composed of cement, fine sand, small stones and pure water, another is cement, fine sand, small stones and magnetized water, which has the above features.

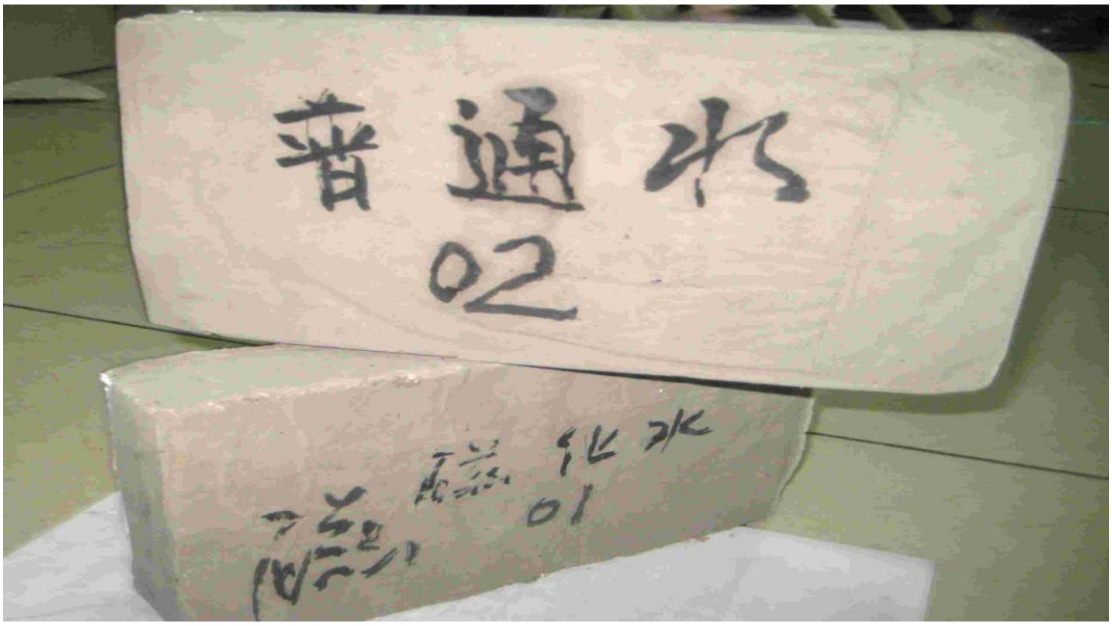


Fig. 1. The concrete samples containing the magnetized water (down) and pure water (up) prepared by us.

III. The Changes of physical property of concretes arising from the magnetized water

III.1. The changes of mechanical properties of concrete arising from the magnetized water

We used the synthetic method including the ultrasonic and rebounded techniques to measure the mechanical properties of two kind of concretes containing the magnetized and pure water, respectively[17-22]. This method collects the advantages of ultrasonic instrument, which can acquire the values of mechanical features of the concrete from the changes of characteristics of ultrasonic wave, and rebounded methods, which acquired the values of mechanical features of the concrete by the changes of characteristics of reflective wave of sound, and eliminates further their shortcomings in the measurement of mechanical properties of the concrete, in which we can obtain the values of many physical parameters of the concretes. Therefore, the results obtained by this method are more accurate. In the experiment, we firstly separate the concrete sample containing the magnetized water as the three small concrete boards of 4.23×4.2×8.71cm^3, 4.24×4.2×8.38 cm^3, and 4.21×4.18×8.37 cm^3, which are named after 1-1. 1-2 and 1-3, respectively, and the concrete sample containing only the pure water as also the three small concrete boards of 4.29×4.3×8.26 cm^3, 4.31×4.3×8.8 cm^3, and 4.29×4.26×8.91cm^3, , which are named after 2-1. 2-2 and 2-3, respectively. The mass densities of the concretes, which were measured using the quantity quadrature method, are shown in table 1.

Table 1. The natural densities of the concretes

sample sort	magnetized water concrete			Pure water concrete		
number of concrete board	1～1	1～2	1～3	2～1	2～2	2～3
natural density(*ρ*（*g/cm^3*）)	2.43	2.41	2.39	2.31	2.35	2.33
Average value（*g/cm^3*）	2.41			2.33		

The table 1 shows that the density of the concrete containing magnetized water is 2.41 g/cm3, which is great than that of pure water, which is only 2.33 g/cm3. This indicates that the magnetic field changes the features and distribution of water molecules, which enhance the combined strength among the components in the concrete, thus the density of the concrete containing magnetized water is increased.

We measured also the tensile strength of the concretes. As it is known, the tensile strength designates the maximum value of the stress of the concrete material in the case of stretched deformation under action of external force. Table 2 exhibits that the tensile strength of the concretes containing magnetized water is 1.33MPa, which is great than that of pure water, which is 1.36MPa, namely, the maximum value of the stress of the concrete containing thee magnetized water lifted about 5.6 % relative to that of pure water. This means that the combined forces among these components in the former through the magnetized water are increased great than that in the latter.

Table 2. The tensile strength of the concretes

sample sort	magnetized water concrete			Pure water concrete		
number of concrete board	1～1	1～2	1～3	2～1	2～2	2～3
natural density (*MPa*）	1.35	1.29	1.34	1.23	1.28	1.28
average value (*MPa*）	1.33			1.26		

We determined further the compressive strengths of the concretes. The compressive strength represents the loaded weight on the unit surface area when the concrete will be destroyed under action of a pressure with signal-direction. The results obtained is denoted in table 3, which manifests clearly that the compressive strengths of the concretes containing magnetized water is increased to 32.7 MPa in natural condition and 28.6 MPa in water environment form 29.8 MPa in natural condition and 27.6MPa in water environment for that of pure water, respectively, its ratios of increase are 8.9％ and 3.6% in natural and water condition, respectively. These imply that the capability of bearing destruction effect is enhanced for the concretes containing magnetized water relative to that of pure water.

Table 3. The compressive strengths of the concrete samples

sample sort			magnetized water concrete			pure water concrete		
number of concrete board			1～1	1～2	1～3	2～1	2～2	2～3
compressive strength	natural condition	True value(*MPa)*	33.4	32.7	32.8	30.3	29.8	29.5
		average（*MPa*）	32.7			29.8		
	water condition	True value(*MPa)*	29.9	28.3	27.6	28.2	26.9	27.7
		average（*MPa*）	28.6			27.6		

We find also out that the deformation modulus and Poisson's ratio (coefficient of lateral deformation) of the concretes. The deformation modulus expresses the ratio between the absolute values of increment of the stress and strain for the concrete in the condition of action of the loaded pressure. In practice, it is just a compressibility index obtained from the loaded experiment. The Possion ratio is the ratio between the horizontal strain and axial strain of the concrete under action of tensile or pressure force. The results obtained from this experiment are shown in table 4. We see clearly from table 4 that that the deformation moduluses of the concrete containing the magnetized water decreases to 1.1 and 0.98 MPa from 1.2 and 1.1MPa in those of pure water in both natural and water conditions, respectively. On the other hand, the Possion ratio of the concrete containing the magnetized water depresses to 0.19 and 0.18 from o.23 and o.19 in those of pure water in both natural and water condition, respectively. These results indicate that the concrete containing the magnetized water distorts not easily, or speaking, it is able to prevent its distortion relative to that of pure water under action of the loaded pressure. This means that magnetized water improves the quality of the concrete in a certain extent.

Table 4. The values of deformation modulus and Poisson's ratio of concrete samples

<table>
<tr><td colspan="3">sample sort</td><td colspan="3">magnetized water concrete</td><td colspan="3">pure water concrete</td></tr>
<tr><td colspan="3">number of concrete board</td><td>1～1</td><td>1～2</td><td>1～3</td><td>2～1</td><td>2～2</td><td>2～3</td></tr>
<tr><td rowspan="4">The concrete in natural condition</td><td rowspan="2">deformation modulus</td><td>True value ($10^4 MPa$)</td><td>1.1</td><td>1.1</td><td>1.2</td><td>1.2</td><td>1.3</td><td>1.2</td></tr>
<tr><td>average ($10^4 MPa$)</td><td colspan="3">1.1</td><td colspan="3">1.2</td></tr>
<tr><td rowspan="2">Poisson ratio</td><td>True value</td><td>0.21</td><td>0.19</td><td>0.19</td><td>0.23</td><td>0.15</td><td>0.21</td></tr>
<tr><td>average value</td><td colspan="3">0.19</td><td colspan="3">0.23</td></tr>
<tr><td rowspan="4">The concrete in water condition</td><td rowspan="2">deformation modulus</td><td>True value ($10^4 MPa$)</td><td>0.9</td><td>0.9</td><td>1.1</td><td>1.0</td><td>1.2</td><td>1.1</td></tr>
<tr><td>average ($10^4 MPa$)</td><td colspan="3">0.96</td><td colspan="3">1.1</td></tr>
<tr><td rowspan="2">Poisson ratio</td><td>True value</td><td>0.18</td><td>0.17</td><td>0.19</td><td>0.20</td><td>0.18</td><td>0.19</td></tr>
<tr><td>average value</td><td colspan="3">0.18</td><td colspan="3">0.19</td></tr>
</table>

We inspect also that the shear strength of broken of the concrete. In general, the fracture of the concrete is due to the force of shear failure. The shear strength of broken represents the maximum of the shear stress on the shear surface when the concrete is clipped along the direction of stress change under action of .normal pressure. It is denoted by using the cohesive force and internal friction angle. The former manifests that mutual attraction interaction among the same components in the concrete, the latter is the slant angle between two dislocation surfaces in generation of dislocation arising from the shear failure under action of vertical gravity. Therefore, its value signs the size of friction forces occurred among the displacements each other of the corpuscles. The results of the cohesion and internal friction angle of the concrete are shown in table 5. From the experiment we know that the cohesive force in the concrete containing magnetized water is increases relative to that of pure water, thus the incorporated or attraction force among the components in the concrete increases due to the injection of magnetized water relative to that of pure water. Then the mass density increases necessarily in the concrete containing magnetized water in this case as mentioned above. However, the internal friction angle in the concrete containing magnetized water decreases to 23.3 from 27.3 in that of pure water. This means that the magnetized water can restrain the dislocation effect of concrete arising from the shear failure under action of external force in certain degree due to the enhancement of cohesive force among the components.

Table 5. The shear strength of broken of the concrete

sample sort			magnetized water concrete			pure water concrete		
number of concrete board			1～1	1～2	1～3	2～1	2～2	2～3
The concrete in natural condition	cohesive force	True value *(10^4MPa)*	1.12	1.03	1.13	0.98	0.99	1.11
		average *(10^4MPa)*	1.093			1.031		
	internal friction angle φ^0	True value	23	25	22	28	27	28
		average value	23.3			27.3		

III.2. The changes of optic property of concrete arising from magnetized water

We collected also the infrared spectra of the concretes containing magnetized and pure water in the region of 400- 4000 cm^{-1} using a Nicolet Nexus 670-FT-IR spectrometer with resolution of $4cm^{-1}$ made by USA , respectively, which are shown in Fig.2. From this figure we see clearly that some new peaks occur in 2000-3000 cm^{-1}, for example, five peaks at 2600, 2450 1900, 1850 and $1780cm^{-1}$ occur and the strengths of peaks in the region of 400-1700 cm^{-1} reduce in the concrete containing magnetized water relative to those of pure water. This manifests that externally applied magnetic field changes the distribution and structure of molecules in water, which result in the variations of infrared spectrum due to the interaction and combination of the magnetized water with the components in concrete.

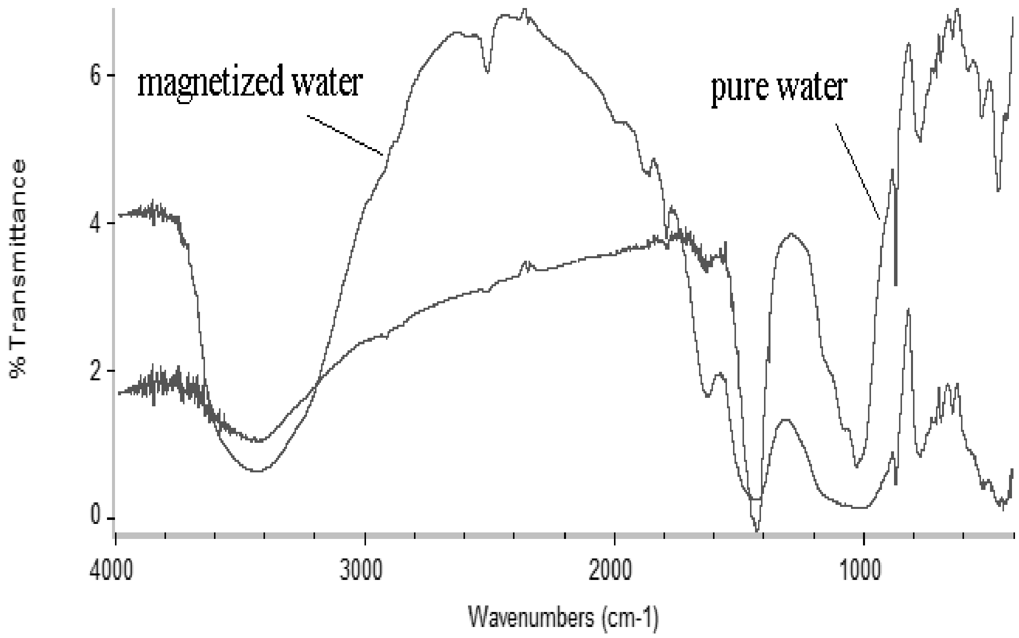
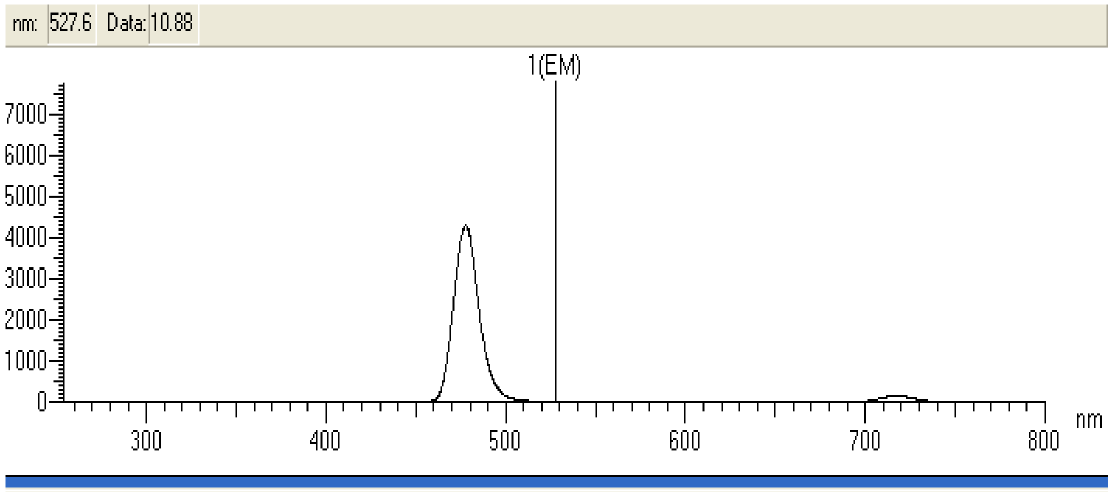


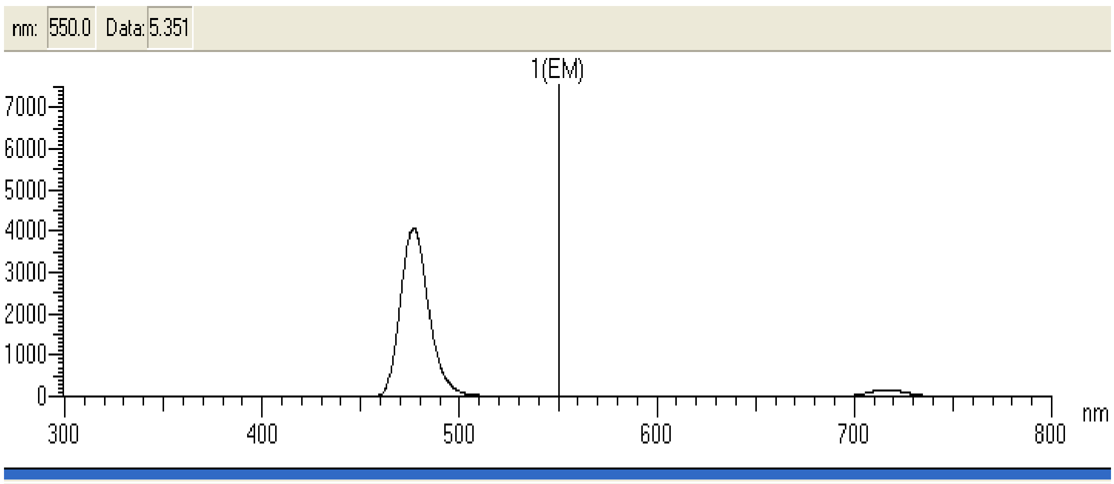
Fig.2. the infrared spectra of the concretes containing magnetized and pure water i**n the** region of 400- 4000 cm^{-1}, respectively,

We collected the fluorescence spectra of the concrete containing the magnetized and pure water using a F-2000 fluorescence-meter made by Japan. The results are shown in Fig.3-6, which are excited by the light having the wavelengths of 236nm and 260nm, respectively. From these figures we see that the basic feature of fluorescence spectra of the concrete have not been changed, although the pure water is replaced by the magnetized by the magnetized water. This indicates that the atomic and electronic structures in these molecules in the concrete have not be changed in this case. However, we see also that the strengths of the peaks in the fluorescence spectra of the concrete containing the magnetized water reduce relative to that of pure water. Obviously This is due to the enhancement of incorporated force among the molecules in the components in the concrete arising from the magnetized water as mentioned above, which restrains the transition of the electrons in these molecules.



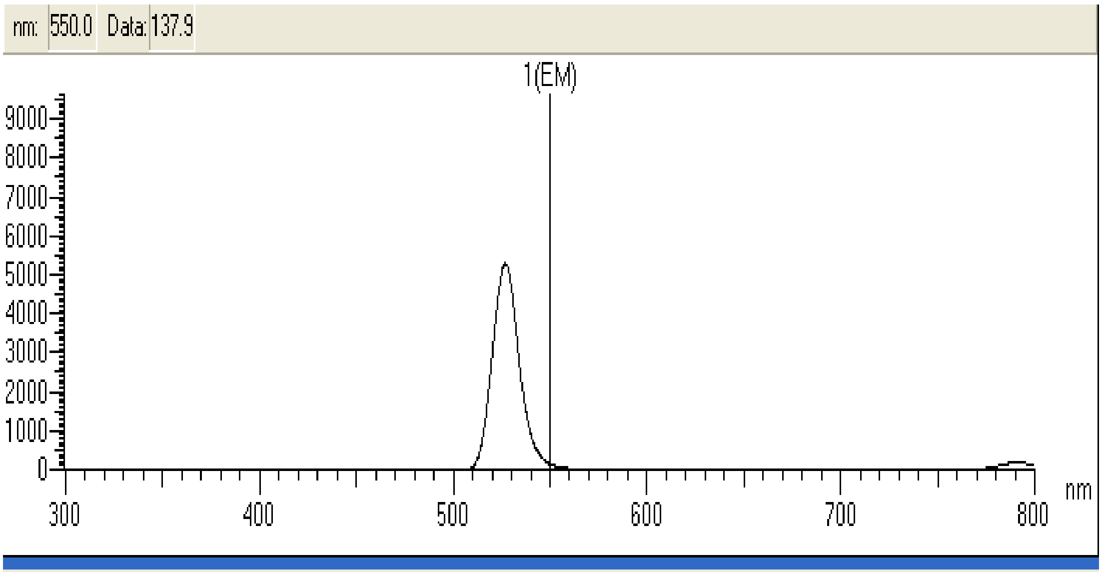
No.	Start(nm)	Apex(nm)	End(nm)	Height(Data)	Valley(nm)	Valley(Data)
1	255.0	354.2	447.6	23.18	447.6	17.93
2	447.6	478.0	690.4	4284	690.4	0.982
3	690.4	716.6	800.0	150.9	800.0	-0.059

Fig. 3. The fluorescence spectrum of the concrete containing the pure water excited by the light of wavelength of 236nm.



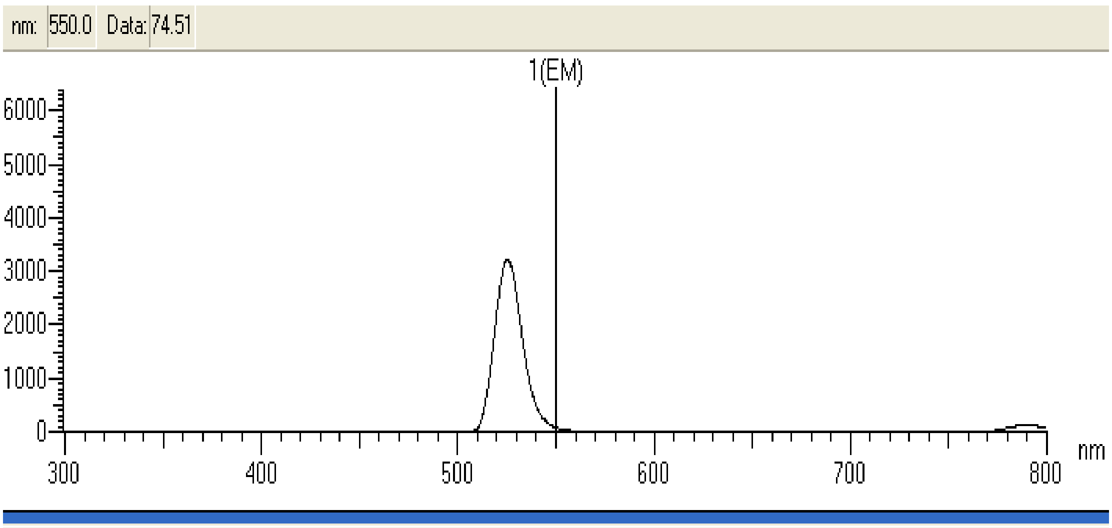
No.	Start(nm)	Apex(nm)	End(nm)	Height(Data)	Valley(nm)	Valley(Data)
1	300.0	342.0	418.8	13.78	418.8	9.043
2	418.8	476.8	681.0	4081	681.0	1.111
3	681.0	716.4	800.0	167.6	800.0	0.629

Fig. 4. The fluorescence spectrum of the concrete containing the magnetized water excited by the light of wavelength of 236nm.



No.	Start(nm)	Apex(nm)	End(nm)	Height(Data)	Valley(nm)	Valley(Data)
1	300.0	472.2	489.2	11.45	489.2	9.291
2	489.2	526.8	755.6	5281	755.6	0.381
3	755.6	791.0	800.0	172.8	800.0	106.1

Fig. 5. The fluorescence spectrum of the concrete containing the pure water excited by the light of wavelength of 260nm.



No.	Start(nm)	Apex(nm)	End(nm)	Height(Data)	Valley(nm)	Valley(Data)
1	300.0	301.2	437.4	9.574	437.4	5.080
2	437.4	525.6	745.4	3223	745.4	0.360
3	745.4	789.0	800.0	125.8	800.0	65.45

Fig. 6. The fluorescence spectrum of the concrete containing the magnetized water excited by the light of wavelength of 260nm.

IV. Changes of hydrophilic feature of water under action of magnetic-fields

From the above investigations we know that the changes of mechanical and optic properties of the concretes under influence of magnetized water. Why is this ? This is worth to study further.

In order to solve this problem we here measure the variation of surface tension force or the soaking degree of magnetized water on a planar surface of material. This effect is signed in the size of angle of contact of magnetized or pure water on a planar surface of materials. In our experiment, we measure the angle of contact of magnetized and pure water on a planar surface of copper, graphite, muscovite and silica gel of PDMS183 in the region of 0^0 -180^0 and in the condition of humidity of 27^0 by using OCA40 and OCA20 Micro optical-vision instrument with the accuracy of ±0.3° made by Germany, respectively, where the magnetized water is taken from a beaker of 250ml of pure water at 25^0C ,which is exposed in the magnetic-field of 4400G for 30 minutes. In this measurement, the water injected is about 3μL, the speed of water injected is about 0.5μL/s. As are known, the muscovite is hydrophilic, but copper, graphite and silica gel of PDMS183 have different hydrophobicities. We measure first the sizes of angle of contact of magnetized and pure water at five different positions on the planar surface of these materials, respectively, finally find the average value of five different values for the angle of contact of magnetized and pure water, respectively. The experimental results of the copper, graphite, muscovite and silica gel of PDMS183 are shown in Figs. 7, 8, 9 and 10, respectively. From the four figures we see that the angles of contact of magnetized and pure water on the muscovite are almost zero, the difference between them is extremely small. Therefore, the soaking degree of pure and magnetized water to the muscovite are very large. However, for the copper, the angles of contact of magnetized and pure water are about 146.8^0 and 147.2^0, respectively; for the graphite, they are about 91.2^0 and 92.6^0, respectively; for the silica gel of PDMS183, they are about 97.9^0 and 101.03^0, respectively. Therefore the angles of contact of magnetized water on the surfaces of hydrophobic materials are decreased relative to that of pure water, the extenuation quantities of the angles of contact are about 0.4°,1.4°and 3.13^0 for the copper, graphite and silica gel of PDM S183, respectively, i.e., for the silica gel of PDMS183, the extenuation of the angles of contact of magnetized water is extremely evident. This means that the soaking degree of magnetized water to the hydrophobic materials increases, thus its hydrophobicity decreases. This shows that the magnetic-field can change the hydrophobicity of water. Obviously, the extenuation of angles of contact of magnetized water is due to the increases of polarized effect and the changes of distribution of molecules in magnetized water. Thus we conclude the surface tension force of magnetized water does decrease relative to that of pure water in such a case. Thus the magnetized water enhances the combined force with the molecules or corpuscles or components and lifts its mass density in the concretes. Then it is very natural to change the mechanical properties and infrared spectrum of absorption of the concretes.

Fig.7. The angels of contact of magnetized water (a) and pure water (b) on the surface of muscovite

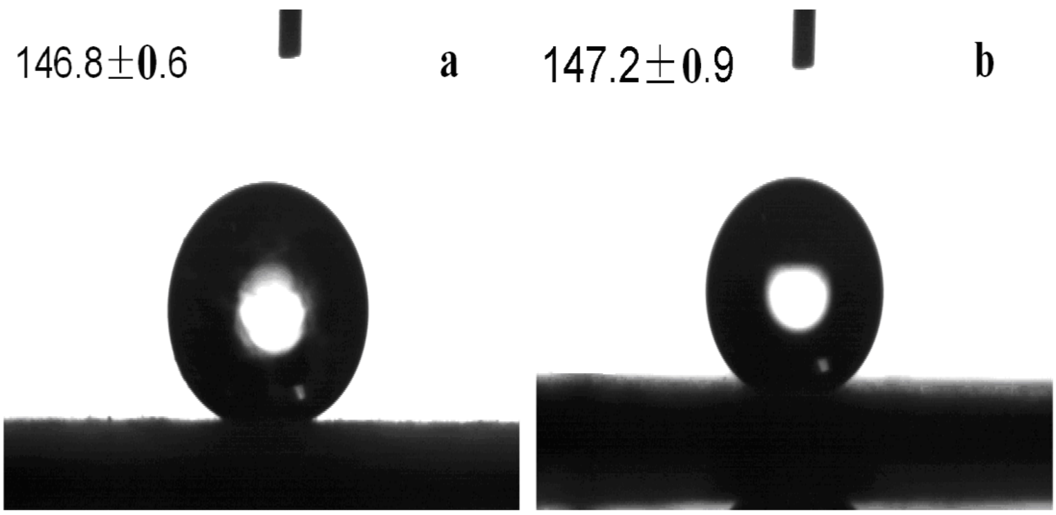


Fig 8. The angels of contact of magnetized water (a) and pure water (b) on the surface of copper

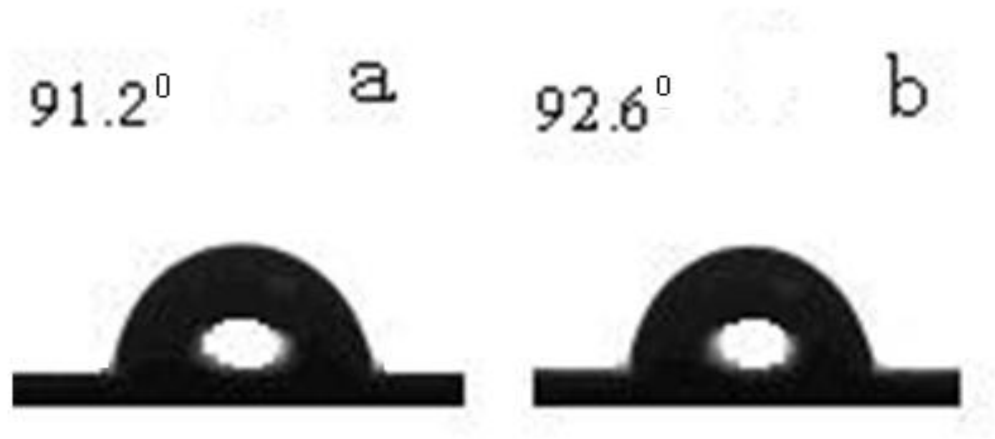
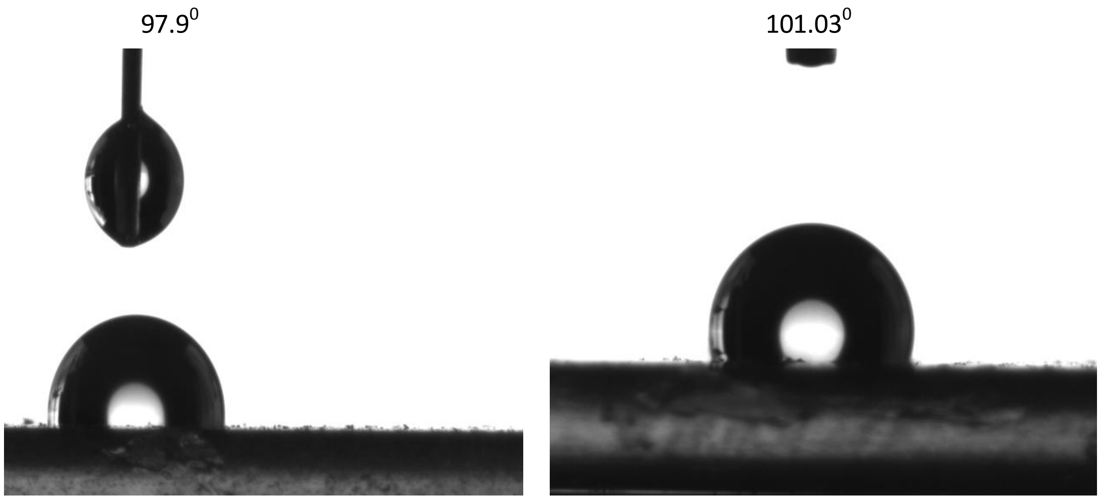


Fig 9. The angels of contact of magnetized water (a) and pure water (b) on the surface of graphite.



(a) (b)

Fig.10. The angle of contact of magnetized water(a) and pure water (b) on the surface of silica gel of PDMS183

V. Conclusion

When water is exposed in a magnetic-fields, we find that its properties are changed. This is called magnetization of water. The properties of concretes are changed when the magnetized water is injected into the concretes to replace the pure water. In this paper we studied and measured in detail the influences of magnetized water on the mechanical and optic properties of concrete, including mass density tensile strength, tensile strength, compressive strengths, deformation modulus and Poisson's ratio, shear strength of broken (cohesive force internal friction angle) as well as the infrared spectrum of absorption and fluorescence spectrum by different methods involving synthetic method including the ultrasonic and rebounded techniques as well as infrared and fluorescence spectra, respectively. The results obtained from these investigations indicate that the mass density tensile strength, tensile strength, compressive strengths, deformation modulus and Poisson's ratio of the concretes increase, but its cohesive force internal friction angle decrease as well as some new peaks in the concrete occur under influences of magnetized water relative to those of pure water. These show clearly that the magnetized water enhance the combined force among the molecules or corpuscles or components in the concrete and lifts its mass density. Thus the changes of mechanical and optic properties of the concrete under influence of magnetized water. Based on these results we studied the reasons generating these changes of property in the concrete arising from the magnetized water. Thus we checked the changes of hydrophilic and hydrophobic features of water under action of magnetic-field. This experiment released that the hydrophilic feature of magnetized water is high than that of pure water. Then we can explain the reasons of change of property of the concrete under influence of magnetized water, which is due to the enhancement of combined forces among the molecules, corpuscles and components in the concrete and its increases of mass density.

VI. Acknowledgement

The authors would like to acknowledge National Basic Research Program of China (973 Program) (grate No: 212011CB503 701).

References

[1] Xie WenHui, Magnetized water and its application, Science Press, Beijing 1983, p34
[2] K.M.Joshi, P.V.Kamat, J.Indian Chem. Soc. 43 (1965) 620
[3] K.Higashitani, J.Colloid and Interface Science, 152 (1992) 125
[4] K.Higashitani, J.Colloid and Interface Science, 156 (1993) 90
[5] B.N. Ke LaXin, Magnetization of water, Beijing, Measurement Press, 1982, p56
[6] Jiang Yijian, Jia Qingjiou, Zhang Peng Cheng, Xu Lu, J. Light Scattering, 4 (1992) 102
[7] K.Muller, Z.Chem, 10 (1970) 216
[8] J.Liemeza, Z.Phys. Chem. 99 (1976) 33
[9] P.Bour, Chemical Physics Letter, 365(2002)82
[10] M.C.Amiri, A.Dadkhah,Colloids and Surfaces A: Physicschem. Eng. Aspects, 278(2006)252
[11] A.D.Kneya, S.A.Parsonsb, Water Research, 40(2006)518
[12] Eisenberg, D.; Kauzmann, W. The Structure and Properties of Water; Clarendon Press: Oxford, 1969, p67
[13] Pang Xiao-feng, Chinese J. Atom. Mol. Phys.23(supp),1(2006)1
[14] Pang Xiao-feng, Biological electromagnetics, National Defence Industry Press, Beijing, 2008, pp35
[15] Pang Xiao-feng, European Phys. J. B49(2006)5
[16] Pang Xiao-feng and Feng Yuan-ping, quantum mechanics in nonlinear systems, World Scientific Publishing Co. NewJersey, 2005, p557
[17] Jean-Joseph Maxa and Camille Chapados. Water Treatment. Journal of Chemical Physics. 2004, 14: 6626-6643
[18] Luo Man and Lue Zhu, Roman, The current situation of research and development of

magnetic treated water. Water treatment technology, 1999, 25（6）：340-343

[19] Xie Sheng-fa, The influence of magnetic-field, J. Dalian ocean shipping Institute, 1992, 18（3）：320-322

[20] Zhu yun-hui,Cheng She-sheng and Lu Qu-sheng, The determination and evaluation of magnetic treatment of water, Physical and chemical inspection-chemical volume, 2001.37（6）：279-279

[21] Yang De-qi and Yang lie-li, The magnetic treatment of water and the magnetic treated water, Bio-magnetism, 2000,（3）：20-25

[22] Masakazu. Effect of Gradient Magnetic Field on Diffusions Process of Glycine in Water.. Transactions on Magnetics. 1997, 33(5): 4254-4256