CHEMICAL ENGINEERING TRANSACTIONS
VOL. 66, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Songying Zhao, Yougang Sun, Ye Zhou

ISBN 978-88-95608-63-1; **ISSN** 2283-9216
DOI: 10.3303/CET1866207

Admixture in Concrete in the Machanism Research

Zhongxuan Yang*

School of economics and management, system and Industrial Engineering Research Center, Zhongyuan University of Technology, Zhengzhou 450007, China
yangzhongxuan111@163.com

With the rapid development of the domestic economy, China's infrastructure construction has also maintained rapid growth. Some major projects have been proposed immediately, not only does it have a huge demand for concrete, but it also has very high demands on the quality of concrete. Concrete admixtures are chemical substances added to concrete. Reasonable use of admixtures can effectively improve the properties of concrete. In recent years, with the continuous improvement of the quality requirements of concrete in the construction industry and advances in chemical technologies, many new chemical materials have been used in concrete admixtures, and it has become necessary to study the effect of admixtures in concrete. The types of admixtures are various. In this paper, the effects of antifreeze, hardener and compound admixtures in concrete are explored, which provides technical guidance for the application of admixtures in concrete.

1. Introduction

Concrete is still a very important building material during the construction of a building project. With the continuous development of science and technology, the application of concrete is becoming more and more widespread. In this process of change, the use of admixtures is extremely important. China's infrastructure construction has maintained a rapid growth, and the demand for concrete admixtures has continued to flourish in railways, highways, airports, coal mines, municipal engineering, nuclear power plants, and dams. As a result, China's concrete admixtures industry has also been in rapid development (Wang et al., 2016). Additives (Schröfl et al., 2012; Qian and Dong, 2012) mainly refer to the addition of chemical substances in the concrete mixing process in addition to the various types of raw materials and mixes that make up the concrete, which has the characteristic of improving the performance of the concrete material. Concrete admixtures are an important technology and method. Due to a large number of influencing factors (Jiang, 2017; Łaźniewska-Piekarczyk, 2013), it is necessary to understand the classification and mechanism of admixtures during the construction process. According to the requirements of the concrete construction system and control mechanism, it is necessary to make reasonable choice, and the choice will increase the overall performance and quality of the concrete material.

2. Antifreeze

The daily average temperature is lower than 5°C for 5 consecutive days, and the concrete works will enter the winter construction. At this time, the concrete project needs to consider the low temperature from the design of the mix ratio, the initial temperature of the raw materials, to the pouring, forming, curing, and removal of the mold. The impact. Low temperature mainly affects the hydration rate of cement and volume expansion after water freezing, leading to prolonged coagulation hardening, internal structural damage and slow growth of strength. If the curing temperature of the concrete is reduced to 10°C, the setting time will be doubled. If the concrete curing temperature is lowered to -5°C, the fresh concrete will be subjected to freezing damage, and the compressive strength at the later stage will be lost by more than 50%. Therefore, a series of winter construction techniques in cold regions is to protect early-stage concrete from freezing damage. Under negative temperature, incorporation of antifreeze in concrete and proper insulation measures are common methods in winter construction of concrete in cold regions.

Please cite this article as: Yang Z., 2018, Admixture in concrete in the machanism research, Chemical Engineering Transactions, 66, 1237-1242 DOI:10.3303/CET1866207

According to the “Construction Project Winter Construction Regulations” (jgj104-97), if the daily average outdoor temperature will be below 5 degrees Celsius for 5 consecutive days and will enter winter construction. When the outdoor average daily temperature is stable above 5 degrees Celsius for 5 consecutive days, lift the winter construction. Due to the regional conditions in the North Region of China, about one third of the time in the year is during the winter construction period. Due to the tight construction schedule and heavy tasks in civil engineering, it is inevitable to continue construction in winter. If not taking effective measures or improper measures in such a low temperature, causes the concrete to suffer freezing injury and will cause accidents to the quality of the project. Studying and understanding the mechanism and laws of concrete frost damage, and correctly using antifreeze agents, are of great significance to ensure project quality and achieve balanced construction throughout the year.

2.1 Mechanism

Antifreeze refers to a chemical substance that makes a concrete mixture free from freezing damage in a negative temperature environment. Many inorganic salts and some organic substances have antifreeze function. The mode of action can be divided into two categories: one is a very low eutectic temperature with water, which has the ability to reduce the freezing point of water, and allows the concrete to perform hydration at negative temperatures, such as sodium nitrite and sodium chloride. However, if the amount is insufficient or the temperature is too low, it will still cause freezing damage. The other is to make it possible to reduce the freezing point of water as well as to seriously deform the lattice structure of ice containing this type of material, thus failing to form frost heaving stress and destroying the hydration mineral structure to impair the strength of the concrete, such as urea and methanol. When the dosage is insufficient, the intensity stops growing at negative temperature but the positive temperature has no effect on the final strength; The second type is that although the aqueous solution has a low eutectic temperature, it cannot significantly reduce the freezing point of the water in the concrete. Its role is to react with the cement directly to accelerate hydration of the concrete and accelerate the setting and hardening of concrete, which is beneficial to the development of concrete strength, such as calcium chloride and potassium carbonate.

Table 1: Common antifreeze chemical composition

Material	SiO_2	AL_2O_3	Fe_2O_3	CaO	MgO	SO_3	LI
OPC	19.52	6.47	3.96	62.28	1.73	2.63	1.61
FA	63.40	19.52	3.10	9.41	0.82	0.13	6.80
SF	94.52	0.57	0.98	0.64	0.97	—	1.91

Table 1 shows the chemical composition of common antifreeze. 0PC-Ordinary Portland Cement; FA-Fly Ash; SF-Silica fume.

2.2 Usage and precautions

(1) Correct understanding of "use temperature"
Any antifreeze (Çullu and Arslan, 2013; Polat, 2016) product that meets the standard has a clear “use temperature” (eg -15 degrees Celsius, -20 degrees Celsius). It is not wrong to say that the use temperature is “allowing the concrete construction temperature” but it should be focused on concrete. The criticality of frost resistance is related to understanding, That is, before the ambient temperature drops to the "use temperature" of the admixture, the concrete must achieve the critical strength against freezing, so that the concrete is safe, otherwise it may be frozen. The lower the use temperature of concrete, the better the effect of the antifreeze, and the more concrete has more time (including the negative temperature zone) to increase the strength, so as to greatly increase the criticality of the antifreeze.
(2) Take measures to cover insulation
The basic approach of the integrated heat storage method is to add anti-freezing agent and, if necessary, to heat water and gravel. The role of coverage is to make the heat of cement hydration and the heating heat of raw materials stay in the concrete for a longer period of time, and it is very important to extend the time for the warm hydration of the cement as much as possible. The better the insulation is done, the longer the concrete falls to the “usage temperature” of the admixture, and the more time it takes to reach the critical freezing strength. In order to achieve this effect, the type and thickness of the covering material should be determined by thermal calculation in conjunction with the use temperature of the admixture, the critical strength against freezing, and the ambient temperature.

3. Hardener

Concrete hardener (Zhang et al., 2009; Yuan et al., 2010) refers to an admixture that can improve the early strength of concrete and has no significant effect on the later strength. Its main role is to accelerate the speed of cement hydration and promote the development of early strength of concrete. The admixtures with early strong functions and certain water-reducing enhancement functions are called water-reducing hardener.

Table 2: Common hardener dosage limit

Type of concrete	Use environment	Component	Dosage / %
Prestressed Concrete	Dry environment	Sodium sulfate	<= 1.00
		Triethanolamine	<= 0.05
Reinforced concrete	Dry environment	Chloride	<= 0.60
		Sodium sulfate	<= 2.00
		Sodium sulfate combined with retarder and water reducer	<= 3.00
		Triethanolamine	<= 0.05
	Wet environment	Sodium sulfate	<= 1.50
		Triethanolamine	<= 0.05
Concrete facing requirements		Sodium sulfate	<= 0.80
Plain cement concrete		Chloride	<= 1.80

Early strength agent is a special admixture that specifically solves the problem of obtaining the strength of cement concrete as soon as possible or as soon as possible. It is mainly used in highway cement concrete projects in the following situations:

1) Fast access to the cement concrete pavement or bridge deck pavement, especially the level crossings of the first, second and third grade highways.

2) Construction of cement concrete structures in low temperature environments where the lowest temperature is not lower than -5°C requires the use of early strength agents to accelerate the setting and hardening of cement concrete to prevent freezing damage of cement concrete at lower temperatures.

3) Pre-stressed reinforced concrete structures require the use of early-strength agents to speed up prestressing and increase the speed of component fabrication.

4) Rapid restoration of cement concrete pavement and bridges.

3.1 Mechanism

Concrete hardener is one of the earliest additive species used in the history of admixture development. So far, people have successively developed various harder admixtures other than chlorine salts and sulfates, such as nitrites, chromates, etc. As well as organic hardener, such as triethanolamine, calcium formate, urea, etc., and on the basis of hardener, production and application of a variety of composite admixtures, such as water reducer hardener, antifreeze hardener and pump delivery hardener. These types of hardener admixtures have been used in practical projects and have played an important role in improving concrete performance, increasing construction efficiency, and saving investment costs.

3.2 Usage and precautions

The composition of chlorine salt hardener mainly includes calcium chloride, sodium chloride, aluminum chloride and the like. The proper addition of chlorine salt hardener is beneficial to the early strength development of concrete. However, the chlorine salt hardener is only allowed to be blended in non-reinforced concrete. For reinforced concrete, especially for prestressed reinforced concrete, and for concrete with metal embedded parts., the Cl content should be used with caution and even prohibited. Nitrate and nitrite both promote the cement hydration process. These salts can be used not only as hardener for concrete, but also as components of concrete antifreeze.

4. Compound admixtures

Compound admixture (Lu et al., 2009; Zhang et al., 2009) refers to the mixing of several admixtures with different properties by means of mechanical mixing. In the highway project, in order to meet the standards required by the “Test Procedure for Cement and Cement Concrete for Highway Engineering”, the use of additives should first enable the strength of the cement to reach a certain standard, so that the concrete can maintain certain workability. Therefore, the determination of a suitable compound admixture is an unavoidable important link in the project. Now three different compound admixtures are used in the experiment. According to the results of measured cement paste fluidity and mortar strength, the results are optimized and compared. The best solution.

4.1 Raw materials

Table 3: Compound with admixture formula

No.	Naphthalene series	Air - entraining agent	Polyvinyl alcohol	Retarder	Sulfamate	Water
1	35.00	0.14	0.11	0.35	-	64.40
2	-	0.14	0.11	0.35	31.00	68.40
3	25.00	0.14	0.11	0.35	7.00	67.40

Cement: Dongyue brand ordinary silicate 42.5 cement, Jinan, Shandong;
Sand: medium sand fineness modulus Mx = 2.7%, good grading, Jinan, Shandong;
Water: tap water;
Admixtures: naphthalene, polyvinyl alcohol, sulfamate, air-entraining agents, retarders, and compounding admixtures, Jinan, Shandong.

4.2 Cement paste

Cement paste fluidity experiment with different compound admixtures:
(1) Equipment and equipment
Cement paste flow mold: paste mixer, long ruler, glass plate, balance, measuring cylinder and so on.
(2) Ambient temperature and humidity
Room temperature (20 plus or minus 2) °C, indoor humidity greater than 50%.
(3) Implementation of standards
According to the “Test Regulations for Cement and Cement Concrete for Highway Engineering” (JTG E30-2005) issued by the Ministry of Communications of the People's Republic of China.
(4) The degree of cement paste fluidity is shown in Table 4

Table 4: Cement net pulp flow degree

Additives sort	Cement net / g	Water / g	Additives w / %	Fluidity /m		
				30s	30min	60min
1	200	56	1.8	204 / 206	168 / 166	118 /116
	200	56	2.0	212 / 212	177 / 176	131 / 124
	200	56	2.5	222 / 224	186 / 184	148 / 146
2	200	56	1.2	226 / 225	218 / 216	208 / 210
	200	56	1.5	240 / 238	230 / 232	220 / 224
	200	56	1.8	250 / 248	240 / 238	226 / 224
3	200	56	1.8	181 / 182	178 / 181	171 / 174
	200	56	2.0	201 / 204	198 / 195	192 / 194
	200	56	2.5	232 / 235	220 / 226	221 / 222

4.3 Cement Mortar

Cement mortar mixed with different composite admixtures:
(1) Equipment and equipment
Mortar mixer, mortar fluidity meter, mortar forming mold, mortar vibrometer, steel ruler, scraper, etc.
(2) Ambient temperature and humidity
The sample forming laboratory temperature is (20±2) °C, the relative humidity is greater than 50%, the curing box, the mist chamber temperature is 20±1 °C, the relative humidity is more than 90%, and the protection water temperature is 20±1 °C.
(3) Implementation of standards

According to the “Test Regulations for Cement and Cement Concrete for Highway Engineering” (JTG E30-2005) issued by the Ministry of Communications of the People's Republic of China.
(4) Mixture ratio of cement mortar experiment
Water-cement ratio: m (water): m (gray) = 1:2
Sand ratio: m (rubber): m (sand) = 1:3
(5) The fluidity of cement mortar is controlled to be 180±10 mm within 30 seconds. See Table 5 for numerical values.

Table 5: Cement mortar slump

Additives sort	Additives /g	Additives w/%	Standard	Water /mL	M (Water) M (Lime)	Fluidity /min
Baseline	0	0	1300	220	0.5	115
	0	0	1300	280	0.65	173
1	4.3	0.96	1300	220	0.5	221
	3.7	0.82	1300	220	0.5	174
2	4.5	1.00	1300	220	0.5	243
	3.8	0.84	1300	220	0.5	182
3	5.8	1.29	1300	220	0.5	226
	4.6	1.02	1300	220	0.5	181

Through the determination of the fluidity of cement mortar, the material ratio of mortar molding is formed according to the material processing method listed in the above table, and the pressure, flexural strength of 3d, 7d, and 28d patterns are tested by curing in the curing chamber. ,Record data.
(6) The flexural and compressive strengths of the 3d, 7d, and 28d after cement mortar molding are shown in Table 6.

Table 6: Cement mortar 3d, 7d, 28d compressive and flexural strength data

Additives sort	3d		7d		28d	
	Folding / MPa	Folding / MPa	Folding / MPa	Folding / MPa	Folding / MPa	Folding / MPa
Baseline	4.12	20.52	4.78	26.42	6.72	28.30
1	4.60	22.01	5.89	27.86	7.47	35.41
2	4.23	20.35	5.12	26.34	8.18	33.21
3	4.70	21.12	5.78	25.31	8.82	34.02

In order to make the additive play the correct role and achieve the desired effect, there will be certain requirements for the selection and use of the additive. With the continuous development of the social economy, the building construction will gradually increase, and the production of concrete admixtures will enter a stage of rapid development. In the future, concrete admixtures will develop in a clear direction, that is, energy saving, high-efficiency, environmental protection and sustainable development.

5. Conclution

In modern buildings, concrete is an indispensable building material, and the rational use of admixtures can effectively improve the performance of concrete. In this paper, the effects of antifreeze, hardener and compound admixtures in concrete are explored. The specific work is as follows:
1) Explained in detail the chemical components of some commonly used antifreeze agents and hardener, and explored its mechanism of action. Finally, the matters that should be noted when using antifreeze and hardener are given.
2) For compound admixtures, naphthalene, polyvinyl alcohol, amino sulfonate, and air-entraining agents were selected as compound formulations, and the effects of different ratios on the properties of the concrete in different environments were discussed.

References

Çullu M., Arslan M., 2013, The effects of antifreeze use on physical and mechanical properties of concrete produced in cold weather, Composites Part B Engineering, 50(50), 202-209, DOI: 10.1016/j.compositesb.2013.02.012

Jiang S.S., 2017, Analysis on the Concrete Admixture Quality Detection Problem, Construction & Design for Engineering, 2017(4), 144-145, DOI: 10.13616/j.cnki.gcjsysj.2017.02.161

Łaźniewska-Piekarczyk B., 2013, The influence of chemical admixtures on cement hydration and mixture properties of very high performance self-compacting concrete, Construction & Building Materials, 49(1), 643-662, DOI: 10.1016/j.conbuildmat.2013.07.072

Lu W.X., Zhou H.W., Zhuang Y., Li X.L., Yang J.J., 2009, Influence of Modified Polypropylene Fiber and Compound Mineral Admixtures on the Properties of Concrete, Journal of Building Materials, 12(3), 315-317, 331.

Polat R., 2016, The effect of antifreeze additives on fresh concrete subjected to freezing and thawing cycles, Cold Regions Science & Technology, 127, 10-17, DOI: 10.1016/j.coldregions.2016.04.008

Qian D.X., Dong X.S., 2012, Study on the characteristic performance of desulphurization gypsum as high performance concrete admixture, Concrete, 40(12), 78-80.

Schröfl C., Mechtcherine V., Gorges M., 2012, Relation between the molecular structure and the efficiency of superabsorbent polymers (SAP) as concrete admixture to mitigate autogenous shrinkage, Cement & Concrete Research, 42(6), 865-873, DOI: 10.1016/j.cemconres.2012.03.011

Wang L., Zhao X., Gao R., Gao H.Q., Lin H., 2016, Production statistical analysis and market prospect estimate of concrete admixture in China, New Building Materials, 43(7), 1-6, DOI: 10.3969/j.issn.1001-702X.2016.07.001

Wang Z., Lai Q., Hao K., 2017, The Research on Present Status of Straw Ash as High Performance Concrete Admixture, International Conference on Architectural Engineering and Civil Engineering, DOI: 10.2991/aece-16.2017.9

Yuan X.L., Li B.X., Cui G., Zhao S., Zhou M., 2010, Effect of fly ash and early strength agent on durability of concrete exposed to the cyclic sulfate environment, Journal of Wuhan University of Technology (Materials Science Edition), 25(6), 1065-1069, DOI: 10.1007/s11595-010-0151-7

Zhang J., Han Z., Wang L., Deng P., Zhang W., Jin L., 2009, The study on the effect of compound of the crack-resistance waterproofing agent and mineral admixtures to concrete chloride-ion-diffusion-coefficient, Journal of Shenyang Jianzhu University, 25(5), 948-953.

Zhang J., Zhang W., Deng P., Han Z., Wu X., Zhu L., 2009, Study on chloride-ion-diffusion-coefficient of concrete mixed admixture, early strength agent after freeze-thaw cycling, Journal of Shenyang Jianzhu University, 25(1), 143-147.