

Experimental Study on Influence of Slurry Concentration on Gel Time of Double Liquid Grouting Material

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Abstract. The selection of cement slurry with different consistency and different concentrations of Sodium silicate, design and test research on the mixture ratio of cement-Sodium silicate grouting material, 4 W/C and 4⁰Bé co design 16 groups of proportion, through the collation and analysis of experimental data, obtained the relationship of mud-water slurry concentration influencing on cement-Sodium silicate double liquid grouting material's gel time.

Introduction

With the progress of the society, the development of science and the wide spread and application of grouting equipment and technology, in foundation reinforcement, the formulation composition, construction technology and using performance of grouting material have been greatly developed and improved. Cement-Sodium silicate grouting material in this research (i.e. C-S double liquid grouting material) is one of the advanced grouting materials commonly used in building foundation reinforcement engineering. It uses cement, Sodium silicate as the main agent (if necessary, adding additives), will both proportionally and respectively pump mixed, then injection of grouting process of formation.

Test Materials and Equipment

Raw Materials. The main test parameters of raw materials used in this project and its basic properties (Table 1).

Table 1 Raw materials

Name of the raw materials	Manufacturers	Performance parameters of raw materials
P·O 42.5 cement	Zhangjiakou jinyu cement co., LTD	3d: $f_{tm}=5.0\text{MPa}$, $f_c=23.8\text{MPa}$ 28d: $f_{tm}=8.0\text{MPa}$, $f_c=47.0\text{MPa}$
Sodium silicate	Zhangjiakou qiaoxi yongsheng chemical plant	Modulus $n=2.8$, Baume ⁰ Bé=37

Equipments. The main equipments used in this subject (Table 2).

Table 2 Equipments

Name of equipments	Specification	Manufacturer
Medical balance	HC·TP11B·10	Beijing Medical Balance Factory
Cement paste mixer	ST-160	Shenyang North Test Instrument Plant
Baume meter	⁰ Bé: 0-70, length: 23cm	Huanghua Automation Instrument Factory

Experimental Research

Test Scheme. In order to reasonably control the diffusion radius of C-S double liquid grouting slurry material, obtain good grouting plugging effect, and effectively reduce the phenomenon of clogging of pump pipe line, gel time of C-S double solution grouting slurry should be strictly controlled, the gel time is connected with the types of cement, cement slurry consistency (i.e., water cement ratio, W/C), the concentration of Sodium silicate (i.e. Baume ⁰Bé), cement and Sodium

silicate volume ratio, the types and admixture of additives and admixture and species of admixture and other factors. The subject of experimental research on mixture ratio design: select the P·O 42.5 cement, cement and Sodium silicate volume ratio is 1:1, cement slurry W/C is 0.6, 0.7, 0.8, 0.9, ⁰Bé of Sodium silicate is 21, 25, 29, 33, combine into 16 groups ratios for determination of gel time.

Experimental Data. Mixture ratio designed and gel time tested of C-S double liquid grouting material (Table 3 and table 4).

Table 3 Mixture ratio of double liquid grouting material

Serial number of mixture ratio	number of mixture ratio	Cement slurry(1000ml)		Sodium silicate(ml)
		Cement (g)	Water(ml)	
H01	C6V1.0S21+N	1100	660	1000
H02	C6V1.0S25+N	1100	660	1000
H03	C6V1.0S29+N	1100	660	1000
H04	C6V1.0S33+N	1100	660	1000
H05	C7V1.0S21+N	993	695	1000
H06	C7V1.0S25+N	993	695	1000
H07	C7V1.0S29+N	993	695	1000
H08	C7V1.0S33+N	993	695	1000
H09	C8V1.0S21+N	900	720	1000
H10	C8V1.0S25+N	900	720	1000
H11	C8V1.0S29+N	900	720	1000
H12	C8V1.0S33+N	900	720	1000
H13	C9V1.0S21+N	850	765	1000
H14	C9V1.0S25+N	850	765	1000
H15	C9V1.0S29+N	850	765	1000
H16	C9V1.0S33+N	850	765	1000

Description: meaning of symbols in the number of mixture ratio in the follow:

C--indicate the cement slurry;

6, 7, 8, 9--indicate the cement slurry water cement ratio, that is, W/C are 0.6, 0.7, 0.8, 0.9;

V1.0--indicate the volume of Sodium silicate was 1 time cement slurry;

S--indicate Sodium silicate;

21, 25, 29, 33--indicate the Baume of Sodium silicate, that is ⁰Bé are 21, 25, 29, 33;

N--indicate do not add additive and admixture.

Table 4 Gel time of double liquid grouting material

Serial number of mixture ratio	Number of mixture ratio	Gelation time t(s)	Serial number of mixture	Number of mixture ratio	Gelation time t(s)
H01	C6V1.0S21+N	57	H09	C8V1.0S21+N	50
H02	C6V1.0S25+N	54	H10	C8V1.0S25+N	52
H03	C6V1.0S29+N	39	H11	C8V1.0S29+N	55
H04	C6V1.0S33+N	67	H12	C8V1.0S33+N	37
H05	C7V1.0S21+N	48	H13	C9V1.0S21+N	57
H06	C7V1.0S25+N	47	H14	C9V1.0S25+N	56
H07	C7V1.0S29+N	33	H15	C9V1.0S29+N	47
H08	C7V1.0S33+N	61	H16	C9V1.0S33+N	57

Data Analysis

Analysis of Gel Time of C-S Double Liquid Grouting Material. According to data of C-S double liquid grouting material of gel time in table 4, the influence diagram of water cement ratio and the Baume degree of grouting materials on gel time can be respectively made(Fig.1 and Fig.2).

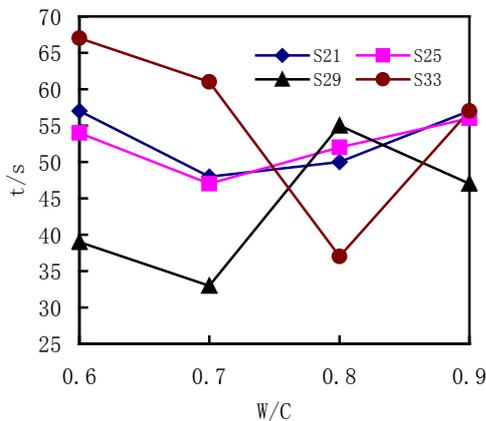


Fig.1 Influence of W/C on the Gel time with different ⁰Bé

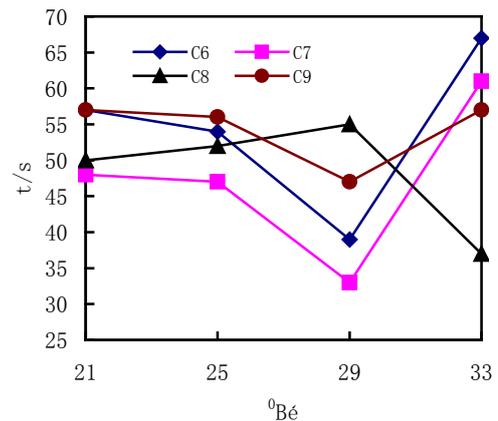


Fig.2 Influence of ⁰Bé on the Gel time with different W/C

The analysis from fig.1: when the Sodium silicate slurry of ⁰Bé are 21 and 25, the gel time of C-S double liquid grouting material along with the increase of cement slurry W/C presents basically stable trend; when the Sodium silicate slurry of ⁰Bé are 29 and 33, the gel time of C-S double liquid grouting material along with the increase of cement slurry W/C, shows the phenomenon of larger change and not obvious change rule, but still in range of requirement of setting time of the double liquid grouting material used in the project.

The analysis from fig.2: when the cement slurry W/C are 0.6, 0.7 and 0.9, the gel time of C-S double liquid grouting materials with the increase of the Sodium silicate grouting Baume ⁰Bé presents firstly decreasing and then increasing; when the cement slurry W/C is 0.8, the gel time of C-S double liquid grouting material with the increase of the Sodium silicate grouting Baume ⁰Bé presents firstly increasing and then decreasing, that is, when the water cement ratio is 0.8, the gel time shows the opposite rule.

Analysis of C-S Double Liquid Grouting Material's Technology Economy. The cement has wide source and low price, the high compressive strength of cement stone, good permeability

performance, simple process and equipment, convenient operation etc.. Sodium silicate slurry is rich in resources, low price, less pollution, good groutability, with many new curing agent, properties of Sodium silicate seriflux have been improved, is a kind of promising slurry. C-S double liquid grouting material in the prerequisite of having cement slurry single liquid grouting material's basic advantages, overcome the single liquid grouting cement slurry gel time is long and not easy to control, low rate of stone; and make the biggest play of cement-Sodium silicate two grouting material, improve the effect of grouting and the quality of the project ; in construction foundation reinforcement ,water-glass cement volume ratio is 1:1 for use and can save a large amount of cement, further reduce the cost; besides, in recent years, C-S double liquid grouting technology is constantly improving, perfecting and advancing in engineering practice, so its construction equipments and technology are quite mature.

Conclusion and Prospect

Based on the measurement and comparative analysis of C-S double liquid grouting material of gel time, can be clearly found: the incorporation of Sodium Silicate in cement slurry can effectively short and control the gel time of grouting material; and low Baume mixed into cement slurry (i.e. $^{\circ}\text{Bé}$ 21 and 25) more easily control the stability of the grouting material than high Baume(i.e. $^{\circ}\text{Bé}$ 29 and 33) Sodium silicate.

Considering the current grouting material's environmental issues, such as shortcomings of poor durability and so on, seek the injectability, strong permeability, cheap price and convenient construction of green new grouting material will be the leading direction of grouting materials in the future.

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