

# QCE-Series Single Liquid Grout

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## ABSTRACT

The application of single liquid cement for fracture grouting in base rock may have history more than 120 years. The disadvantage of it is difficult to increase the grouting efficiency, because the jelling time of it is very long and hard to control. The double liquid grout, such as chemical grouts and cement water glass grout was developed at the end of 1960's. Although the jelling time of this kind of grout can be controlled, it must adopt double liquid grouting technology, use complicated equipment and is not easy to control component's ratio of the grout. Another disadvantage for chemical grout is high price, and have pollution to environment.

QCE series single liquid grout is the effective grout material developed recently by making large efforts in China. Main feature of it is that the jelling time is easy to control, materials from cement and clay are very cheap and without pollution to environment, and the grout can be injected by single liquid technology.

The effect of QCE-series grout has been proven by its application in China. It can be believed that QCE grout has great economic efficiency and will give a push to develop grout material.

## PRINCIPLE AND FEATURE

Main components of QCE series single liquid grout are cement and clay or cement together with clay. The additive agents are A, S, H, or together with each other. Each of them can be mixed with main components to produce a grout in the series products, as QCE-A, QC-A, QCE-S, QC-S, QE-S etc. The favourable grout can be made easily by means of mixing the main components with one additive agent or more than one

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additive agent together and provided with common features as following.

- 1, Jelling time of grout can be controlled smoothly from ten minutes to several hours according to partical requirement;
- 2, Compared with doudle liquid grout, the grout can be injected by single liquid technology, the equipments used are simple and easy to operate;
- 3, The compressive strength is 5-10 MPa in normal case. It can meet the need of sealing off water and consolidation for fractures in the base rock;
- 4, The consolidation ratio of QCE grout is more 10-20% higher than that of ordinary single liquid grout, in some cases it can reach up to 100%;
- 5, It is more safe than that grout using chemical material as additive agent, QCE grout have no poison and pollution to ground water and environment
- 6, Low price and rich in resource.

#### GROUT SPECIFICATION

Based on the method used at present in China, the specifications of QCE series single liquid grout have inspected as following;

##### 1, Specific gravity:

Several densities of grout were made on the bases of different water cement ratio. The cement called here is the cement or clay plus additive agent with certain ratio. The specific gravity of the grout was detected by the meter of mudspecific gravity. By testing QC-S grout for example, the fig. 1 was plotted which expresses the relationship between the grout density and specific gravity, and can be represented by the formula as follows;

$$d_g = 1 + 2 / (1 + 3w/c)$$

$d_g$ -specific gravity of grout

$w/c$ -water cement ratio.

##### 2, Viscosity

The viscosity of the grout have inspected by the viscosity meter. The additive agent H was put into the cement with certain ratio. The fig.2 is the relationship between the viscosity and additive agent H under the constant water-cement ratio. It shows that the visco<sup>s</sup>ity change is not evident with increasing additive agent H.

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### 3, Consolidation ratio

The consolidation ratio is a very important specification for grout material, it represents the grout efficiency that is to the meaning to fill up the fracture in base rock, the better the grouting efficiency, the consumption of the grout and the engineering cost.

The consolidation ratio of QCE single liquid grout is increased by 10-20%, as compared with ordinary single liquid grout. In the case of increasing the additive agent up to 30%, the consolidation ratio can reach up to 100% shown in fig.3.

### 4, Jelling time

To control the jelling time of the grout is also a very important, which involves with the success and failure of a certain grouting engineering project. So large efforts have been taken at lab. so as to verify the jelling time for each product of QCE series grout. The jelling time measured is the time when grout begin to jell based on normal test method. The fig.4 is the relationship between the jelling time and used quantity of the additive agent which was plotted by testing QC-H grout. The range of the jelling time can be adjusted smoothly by using quantity of the additive agent. The requirement of the time begin to jell for an ordinary single liquid grout is not less than 30 minutes, 1-2 hours in optimum cases. From the fig.4 it is shown evidently that there will be a instantaneous change process when the additive agent is occupied the range of 15-25% that is an optimum range to make up prescription for a certain grouting construction project.

### 5, Mechanical strength

The mechanical features of the consolidation body for each period with making up different prescription have detected including shearing strength and compressive strength. Three kinds of consolidation body as sample that were 1 day, 3 days, 28 days after the grout jelled have tested. Fig.5 is the relationship between the compressive strength and used quantity of the additive agent, the sample was from the QC-A grout consolidated 28 days later. It is shown evidently that the compressive strength will be decreased with increasing used quantity of the additive agent, because using more additive agent is the meaning of high consolidation ratio and more water inside of consolidation body. The minimum value is larger than 2 MPa which can meet needs of engineering requirements.

## APPLICATION EXAMPLES

1, Main water bearing strata at Yunjaoling is at section of top sand, 210.62-222.37 m in depth, most part of the strata are silicon sand with gray colour and crack developed,

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hydro-static pressure was up to 1.8 MPa. When sinking vertical shaft to the 207 m in depth water inrush with 240m /h happened. So advance-grouting at working face were taken so to sealing off the water from the fracture.

According to grouting design, 8 grouting holes were drilled and injected by QC-S grout with end pressure 8.4 MPa. water inrush was blocked up thoroughly by injecting grout 141 m , and shaft sinking was passed through this water bearing strata successfully. The average consumption of the grout for shaft each meter was equal to 12 m . In the course of grouting construction hard and dense consolidation body have verified from the rock core.

2, When shaft sinking at Pucheng coal mine was down to the 148 m in depth, water inrush with 60 m /h from the sand and gravel happened. According to the grouting design, the advance-grouting were carried on to inject the QC-H grout into 7 grouting holes, the end grouting pressure was 3 MPa. Total number of grout injected was 110 m , the consumption of cement was 57.2 T and 17.21 T for H additive agent. The remains of water inrush was than 4 m /h, so sinking shaft was passing through the water bearing strata easily.

3, Heyang coal mine could not put into operation after finishing the construction of main shaft, because water inrush from the shaft wall was up to 43 m /h. The main section of water inrush was at 80.02-94.65 m in depth. In order to sealing off ground water in this place three technical steps have adopted. The first step was to produce a curtain of insulating water. The distance of it was two meters both from above and below water bearing strata. The second step was to drill holes at the place where water leaked from the shaft wall and to inject 78.64 m CS grout for consolidation of shaft wall and making preparation for sealing off water; The third step was to drill deep holes into rock strata. In order to sealing off water, the fractures which had water inside of it were injected by 15.56 m QC-H grout. After finishing the technical measures mentioned above the water inrush in the shaft was decreased to the 2 m /h.

#### SUMMARY

Through analyzing the research work at lab and test in site. it has proven that QCE series single liquid grout is a favorable and effective grouting material. The main agents of it are cement and clay which have low cost and rich in resource. The grout can be injected by single liquid technology, and the jelling time can be adjusted precisely. So this kind of grouting material may be considered as a tendency to develop. Compared with other grouting material the advantages of QCE grout are evident not only at technology, but also at economy, it should make effects to spread its application.

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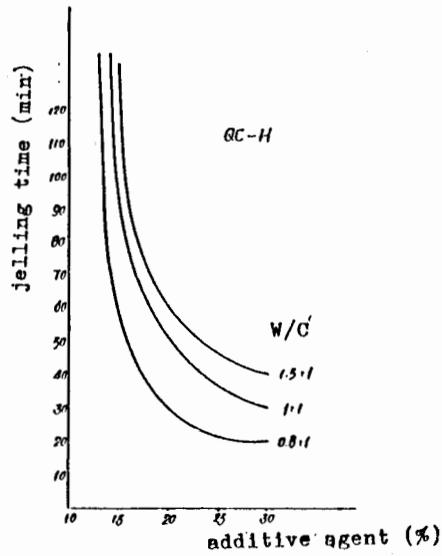


Fig.4 The relationship between the jelling time and additive agent

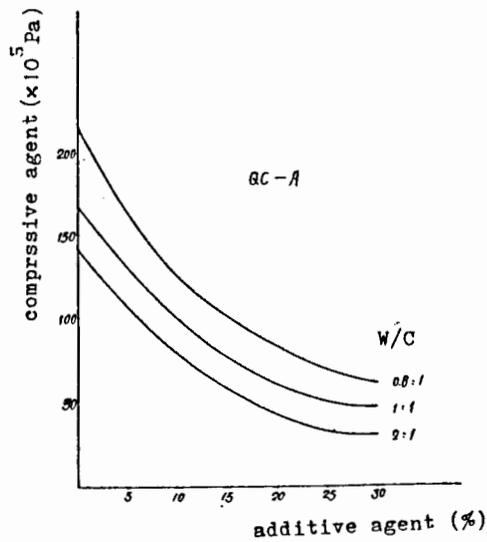


Fig.5 The relationship between the compressive strength and additive agent

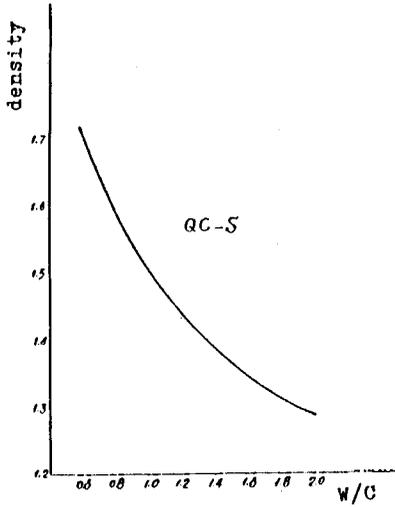


Fig.1 The relationship between the grout density and specific gravity

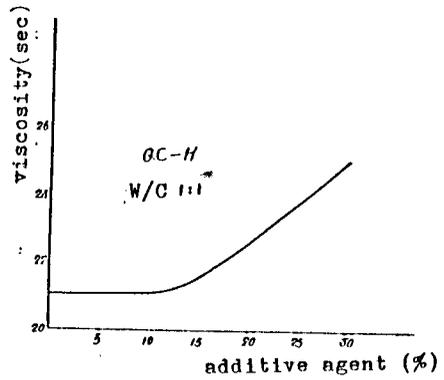


Fig.2 The relationship between the viscosity and additive agent

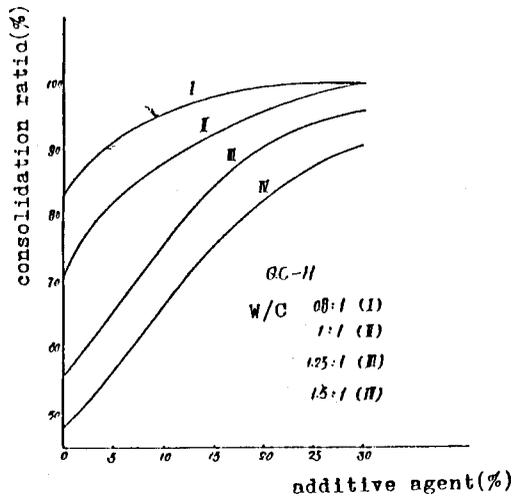


Fig.3 The relationship between the consolidation ratio and additive agent