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A STUDY OF PRETREATMENT GROUTING TECHNOLOGY AT WORKING FACE IN AN AUXILIARY SHAFT OF HUANGHUAI COAL MINE

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Abstract

This paper deals with a pretreatment grouting technology used in an auxiliary shaft sinking which sunk through a soft-broken and water-bearing stratum and a test result obtained from the sinking. Through a pretreatment with chemical agents, it has an obvious function on the quantity increasement of grout injected and it plays a good role to make a use of pretreatment, what are the suitable parameters for a pretreatment, what is density and quantity of pretreatment material and what is the result of the pretreatment, are detailly described in this paper. The grouting equipments and materials used in the application are briefly presented in the paper.

Preface

An auxiliary shaft with concrete lining at Huanghuai Coal Mine is 371m in depth and 5.2m in diameter. A water inrush of 16.3m^3 per hour bursted when the operation of shaft sinking was down to 194.2m in depth, and in the course of time the average water inflow of the shaft incresed up to 70m^3/h and the max.inflow was up to 101m^3/h.

Although emergency pumping inflow was lasted about a month the construction of excavation and lining had to stop, because the monthly advance only was 3.3m and heavy water inrush occured the collapse. So it was decided that pregrouting measure at working face must be taken for sealing off water inflow.

The scheduled grouting section of the shaft was a loosened rock stratum with rich water bearing. Total section is 40m in high with scope from 196.7m down to 236.7m in depth.

Based on the geological and hydrogeological condition the loosened stratum is made up of carbon iferous mud-stone, silt mud-stone and igneous rock intrusion. It appears as powder, sandy and angula gravel. Andesitic porphyrite intruded into grouting section irregularly which is called as white mud stratum has the

proporty of plasticity, water solubility and less strength, and the number of seams was up to 2--3.

During the drilling grouting hole it frequently occured the outbursting fragment, cave-in and shrink of the hole. The water inflow from hole normally was 20--30m^3/h. It is estimated that the water inflow of the shaft at grouting section was 110m^3/h.

Pregrouting at such complicated stratum mentioned above mainly deals with two problems: one is sealing off water from the fissures and fracture, another is consolidating the loosened stratum and andesitic porphyrite to increase mass strength and stability of surrounding rock and form a reliable grouting curtain for safe and successful shaft sinking.

In the early stage the cement grouts were made use of blocking up fissures and fractures filling up the space formed by outbursting fragment. Although it has been played a good role in sealing off water and consolidating loosened stratum, the outbursting fragment, cave-in and shrink of hole still exist when inflow is heavy.

In order to excavate at working face continously in this situation two schemes can be chosen: one is using chemical agents, the disadvantage of it is high cost and will produce the pollution to environment; another is by means of the conventional particulate grouts with modifying grouting technology. That is a method of pretreatment-high pressure grouting which can increase the quantity of cement-grout injected and its permeability, and will appear as some chemical characteristics, so as to block up the fine fissure and consolidate the loosened stratum for creating a good condition for shaft sinking.

It has been proven that the efficiency is not only to consolidate the surrounding rock but also to cut off the water inflow. The results from practical measurement have shown that the max. water inflow was 15.21m^3/h. The efficiency of cut-off water was up to 86.2%, so the study of pretreatment-high pressure grouting technology at Huanghuai Coal Mine is successful and have obtained rich experience.

Pretreatment Technology

The water glass were undertaken for pretreatment at loosened stratum, the reason is that water glass injected into ground will form a very thin film on the surface of nature fissure and fracture, it plays a lubrication role for particulate cement grout which can reduce the flow resistance and increase the quantity of cement injected;another one is water glass having good permeability, so the injectability of cement grout at loosened stratum are increased.

In the course of consolidation and dehydration, the grout so-

lution permeated out will react with water glass and consolidate together. It is obviously that grout pretreatment by means of water glass can be increased reinforcement range of cement grout and improved the consolidation efficiency at loosened stratum.

Table.1 shows that through the pretreatment the quantity of cement grout injected into ground is more 1.3--13.8 time than that without pretreatment.

Tab.1 Contrast of quantity injected into hole between the pretreatment and without pretreatment

Grouting hole				Comment
number (No)	depth (m)	inflow (m^3/h)	cement grout (T)	
5	22.8	1.95	0.9	without pretreatment little injected
5	27.8	3.25	12.45	pretreatment
11	40	25.33	2.0	without pretreatment little injected
11	40	3.24	11	pretreatment
13	40	8.55	2.0	without pretreatment little injected
13	40	1.05	5.5	pretreatment
21	60	12.20	2.0	without pretreatment little injected
21	60	1.2	3.6	pretreatment
Note: zero level = 196.7m in depth				

Pretreatment procedure

Pretreatment procedure has four steps. The operation must be performed continously one step by next step, there is no gap between them, otherwise it might be appeared pressure leakage and cave-in hole, and produced grouting difficulty.

Pretreatment condition

The condition might be as follow:
1. hole's water inflow less than $10m^3/h$;
2. the fragment and andesition porphyrite rushed out from hole;
3. it's difficulty to drill grouting hole due to cave-in and shrink, if water inflow which comes from fissure and fracture is larger than pretreatment is normally not considered.

Pretreatment parameter

The major pretreatment parameters are as follow:
1. grouting pressure;
2. grouting flow;
3. quantity of water glass injected;
4. concentration of water glass.

Fig.1 is an example for hole No.26 which pretreatment were undertaken at all individual grouting section. There are three curves on it. The curve 1 shows the relationship between pressure (Pw1) and flow (Qw1) when water injected into hole at first time, the curve 2 explains the relationship between the pressure (Ps) and flow (Qs) when the water glass injected into the hole. The curve 3 represents the relationship between the pressure (Pw2) and flow (Qw2) when water injected into hole at second time. As Fig.1 if Pw1 = Pw2, then Qw1< Qw2, that is to say, if the grouting pressure keeps constance the water flow at second time is larger than that at first time. In other words, if water flow keeps constance the pressure which water injected into hole at second time is less than at first time, in formula if Qw1 = Qw2, then Pw2< Pw1.

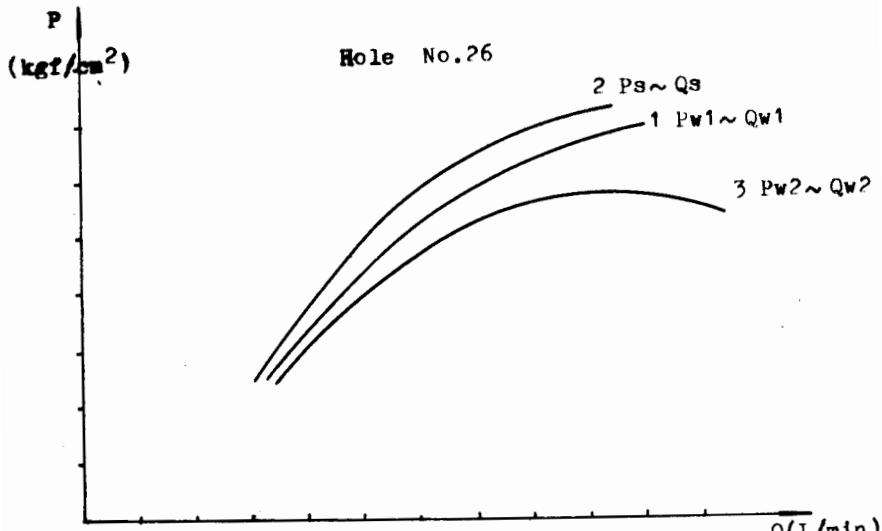

Fig.1 P Vs Q

It's proven that water glass injected into ground has a lubrication function to reduce the ground resistance, it also gives the answer on theory why the quantity of cement grout injected can be increased by using pretreatment.

The various concentration of water glass which has adopted

in practice is varied from 20 to 45Be', and there is an optimum scope.

High pressure grouting technology

During pregrouting at working face of Huanghuai Coal Mine when the condition was suitable the pretreatment was considered as a necessary program. The major pregrouting parameters are as follow:

1. pressure P;
2. flow Q;
3. quantity of injected Cq;
4. water-cement ratio.

The analysis of grouting parameter is mainly to study the variation of P,Q and Cq and relationship between them.

At the auxiliary shaft of Huanghuai Coal Mine,26 holes were carried out the technology of pregrouting, total number of pregrouting times were over 173. Throughout the data from the grouting operation. It's difficult to find two data which are equal, but by plotting the curves of pressure (P) vs grouting time (T) and flow Qvs T, the relationship between the parameter of P,Q,Cq. Fig.2 is an example for the level 196.7m in depth below. There are two curves on it which also can explain grouting situation ,in other section and hole.The curve of Q vs T shows that the tendency for the grouting pressure is to arise slowly veried with grouting time, at last increase up to the end pressure. The curve of Q vs T shows that with the increase of grouting time the flow arise slowly to the max. value. then decrease quickly to zero. The area of section drawing below the curve of Q vs T represents the quantity of grouts injected,Cq, The Fig.3 shows the relationship between P and Q, which is similar to parabola. With the increase of the P, the Q increases up to the max. value, then decreases to the zero. The variation tendency of three curves on Fig.2 and Fig.3 indicates the proporty of high pressure grouting, after grouted pretreatment by water glass the cement grout is ease to permeate due to flow resistance decreased. In the early grouting stage, the pressure raises with increasing flow, at the time when the fissure and fracture have filled up, the flow became decreasingly which caused the expulsion of water from grouts. In the end of stage the pressure is up to end value, at the same time the flow is down to end value zero. The end pressure taken by high grouting technology is usually bigger than that of grouting to fissure. In a general way the end pressure used by fissure-grouting is 80--85kgf/cm^2, but the end pressure is about 1.375--1.412 times than that of the fissure grouting. This is the reason why we call it as high pressure grouting by this kind of technology, the grouting flow is lower . That can make cement-grouts slowly and uniformly permeated at loosened stratum and increase the quantity of grouts injected and it's permeable scope.

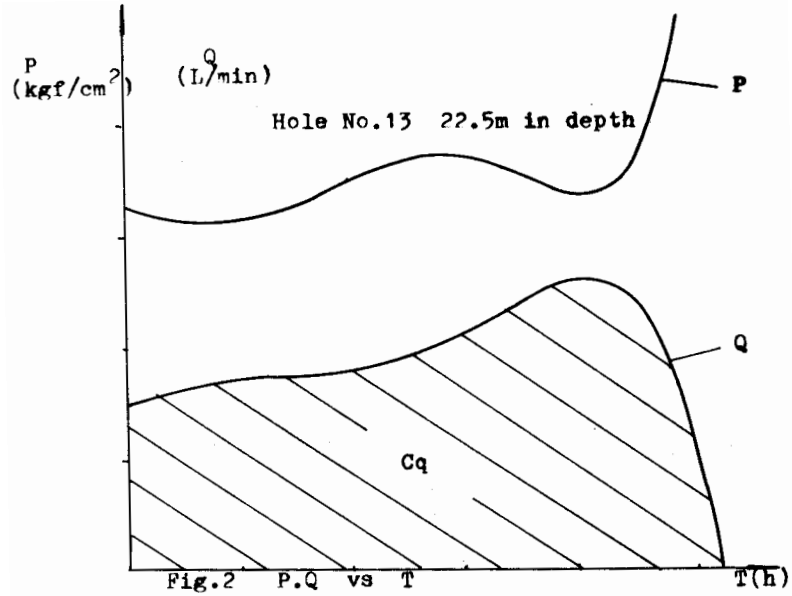

Fig.2 P.Q vs T

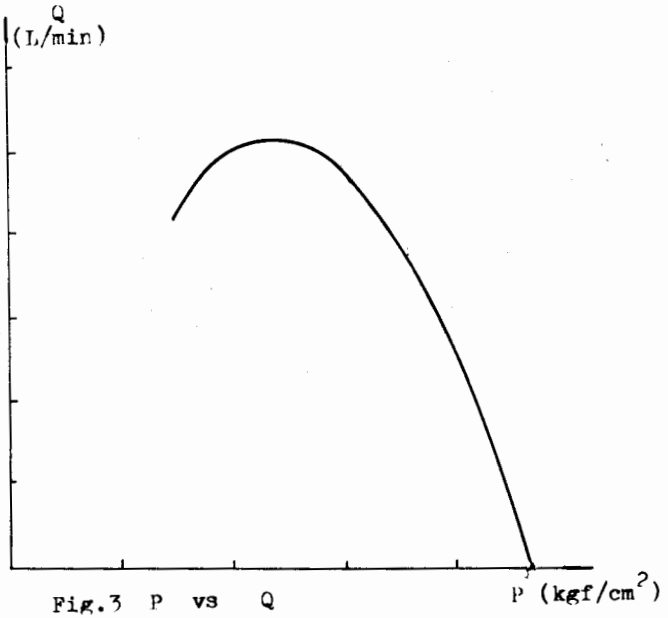

Fig.3 P vs Q

The control of quantity injected is to produce a grouting curtain with necessary thickness, parameters of P,Q and Cq are supplemented each other, every parameter must accorded with its own scheduled requirements so as to ensure the quality and efficiency. Another parameter is water-cement ratio which is one of the important measure to make P,Q and Cq accorded with design requirement, the scope of water-cement ratio used in practical vary from 3:1 to 0.8:1, 3:1--1.25 in general case.

Other's technical measures

1. Model TXU 300-2A drill-rig was undertaken to drill grouting holes, because the machine has sufficient capacity of torque and lifting and high reliablity.

2. Model HFV-C hydrualic grouting pump which has pressure of 30--130kgf/cm^2 and flow of 0--200L/min, attach a data log for recording the parameter of P and Q automatically, the piston of machine has stroke of 300mm long and reciprocating times are 0--27 per minute, and the hydrualic system incorporated a protecting device as well.

3. Section high is usually 5m at loosened stratum which can expend up to 10m, but in the case of outbursting fragment and cave-in hole the section high must be decreased.

4. The number of hole was increased from 18 scheduled to 26, the number of holes by this method is more than that by fissure grouting.

5. When the operation of drilling holes appears outbursting fragment the sequence of drilling hole must adjusted in time, in other words it must stop the operation instead of drilling and grouting hole in another place.

Observation

The observations were carried out at the time when shaft excavation was performed again.

Consolidated results:

After pretreatment the decayed andesitic porphyrite has become consolidated and dehydrated, compactness, having no-plasticity and no-collapse, the loosened stratum which appeared as powder, sandy, angular gravel before the grouting has consolidated together with cement-grouts water-glass and the grout permeated but not very strong. The interface between the layers of rock has been filled with grouts which appears as distribution of strip, bend and lens-like. For most parts of rock fissure were filled up, the mass strength and stability of the surrounding rock were increased greatly.