Hydrogeological Testing in Underground Holes during Grouting

By JU. N. SPICHACK[1]

S T G Specialized Association
7a Petrovski St., Antratsit
Voroshilovgrad Region, USSR

ABSTRACT

The paper describes major principals in hydrodynamic testing of horizontal and inclined boreholes using flowmetering and pressure build-up techniques while tunnelling and driving permanent workings through water bearing rock and faulted zones. A number of case histories is given together with the description of technical means and special equipment.

INTRODUCTION

Quality and reliability of grouting programs accomplished during drifting under severe hydrogeological conditions depend much on the scope and accuracy of data on every aquifer intersected during drivage including the depth of water bearing zones and their thickness, water pressure head, conductivity and permeability factors, fracture voidage, fissuring nature, volumetric elasticity factor, ground water chemical content, potential water make into a future opening. The STG Company has developed and introduced on a broad scale innovated equipment and methods of hydrodynamic testing for horizontal and inclined pilot, grout or proving holes to provide the acquisition of the above mentioned data with regard to the strata to be treated by grouting. The information obtained during borehole testing forms the basis for engineering analysis of the entire grouting design, i.e. from the size of grout covers around an underground excavation up to the number and arrangement of grout injection holes, grout quantity and injection regimes.

TECHNICAL MEANS FOR FLOWMETERING

The DAU-3M-G flowmeter designed by the STG Company (Fig.1) is very often used for testing horizontal or inclined boreholes. The probe consists of a 73 mm steel pipe casing which incorporates a two-blade impeller. The impeller rotates on supports within the casing. Free rotation of the impeller is provided by an adjusting screw and centering device. The flowmeter is run down the hole on drill pipes to which it is fastened via a sleeve and adjustor. The casing has an aperture for armoured cabling that connects the probe and battery. The logging cable connecting the probe and control panel is fastened inside the sleeve and is sealed by rubber O-rings. To protect the impeller from rock particles a protective screen is screwed at the end of the flowmeter. The instrument has openings in the casing for outflow of liquid. The instrument enables measurings of downhole flow in the range of 0.01 to 2×10^{-2} cu. m/s at hydrostatic pressure head of up to 12 MPa. The error of measurements is not more than 1%.

FLOWMETERING INVESTIGATIONS

Flow of liquid within a borehole is obligatory for carrying out flowmetering tests. Flowmetering is executed when a stable discharge from boreholes is obtained. The testing can be carried out both while running the instrument downhole and in reverse order. The borehole collar has to be equipped with a shutter and preventer, and the standpipe should be grouted to take care of a possible inrush (See Fig.1). On the intersection of a water bearing crack or karst void water comes into the flowmeter casing through special openings. The flow of liquid forces the impeller to rotate at a velocity that is proportional to the discharge of liquid. The speed of rotation is displayed on the control panel.

The above mentioned testing scheme allows to define the depth and thickness of water bearing zones, rock fissuring nature, amount and direction of water overflow between fractured zones.

PRESSURE BUILD-UP TESTING

In carrying out pressure build-up tests the pipeline for grout injection from the ground surface is used. The piping comes from the manifold unit of grouting machinery via a mine shaft to the face of a tunnel. Using adjustors and flanges the pipeline is connected to the borehole standpipe that accomodates a shutter and pressure gauge.

Pressure build-up testing is conducted on the completion of flowmetering tests both by pressurizing the hole with water or without it. If a pressurizing scheme is employed, water is pumped into the hole at a constant rate. The period of pumping-in has to be equal or over the time for the pressure to build up. On the completion of injection the recovery of water level is measured with an electric levelmeter. The latter is lowered from the surface through injection pipeline that has been disconnected at the shaft collar. Every aquifer is tested separately when it has been drilled through.

Pressure build-up testing can be accomplished also without pressurizing the hole. For this purpose the shutter at the borehole collar is opened when the pipeline is connected to the standpipe. The pressure gauge readings are used to monitor pressure recovery in a tested aquifer. To obtain more accurate pressure recovery diagrams for a given fractured zone, the tests are carried out at three different regimes by controlling the pressure at the borehole collar. This can be done by changing the pressure at the collar with the shutter and measuring the rate of water yield. Obtained pressure recovery diagrams are used to calculate permeability parameters of the aquifer.

If several holes have been drilled, during testing of one of them all others are shut and equipped with pressure gauges. When stable discharge and pressure is obtained in the hole under test, pressure reading are monitored in all other holes.

This testing technique allows to define filtration factor, hydrostatic pressure head, hydraulic conductivity factor, elastic capacity and potential inflow into the tunnel.

TESTING IN FAULT ZONES

Major water in the zones of tectonic faults filled with unstable loose ground and coarse rock material is encountered, as a rule, in intensively fractured zones adjacent to the faults. Carrying-out of flowmetering tests in boreholes drilled through fault zones is difficult due to constant discharge of broken material from the hole which disturbs normal functioning of the impeller. To avoid these complications the borehole during flowmetering is cased with filters in the zone of disturbed rock. Pressure build-up testing during the intersection of fault zones is executed according to the above mentioned procedures. To determine permeability parameters of fault zones it is recommended to use integration method.

CONCLUSIONS

The methods of hydrogeological testing in underground holes described above allow to define with sufficient accuracy for practical objectives filtration properties and fracturing nature of rock to be grouted in the course of horizontal openings. The data obtained during testing can provide comprehensive and reliable information for grouting program design and control of designed parameters during drivage and tunnelling under complex mining and geological conditions.

REFERENCES

1. Kipko E.Ja., Lushnikova O.Ju., Spichack Ju.N. Raskhodomer dlya issledovaniya podzemnikh skvazhin. (Flowmeter for testing underground holes). 1978, Stroitelstvo predpriyatiy ugolnoi promyshlennosti, Moscow, vol.8, p.5-7.

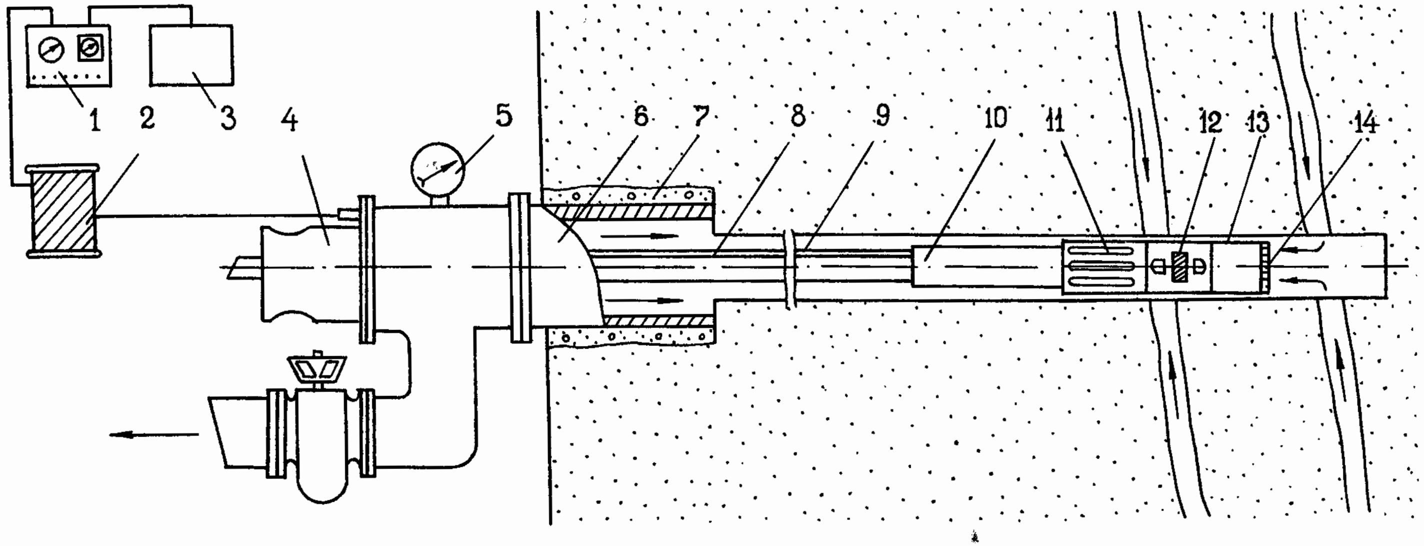

Fig. 1 Arrangement and device for hydrodynamic testing in underground holes

1-control panel, 2-winch, 3-battery, 4- preventor, 5-pressure gauge, 6-standpipe, 7-cemented layer, 8-logging cable, 9-drill pipes, 10-adjustor, 11-slots, 12-impeller, 13-casing, 14-protective screen