Creative Grouting Method Used in Blocking Water Inflow in a Shaft Wall

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Abstract In 2010, a carelessly designed project undergoing in a coalmine broke up a hole of one square meter big on the shaft wall. Because of its location at the pebble layer of alluvial strata, large volume and high speed water inflow made it extremely difficult to stop water using traditional methods. In view of this circumstance, we customized a bag to fit the size and shape of the hole and injected grouting materials in the pre-formed bag. Using this creative method, we successfully decreased over 90% water inflow so that the coal mine could resume production.

Key Words Grouting, Groundwater

Introduction

The coalmine discussed in this paper is located in a small town close to Jiyuan, Henan. Its auxiliary shaft is 120 meters in depth and 4 meters in diameter. The shaft wall was built with 240mm thick clay bricks. This mine could not run at its full capacity due to leaking water from the shaft wall. The water inflow rate ranged from 30 to 40 cubic meters per hour (m^3/h). During 2010 National Day holiday, in order to decrease leaking volume, the management invited one constructional force to grout behind the shaft wall. However, the constructional force drilled through the wall at the depth of 60 meters in the pebble layer of alluvial strata without making sufficient precautious work. Water under 5MPa pressure gushed out of the hole at an amount of 40 m^3/h initially, and soon reached 400 m^3/h before laying down the grouting pipes. Spouting water continuously enlarged the hole until it became 0.7 meter long and 0.5 meter wide. Along with the destruction of wall, pebbles and gravels were flushed into the well. The largest ones were about 0.4 cubic meter big. The whole shaft was at the edge of collapse.

After the incident, the management temporarily blocked the destructed area with a steel board, which was 1 × 1 meter in length and width, 4mm in thickness, and was shaped to the curve of shaft wall. It was fastened by two screw rods that were pushed against it. The board was welded with 2 aqueducts, which were 152 mm in diameter. Flange plates were welded on the aqueducts. After installation, most water flowed out of the aqueducts. The balance squeezed out from gaps between the board and the wall.

In order to prevent the well from flooding, the whole mine stopped extraction. Meanwhile, to keep water level from rising up further, extra pumps ran to discharge water from the shaft. Following Jiahong, Jie, and Lanyun (1998), grout-blocking water method was taken during the same time.

Preparation before Grouting

In order to solve the problem successfully and permanently, we took the following steps:

Construct Work Platform

The temporary work platform was built up on the cage hoist. The cage was stabilized one meter below the gusting point and covered with wood boards.

Strengthen the Steel Board

Even though the board was supported by the screw rods, however, due to the large amount of gusting water, it was under pressure and not in stable conditions. In order to assure that the board could stand the high pressure during grouting process, we strengthen it by two well rings with back board. The rings were made of #20 U-steel, shaped into a curve. Three U-steels pieced up a circle. Its diameter was 200 mm smaller than the shaft net diameters. Each two pieces were overlapped by 400mm and pin-fastened.

These two rings were placed on the up and bottom edges of the board separately and provided extra support to the board. We also put 50 mm thick wooden boards against some part of the wall that was not covered by the steel board and insert wooden wedges wherever needed so that the board and the surrounding area could be strengthened at the same time.

Strengthen the Clay Brick Wall

Clay bricks were of low intensity and could not stand the high pressure in the grouting process. Therefore, we added two more well rings above (below) the upper (lower) well ring at a space of one meter between each. Same method using wooden boards and wedges was applied between rings. By taking all these measures, we strengthened five-meter high brick walls both above and below the gusting point.

Drill Drain Holes

We drilled six drain holes above and below the well ring, which was one meter above the board. There were drain pipes 50 mm in diameter and 500 mm in length installed in the holes. The pipes with high-pressure ball valves stuck out of the wall for 200 mm and were bound together by galvanized wire.

Grouting Process

Due to the large volume of gusting water, only one of the two 19 cm valves on the board could be turned off. If both valves were turned off, large amount of water would flow out of the gaps between the board and the brick wall. In that case, nobody could stand on the working platform because the board would lose stability.

Initially, we tried traditional methods, such as grouting cement-water glass double liquid, adding in cement anchoring agent, and blocking with cotton yarn and wooden wedges as introduced in Jiahong *et al.* (1997), Yang and Li (2009), and Yang and Wang (2005). However, due to the large volume of water, none of the above method could create an enclosed grouting environment, hence all failed.

We tested cement-water glass double liquid quenching slurry (CGDLQS) as well. It didn’t work either. The problem was that the slurry could not stand in the flooding channel because of the large volume, high speed gusting water. It was pushed out whenever injected.

In view of this circumstance, we did hydrogeological analysis similar to Sui *et al.* (2011) and all other careful studies. Based on the result, we designed a creative grouting method – bag-grouting. More specifically, we first fabricated a bag in similar shape and size to the broken area (The recommended material is high intensity parachute fabrics or nylon thin clothes with good air permeability). The bag had a long neck like opening for grouting as shown in Figure 1.

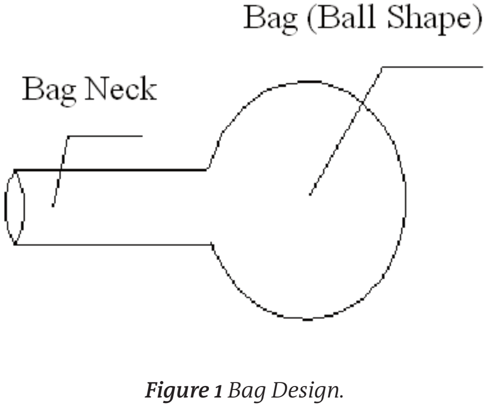

Figure 1 *Bag Design.*

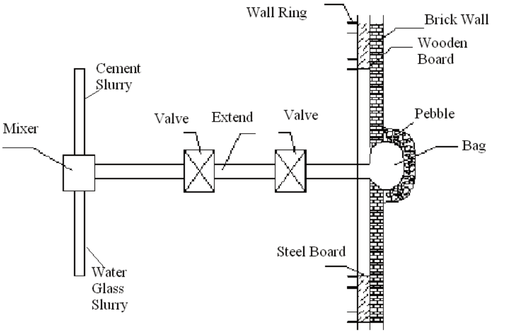

Figure 2 *Grouting Illustration.*

Before grouting, as shown in Figure 2, we first extended each aqueduct with one short pipe which was equipped with one more valve. The bag was placed between the original and the new values before shutting off the original one. It was fastened on the flange plate with screw bolts. The new valve was connected with a grouting system.

After all preparations were done, we quickly injected large volume of cement-water glass double liquid quenching slurry into the bag, which was blown up like a balloon. The slurry inflated the bag and pushed it against the broken area. The grouting amount and pressure was well controlled so that the inflated bag could make an almost complete contact with wall bricks. The steel board prevented the bag from moving into the well. After five minutes grouting, the bag was full and double liquid slurry solidified. All slurry was kept inside the bag. The sudden block of flooding channel caused the water spouted out of those six drain pipes.

After blocking the major gusting water, the drain pipes should not be turned off immediately. It was the time to drill new holes and grout more slurry between the gaps of the bag and pebbles. The drain pipes released some pressure, which made grouting easier. CGDLQS was injected into cracks through two drilled holes. After all cracks were filled up, then we blocked drain pipes one after another using CGDLQS. Valves were turned off whenever the slurry was seen. After all valves were shut off, the pressure returned to 3MPa. The whole process finished up.

Conclusion

We were invited to handle the emergency. Based on our experience and the field condition, we worked out a new bag grouting method. It worked unexpected great. The complete grouting process was in ten days, nine days for preparation and one day grouting. Before grouting, water spouted at 400 m^3/h. After that, no water leakage was found, which meant 100% successful.

This is a typical case how we solve coal mine water problems using our years of experience in grout-blocking water in a short period of time. The management highly appreciated our work.

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