PREDRAINAGE METHODS FOR TUNNEL DEWATERING

Robert G. Lenz, Moretrench American Corporation

STATE OF THE ART

Tunnel dewatering, as it is practiced in the United States today, is partly art and partly science. Although removal of free water from a heading or from unlined stretches of a tunnel has always been a necessary chore in tunneling work, improved dewatering equipment and techniques today have made partial or complete predrainage of soils a relatively common occurrence in tunneling operations. The purpose of a tunnel dewatering program may be any one of the following:

1. To lower the water level so that the static compressed air pressure required to conduct mining operations is within acceptable contractual or physical limits;
2. To lower the water level to within reasonable distances of impervious layers so that the quantity of water and the pressure under which it flows into the heading do not have an adverse effect on the soils and the mining operation; and
3. To lower the water level below the invert of the tunnel to eliminate interior pumping and maximize the stability of soils in the heading.

Predrainage methods that achieve these objectives may be performed either from within the tunnel or from the surface, depending on soil characteristics, surface conditions, and tunnel size and design.

Water has been a problem in tunneling work since the beginning of tunneling activity. Probably the ancients, with more patience than the modern tunnel contractor, made better use of the principle that the tunnel itself may be the best predrainage device and that mining techniques and time can do much for depressing the water table during the course of the tunneling work.

One of the first recorded engineering efforts in which the movement of water in soils was understood and methods of accomplishing predrainage were analyzed was with the Kilsby Railroad Tunnel in England, which was constructed in the 1830s. In that project a pocket of "quicksand" 365.8 m (1200 ft) long was encountered, and this treacherous material was stabilized by pumping from a series of shafts and bore holes, most of which were in the tunnel.

Until the mid-1920s, tunnel dewatering involved crude pumping equipment, and fantastic results were frequently obtained by use of gravel, salt hay, french drains, spiling, sandbags, and other breasting methods and techniques. In 1925 the well point became a commercial tool and, although limited in tunnel applications because of suction lift restrictions, provided a basis for applying predrainage concepts to tunneling work.

In the late 1930s, 1940s, and 1950s, the new science of soil mechanics was applied to tunnel dewatering. For the first time, a scientific basis for predicting dewatering results was available. This new science, along with the advent of the ejector well point, the tremendous improvement in deep well construction techniques, and the practical development of the submersible electric pumps, tremendously improved our ability to predrain soils for tunnel construction.

In most tunnel dewatering applications, the choice of dewatering systems comes down to the ejector well point or the deep well installed from the surface to effect partial or complete removal of water. The choice of the dewatering tool revolves around the quantities of water to be pumped and the necessity for closely spaced pickup points.

Wells have an application in which large quantities of water can be removed from relatively few locations with a reasonably predictable and dependable result between wells. Ejectors are used where communication in the soils from one dewatering device to another (or to the tunnel) is limited or constrained, or where aquifers are rather thin or where horizontal flows would occur over the top of impervious layers at the level of the heading.

Tunnel dewatering systems should incorporate instrumentation to permit the verification of results sufficiently in advance of the tunneling operation so that any modifications to the dewatering program may be made in a timely manner without impeding progress in the tunnel. It may also be necessary to develop installation tools for dewatering equipment that will permit rapid augmentation of a dewatering system should conditions in the heading require it.

Every effort in tunnel construction has the one basic purpose of allowing the heading to be advanced in the shortest possible time cycle consistent with safety and quality. Development of various tunneling machines, breasting techniques, spoil handling methods, and so on all have the common purpose of permitting more rapid and safe progress. Tunnel dewatering has the same purpose. One difficulty in planning for dewatering is that the repetitive nature of the work is not completely consistent because there is a new variable in every shove, and that is the drainage characteristics of the soil. Therefore, the first step in tunnel dewatering is to understand the soils and their drainage characteristics and to provide the type of predrainage systems that can cope with the variation that may occur in soil drainage characteristics.

Surface pumping installation for tunnel dewatering (photo courtesy of Moretrench American Corporation).

FUTURE RESEARCH

Understanding of Soils

Basic understanding of the pertinent soils and their drainage characteristics is necessary. All too frequently it occurs that techniques are lacking for recognizing changes and variations in soils. Accurate and complete soil profiles are essential to success, particularly where the soil stratification is complex and where a major aquifer does not exist at and below the heading elevation. An understanding of the soils is essential for the making of decisions on dewatering design, construction, and evaluation.

Improvement of Installation Equipment

Future improvement of the equipment and techniques that are used to install dewatering devices, generally at significant depth and frequently under congested surface conditions, can be the means of dramatically reducing the cost of tunnel dewatering. Rotary and percussion drills and jetting equipment have all been considerably improved in recent years; however, there is room for further research in this direction.

Improvement of Dewatering Equipment

Dewatering equipment, too, has been improved in recent years. The submersible pump is a practical reality. Piping, screens, and pumps are commonly made of materials that are chosen to provide long life and good wearing characteristics under sometimes severe conditions. Techniques of hydraulic transfer of power are just entering the pumping field, and further research is warranted. Designs and equipment should be continually upgraded to improve the cost and effectiveness of tunnel dewatering.