Design of unlined and lined pressure tunnels

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Abstract:
Power tunnels are required to convey water from the power intake to a powerhouse, which may be either surface or underground. Such tunnels may begin in soil or rock and often pass through a variety of materials and geologic conditions before reaching the powerhouse. Their prime responsibility is to convey the water safely throughout the life of the project, without detrimental effect on the surroundings. Such effects may include excessive leakage from the tunnel, instability of surface soil or rock resulting from the seepage, saturation and softening of agricultural land, and pollution of groundwater and surface streams due to organic content of the tunnel water. These effects can be controlled by careful positioning of the tunnel, and by selection of the appropriate lining and treatment for the various parts of the tunnel.

It is essential to understand the geologic conditions along the tunnel alignment, relative to the hydraulic forces that will be applied during operation. Adequate investigation techniques and tests now exist that will define the geologic and geotechnical conditions. There are also appropriate materials with which to line the necessary parts of the tunnel, and to treat the material surrounding the tunnel. However it is necessary that the conditions be investigated, and that the designs be established by geologists and engineers experienced in engineering geology and applied rock mechanics.

Power tunnels are being called upon to perform under increasingly higher heads. Numerous hydroelectric plants now have heads beyond 1000 m, and projects are now reaching upwards of 1500 m. Although high head tunnels have been built in the past, such tunnels were essentially steel-lined throughout the high-head portion. Modern practice for such projects is to provide shorter steel liners, subjecting long unlined portions of the tunnels to high hydrostatic pressures. The behaviour of rock and the tunnel linings under these high hydraulic pressures is difficult to assess, and the necessary design techniques and factors of safety must be judged carefully.

In some cases, especially for high head projects, failure has occurred, even though traditional criteria for design have been met. It is apparent therefore, that these traditional criteria are not fully adequate and improved design methods are necessary. What has constituted safe practice in the past for relatively low-head projects, with such practice based on simplified or empirical design criteria, can no longer be considered acceptable.

Keywords: hydraulic jacking and uplift; in situ stress; Recommended factors of safety; Head loss; Leakage control; Stability; Steel lined section; Internal pressure; External pressure; Grouting; Debris traps; Plugs; Watering/Unwatering.