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BEHAVIOR AND THE MECHANISM OF WATER LEAKAGE OF CANYON TUNNEL AT KIRIWANELIYA

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Introduction

The Canyon Tunnel, diverting water from Canyon Reservoir to the New Laxapana Powerhouse has created a major leakage at Kiriwaneliya area several years after its commissioning. The leakage which remained insignificant at early stages has grown to a critical stage at present. Occurrence of several major leakage outlets in the area shows that the amount and the intensity of the leakage is significantly high (Figure 1).

Identification of behavior and the mechanism of the leakage has become prime importance to prevent any major catastrophic event and also to take remedial actions to minimize the loss of water.

On a request made by the Ceylon Electricity Board (CEB), the current study was undertaken to determine the behavior, mechanism and the potential risk factors of the Canyon Tunnel leakage at Kiriwaneliya area.

Materials and Methods

A multidisciplinary and stepwise approach was used to detect the potential leakage flow paths in the area. All the leakage outlets and general geomorphological features were identified during the reconnaissance field visit. A series of detailed hydrochemical tests were done for the water samples collected from the Canyon Reservoir, individual leakage outlets, Surge Chamber of the tunnel and the tailrace of the New Laxapana Powerhouse. Physical and chemical parameters such as temperature, pH, electrical conductivity and concentrations of dominant cations and anions were analyzed during the hydro chemical test.

A detailed geological mapping program was carried out to trace the lithological and structural variations present in the study area. After that, a flow rate monitoring was done to detect the flow rates of leakage water in the area. A high frequency GPR survey was conducted at the valve house area (where a large number of leakage springs come out) to detect the existing sub-surface geological conditions using 100 MHz GPR antennas.

Results of an artificial tracer test and the results of a resistivity survey performed during a previous study were also used to draw conclusions in the present study. Finally presence of six major fault zones along the Canyon Tunnel route was identified using available geological maps, topographical maps and satellite images.

Results and Discussion

Eight major leakage outlets and several minor outlets were identified in the area where the tunnel muck has been dumped. Most of the chemical and physical parameters measured helped to conclude the similarity between the Canyon Tunnel water and the leakage waters in the area. Temperature, pH, conductivity and concentrations of different ions such as Ca^{+2}, Mg^{+2}, Na^{+}, K^{+} and Cl^{-} well correlate the similarity of the tunnel water and the leakage waters (Figure 2).

Solid geology of the area also revealed that the presence of major structural features within the charnockite bedrock facilitate the flow of water through the subsurface discontinuities. Artificial tracer test data (of a previous study) has been used to conclude that the leakage is taking place along the section of the tunnel upstream of the surge chamber.

The results of the GPR survey has contributed to conclude the presence of permeable zones in the leakage outlet area (area filled with tunnel muck) that was confirmed by the previous resistivity survey data.

According to the GPR and the resistivity surveys these permeable zones are located around 6 to 12 m depth from the soil surface at the Valve House area (Figure 3). Occurrence of the fault zone categorized as fault zone 6 along which the Seegra Oya flows was very well observed on the satellite images. The place where the tunnel cross over this fault zone can be the most probable ingress areas for the leakage outlets observed at Kiriwaneliya area.

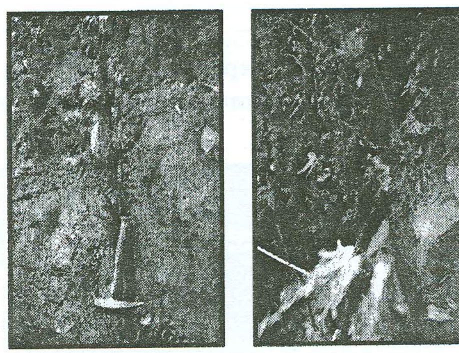

Figure 1. Some of the leakage outlets emerging out from the cliff behind the valve house of the Canyon Tunnel

Table 1. Water sampling locations

Name	Location
Tunnel Intake	L1
Surge Chamber	L2
Leakage Outlet 1	L3
Leakage Outlet 2	L4
Leakage Outlet 3	L5
Leakage Outlet 4	L6
Leakage Outlet 5	L7
Leakage Outlet 6	L8
Leakage Outlet 7	L9
Leakage Outlet 8	L10
Seegra Oya	L11
Tailrace of the Powerplant	L12

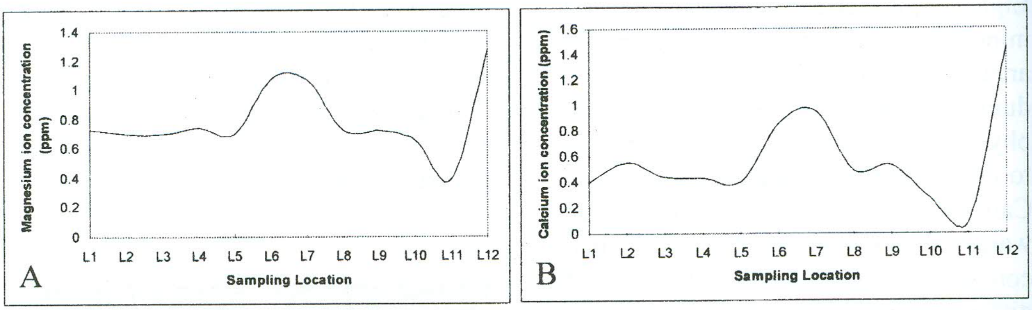

Figure 2. The graph of A.) Magnesium ion concentration at each sampling location B.) Calcium ion concentration at each sampling location

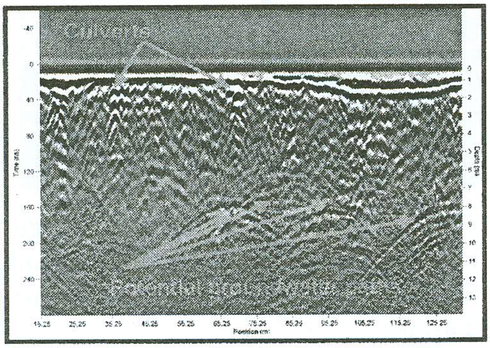

Figure 3. GPR profile diagram showing potential permeable areas

Conclusions

It was concluded that the ingress zones of tunnel leakage exist along a section of the tunnel upstream of the surge chamber where it cross cut the fault zone 6. Considering all geotechnical, geological and structural conditions of the Canyon Tunnel and the sub surface conditions at Kiriwaneliya area, it is strongly recommended to seal the discontinuities on the tunnel walls specifically between the distance 500 m – 600 m (just upstream of the surge chamber) by appropriate remedial measures (most suitably concrete plugging, grouting or shotcreting) after controlled dewatering of the tunnel.

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