Prognostication of Unconfirmity Intersection at Tunnel Grade for 43.93 km Long Tunnel by Geoelectrical Survey

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Abstract

A 43.93Km long tunnel (Tunnel-1) with a finished diameter of 9.2m is being constructed by two tunnel boring machines (TBM) as part of the SLBC Tunnel Scheme of AMRP. During detailed mapping along the alignment in the preconstruction stage, the unconformity between the Archaean basement granites and quartzites of the Srisailam formation was identified. For further investigation to prognosticate its intersection at tunnel grade Geoelectrical survey comprising of deep Vertical Electrical Sounding (VES) of 250m depth was conducted at 200m interval for a length of 1 Km between Ch.28.1 Km and Ch.29.1 Km along the tunnel alignment. The study showed that the dip of the unconformity is 2.4o which is close to the formation dip in the area and the unconformity is prognosticated to intersect at tunnel grade at Ch.21.358Km. In this scenario, the Tunnel -1 will be driven 48.62 % of its length in quartzites from inlet end and the remaining reach of 51.38% in granites from exit end.

Introduction

The Srisailam Left Bank Canal Tunnel scheme (SLBC) of Alimineti Madhava Reddy Project (AMRP) consists of construction of two tunnels of length 43.93 Km and 7.121 Km (Fig.1), interconnected by Link Canal - 1, Dindi Balancing Reservoir and Link Canal - 2. Tunnel-1 has a finished diameter of 9.2 m with a circular cross section. It will be bored by TBM. Tunnel - 2 has a horse shoe shape with diameter 8.758 m. It will be excavated by Drill Blast and Muck (DBM) method. The Tunnel - 1 is aligned in N2° 13' 47.45"at entrance for a straight length of 2.466Km followed by a curve of radius of 10 Km and 2.0599 Km long arc. A 3.151 Km long tangent is followed by a 2.3736 Km long and 10 Km radius second curve. Thereafter it is a straight alignment for a length of 33.8792 Km with bearing N 4° 1' 37.87". This scheme is executed by Irrigation and CAD Department under the "JALYAGNAM" programme of the Government of Andhra Pradesh. Construction work of the two tunnels is executed by M/s Jaiprakash Associates Ltd as an EPC contract.

Scope

During surface mapping along the alignment (Jaypee Ventures Ltd 2007, 2006), a need was felt for a better prognosis of the unconfirmity intersection (GSI Note 2006) at tunnel grade between the Archean granites and Srisailam quartzites. As the tunnel alignment is passing through the "Rajiv Gandhi Tiger Sanctuary and Reserved Forest" exhaustive core drilling required for detailed exploration was not permitted.

Hence a detailed geo-electrical survey was conducted to estimate geological discontinuities up to 250 m depth, within the stretch of 1 Km from Ch.28.1 Km to Ch.29.1 Km along the alignment of Tunnel-1. The area was identified during surface mapping.

Location and Area

The study area is located at about 2 Km north -west of Tirumalapur Village, Amrabad Mandal, Mahaboobnagar District, Andhra Pradesh.

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Geology and Geomorphology of the Area

The area of investigation is a flat topped hill with the surface covered with red murram soil. Granites are exposed on the leeward side of the plateau where the contact between the two formations is exposed. The Srisailam Quartzites occur as cap rocks over the Archean granites.

These granites are grey in color, inequigranular and exhibit porphyritic texture. The Quartzites on the other hand are medium bedded with near horizontal dips towards south.

Methods

Vertical electrical sounding (ves)

To have a continuous resistivity observation up to a maximum depth of 250 m from the surface, Vertical Electrical Soundings were conducted at 5 specified locations. The sub-surface geological formations up to the depth of investigation were inferred based on the true resistivity values obtained through Vertical Electrical Sounding.

The Schlumberger method of Vertical Electrical Sounding (VES) has been used in the present study. In this method an array of four electrodes, A & B two outer current electrodes, M & N two inner potential electrodes are pegged into the ground on either side at equidistance from the point of observation. The electrode separation is so chosen that AB is always larger than MN as shown in Fig. 2. Required strength of current is sent through the current electrodes A & B. The potential difference created between M & N is measured. In-order to record variation in resistivity at various depths at the point of study, the distance between the electrode spacing is progressively increased. The apparent resistivity, which is inverse of the potential difference is estimated and is plotted against the ratio of the electrode separation in a coordinate graph to arrive at true resistivity values. The depth wise true

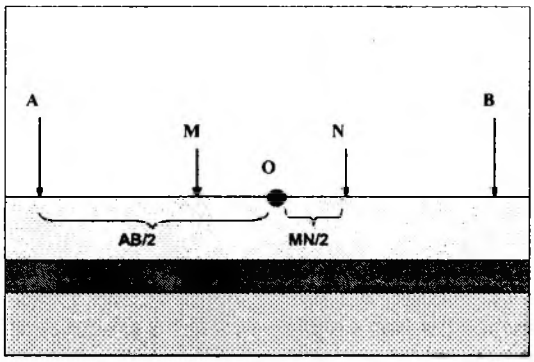

Fig. 1: Layout Plan of SLBC Project

resistivity values are graphically interpreted by "Inverse Slope Method" to find out individual thickness and depth of individual layers. The aerial distribution of these units is plotted through subsurface geo-electrical correlation using "Geo-graphics" software.

VES was conducted at a distance interval of 200 m at 5 locations to have layer wise information about the subsurface geological formations and the data was collected up to a maximum depth of 250 m from the surface in a stretch of 1 Km.

Results and Discussion

The collected data was analyzed and interpreted. The interpretation indicates that the older granite formation may have a zone of weathered rock which might have developed before the formation of quartzite body on it. Similarly the features such as fracturing and bedding planes within the quartzite may have greater influence on the resistivity of quartzite than the granite body which helps in identification of quartzite's vertical extension and the extent of zone of contact between the two formations.

Based on the interpreted results, it was observed that the fractured quartzite and the fractured granites have nearly the same resistivities. A layer of very high resistivity values is present between two low resistivity zones and it exists with progressively increasing depth from Ch.29.100 Km to Ch.28.100 Km. This may be because of the sudden change from one formation to other,

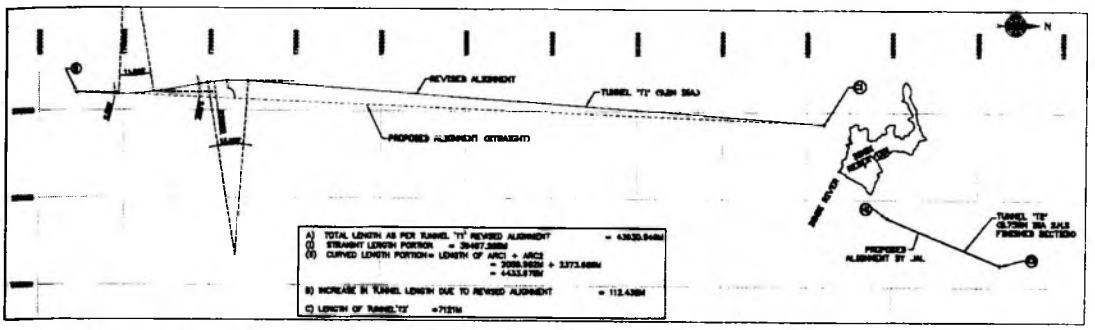

Fig. 1: Layout plan of the srisailam left bank canal tunnel scehme (SLBC)

i.e. from quartzite to basement granite. Based on this, the line of contact was generated and is shown in Fig.3. This line of contact has been inferred as the unconformity and a subsurface map has been prepared based on the litholog inferred from electrical resistivity test (ERT).

Fig.3 shows that the depth of unconformity varies as given in table1 and the dip values have been accordingly worked out.

It can be seen that the dip of the unconformity varies from 1.7° to 3.09°, after ignoring the dip of 0.38° which is unreasonably low for this area. The average dip of the unconformity works out to 2.4° and this has been used in the prognostication.

Accordingly Fig.1 shows the revised geological section of the tunnel based on geoelectrical survey along the revised alignment. This shows that the unconformity is likely to intersect the tunnel at Ch.21.358 Km at the tunnel grade.

Table 1.

Ch.(KM)	Depth of unconfirmity (m)	Dip
28.1	70	3.09°
28.3	40	1.7°
28.5	20	0.38°
28.7	30	2.004°
29.1	16	

In this scenario the tunnel is likely to be bored 48.62% of its length in quartzites and 51.38% of its length in granites.

The unconformity is likely to extend for 200 m of tunnel length and accounts for 0.46% of tunnel length.

Conclusions

1. Vertical Electrical Soundings conducted at 5 locations along the alignment of

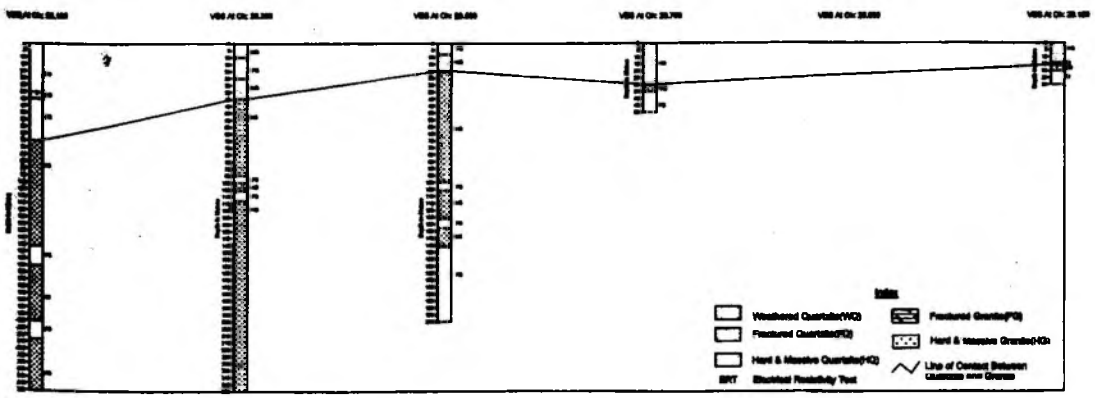

Fig. 3: Litho-logs based on ERT conducted at every 200m interval between Ch.28. 100 km and Ch.29.100 km of Tunnel-1

tunnel 1, indicate a layer of very high resistivity between two low resistivity zones and it exists with progressively increasing depth from Ch.29.100 Km to Ch.28.100 Km .This has been inferred as the unconformity between the Srisailam quartzites and Archean granites.

2. The dip of the unconformity is 2.4° which is close to the formation dip in the area. This shows that the unconformity is likely to intersect at tunnel grade at Ch.21.358 Km. In this scenario the tunnel is likely to be bored 48.62% of its length in quartzites and 51.38% of its length in granites.
3. The unconformity is likely to extend for 200 m and accounts for 0.46% of tunnel length.

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