Tunneling Experience Through Reasi Thrust (MBF) Zone For Katra – Reasi Railway Line Section (J&K)

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Abstract

The paper discusses various tunneling problems Reasi thrust zones encountered along the Jammu-Udhanpur, Srinagar - Baramilla Rail Link (JUS BRL) project. The Rail Link project passes through three major tectonic domanis viz. Muree and Siwalik zone, lesser Himalayan zone and Kashmir Tethyan zone. Reasi thrust in Main Boundary thrust. Muree thrust and Punjab thrust are major tectonic planes along the rail alignment. Besides general problems in tunnelling in weaker rocks, squeezing problems have been encountered in some reaches.

Introduction

The Jammu – Udhampur – Srinagar – Baramulla rail link (JUSBRL) project has been taken up for construction as a National Project with a total length of about 341 Kms. This line is taken up for construction from from different portions. The Jammu – Udhampur railway line section of 54 Kms consisting of 21 tunnels and 5 major bridges has been completed and commissioned during the year 2006. The Udhampur to Katra railway line section of 30 Kms consisting of 10 tunnels and 22 bridges is nearing completion. Katra to Loale of 90 Kms , Loale to Qazigund and Qazigund to Baramulla is of 47 Kms & 120 Kms respectively. These portions of railway line sections consist 65 tunnels and 70 bridges besides two special bridges is under construction partly by Konkan Railway Corporation Ltd. (Km 30 – Km 100) and partly by Ircon Ltd. (Km 100 – Km 167), as shown in fig. 1.

From Katra to Reasi, the railway alignment pass through thrust zone. Most part of tunnel – 1 and about 300 mts length of tunnel – 2 (from Katra end side) are located within thrust zone. Problems encountered during the tunneling through this zone have been described in this paper.

Regional Geological Setup

JUSBRL Project cuts across the three major tectonic domains viz. the outer Himalayas (Muree & Siwalik structural zone), the lesser Himalayan structural zone and the Kashmir Tethyan belt (Fig. 1). The M.B.F (Reasi thrust), Murree and Panjal thrusts are three major tectonic planes of regional importance which are seen along the proposed railway alignment between Udhampur – Katra – Reasi area, along Chinji Nala (Km 100.500) and Sumber – Digdole area. Beside these major thrusts, there are other local faults/thrusts which cut across the alignment or near parallel to the alignment such as Sangalkundi and Saladhar faults/thrusts etc.

(a) Outer Himalayan Belt (Bore Land Basin)

In this section the Siwalik and Muree strata are over lying buried peneplained surface of the northern fringe of the Indian shield. Lithologically these sediments constitute semiconsolidated sandstone, shales, conglomerates and clay beds. Structurally these rocks display broad anticlines and synclines e.g., Jhajjar, Surinsar, Mastgarh anticline and Udhampur syncline. A series of thrusts is a characteristic tectonic feature in the foreland strata. The most prominent

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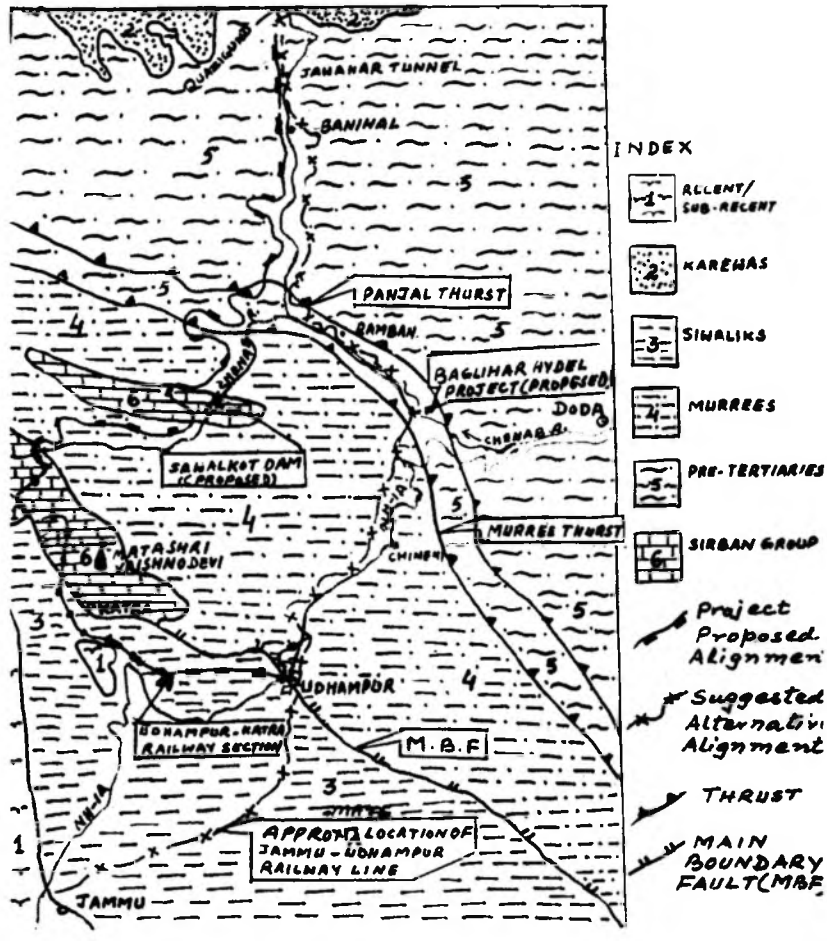


Fig. 1: Index plan showing layout of Jammu - Udhampur - Katra - quazigund railway line

among them are main boundary fault (MBF) or locally called Reasi thrust in Jammu area which delimits Siwalik from Muree and Sirbon dolomite.Railway alignment from Jammu to Udhampur and Udhampur to Sangaldan i.e., around Km 100 falls in this belt.

(b) The Lesser Himalayan Belt

It is tectonically bounded by the Muree thrust in the southern side and by the Panjal thrust in Northern side. Lithologicaliy this belt comprises mainly slates, quartzites, volcanics, phyllities and sub–ordinate metamorphic of sedimentary strata in the sector between Pira and Banihal. All tunnels i.e., from T48 to T57 fall in the lesser Himalayan belt

(c) The Tethyan Himalayan Belt

The strata representing Carboniferous to early Jurassic period, present between Banihal and Qazigund sector. The rock types include sandstone, slates, limestone, dolomite, quartzite, volcanics etc. Last tunnels i.e., from T58 to T80 including longest Banihal tunnel (T80) between Banihal and Qazigund falls in this section.

Geology along Tunnel no. 1 & 2 through Reasi thrust:

The railway alignment for most of its length from Katra to Reasi, is either located along or near to the Reasi thrust. The Reasi thrust separates the youngest Siwaliks from the overlying oldest Sirban dolomite. The width

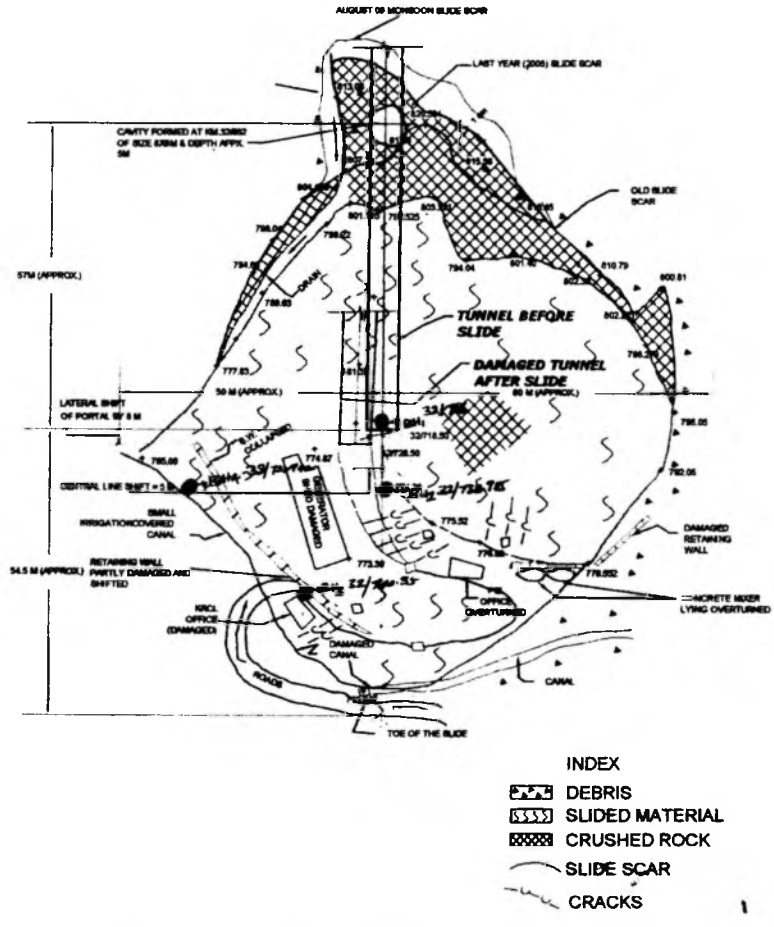


Fig. 2: Geological plan of slide area at portal P-2 (Laole end)

of Reasi thrust zone vary from 300m to 450m and mainly consisting of crushed dolomite pieces and clay gouge. The size of crushed pieces varies from sand size to 25cm but generally of small size. At places caught up outcrops of Muree rocks are also observed at places. Middle Siwalik formation consisting of sand rock with thin bands of reddish clay shale / clay stone underlie the trust zone. Above the thrust zone, closely jointed, fractured and sheared dolomite is present. General trend of the rock units and thrust zone is NW – SE to NNW – SSE and dip at 40º to 70º towards NE.

Tunnel – 1

The 2699 m long tunnel is located between Km 30.000 to Km 32.6899. The construction of this tunnel was taken up in Feb. 2004 from both ends by providing 50 m and 19.75 m long false portals towards Katra end and Reasi end, respectively.

Geological report submitted by M/S RITES in Feb. 2004 had revealed that the Reasi thrust will be intercepted in this tunnel at two reaches viz from Km 30.600 to Km 30.760 and from Km 32.160 to Km 32.560. Sandstone and Claystone was expected to encounter from Km 30.000 to Km 30.600 and from Km 32.560 to Km 32.685. In rest of the reach between Km 30.760 and Km 32.160 intensely jointed dolomite is expected limestone.

However, when tunnel excavation was taken up from Katra end it was found that highly

soft, friable and partly crushed sandstone with thin bands of claystone met around portal area. Due to heavy inflow of water it became difficult to prepare the portal face. To avoid frequent failure of rock mass at the proposed face, it was decided to construct false portal first abutting against the rock surface exposed at the slope so that steel support and concrete shall act as toe support to moving rock mass. The method multiple drifting from the face itself helped to proceed ahead. However, after some length, sand rock behaved as good tunneling media. Similarly, Reasi end portal was started after erecting about 19.75m false portal. From Reasi end also, tunnel excavation including false portal was taken through crushed dolomite (Reasi thrust zone) in place of sandstone/clay as predicted in the RITES report. However, one claystone band belonging to Muree formation was met from RD 70m to RD 130m between invert to springing level.

After encountering frequent failures of tunnel from both ends, partly detailed mapping and reconnaissance of the tunnel area was taken up and found that about 2000m tunnel length would be excavated through crushed dolomite i.e., Reasi thrust zone and remaining portion would be in Siwalik formation. Siwalik formation was though soft, friable and partly crushed but behaved as fair tunneling media. From Katra end tunnel was excavated for about a length of 425m in Siwalik formation.

The tunnel between Km 30.425 to Km 30.875 was excavated completely through dolomite scree which continued partly up to Km 30.900. The deposited material mainly consisted eroded material, partly from Siwalik and partly crushed dolomite. The scree deposits in this case behaved as good tunneling media and sometimes more than 60m progress was achieved in a month. However, at the end, dolomite scree mixed with pulverized dolomite and charged with water, started giving problems in the form of heavy over breaks and cavity formation. This slowed down the progress of the tunnel from this end. Around 875m when crushed dolomite charged with water encountered in the right half, continuous cavity formation took place upto RD 900m in the right half which consumed a lot of concrete and cement grout. For a few meters distance, crushed zone met without water which was tackled without major problem. Again water seepage took place around RD 935m and tunneling work was stopped. After creating bulk head and concreting heading face, work was suspended at RD 917m, again huge cavity formed due to heavy inflow of water (10 – 15 LPS) and work was halted. After great struggle, somehow area was tackled by providing vertical columns of different heights at places 1/3rd and keeping the 4½ dia. pipes for drainage.

An attempt was made on 09.06.2006 to open the heading face. Just after the removal of few concrete laggings provided in the left half as bulkhead , water along with muck started flowing and deposited for about 35m length between RD 900m and RD 935m at an angle of about 10º. Over this material about 2cm thick clay gouge (yellow color) was deposited. This clay gouge layer indicates the presence of crushed dolomite material consists of dolomite pieces mixed with clay gouge. With lot of efforts by forepolling with S.D.A., concreting and grouting about 13m tunnel length (heading only) was excavated between July – 06 and Dec. – 07. Within this reach, besides crushed dolomite, big dolomite boulders were also encountered. Presence of these boulders indicates that during various phases of movement loose dolomite blocks came down into thrust zone.

Squeezing Problem

Besides general tunneling problems discussed above, squeezing problem was also recorded in Siwalik rocks towards Katra end portal (P1) of the tunnel. Rock pressure developed in both sides of the tunnel. Along the left wall side pressure developed between Km 30.033 to Km 30.287 and along right wall from Km 30.044 to Km 30.204. Due to side pressure, wall beams provided between arch

and vertical columns, got twisted and pushed inside the tunnel. At some places, top & lower flanges of beam joined together. Vertical columns pushed inside the tunnel about 35cm or more. To keep the ribs intact, horizontal struts were provided but subsequently these struts too got buckled both horizontally as well as vertically.

After rectification of the damaged ribs, concrete lining was done. In the wall, some cracks were developed in the concrete and slowly 30 cm thick RCC lining buldged inside the tunnel from spring level for about 1.0 m.

From Reasi end, tunnel was excavated for a length of 236m beyond false portal with heading and benching method. During excavation, heavy over break and cavity formation took place and tunnel arches collapsed twice while benching. This side also crushed dolomite material charged with water encountered but did not stop the work for longer period since crushed material generally was made up of bigger pieces and water inflow was also less as compared to Katra end side.

However, due to heavy continuous rains during Feb. – 05, a major slide took place on 10.02.2005 which damaged the tunnel as well as false portal (photograph 1). Toe of this slide appeared at road level below KRCL office i.e., 40m down slope of portal. The slide scar along tunnel is located 67m from tunnel portal i.e., Ch. 32.618. At the start of false portal, about 1m up heaving took place. Water kul provided below the KRCL office was also uplifted and damaged. KRCL office was also got uplifted. Similarly many machines kept outside the portal got overturned and area was cracked. From the nature of the damage, the slide was classified as slump. Besides above damages, survey of the tunnel revealed that the tunnel portal was shifted horizontally by about 8m and 4m down slope side.(fig.2).

After a gap of more than 1½ years, the slope stabilization work was resumed from Reasi end and ribs for false portal were erected for a length of 31m. But due to early and heavy

Inside view of T2/PI

Inside view of T2/PI

monsoon of that year, crushed dolomite started flowing over the erected ribs and work got again suspended, which was resumed after monsoon period (photograph 2). The slope stabilization was done by providing two rows of micropiles 300mm dia. along left and right walls along the alignment of tunnel for a length of about 45m, starting 15m inside the false portal in triangular grid pattern of 2m c/c. Micropiles had reinforcement of 4 nos, 25mm dia. Tor steel and grouted with sand and cement. These micropiles was for strengthening the base i.e., consolidate the loose crushed dolomite and increase the angle of friction. Besides micropiles, 8m high reinforced walls on both sides of the false portal have been provided.

Tunnel – 2

The 5.355 Km long tunnel is located between Km 33.095 and Km 38.450. From Katra end tunnel shall be excavated through crushed dolomite i.e., through Reasi thrust zone for a length of about 320m. Thereafter, tunnel

shall be excavated through closely jointed, fractured and sheared dolomite with chert bands. This constituted about 85% of the tunnel length. Remaining 15% tunnel length shall be excavated through massive to blocky and cherty dolomite. The construction of tunnel was taken up in Oct. – 2004 with false portal of 5.25m length (from Km 33.088 to Km 33.093) from P1 side by conventional heading and benching method. Construction of tunnel from P2 side could not be taken up due to want of approach road upto the face.

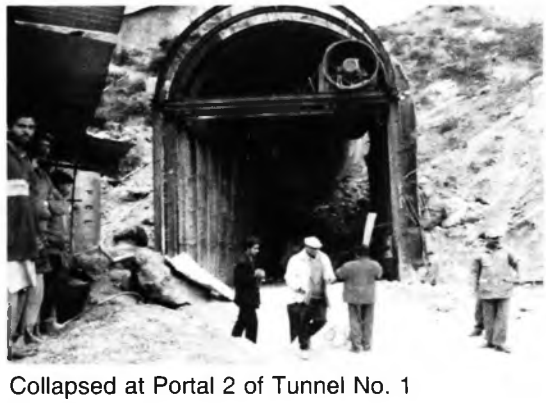
The excavation of the tunnel upto a length of 206m from false portal, did not pose much problem since thrust zone material was almost dry or occasionally some minor water seepage was noticed around SPL especially from left side. By excavating the tunnel from RD 0.00m to RD 206.00m, with multiple drift method i.e., first removal of crushed dolomite by hand/payment breaker from left side and then from right side and in the last from crown portion leaving hump in between. After the excavation of each portal of tunnel, 50mm SFRS was used and then ribs were erected. Around Km 33.299, about 1m thick purple colored crushed slaty band encountered which acted as barrier towards tunnel portal.

On 09.04.2005, when tunnel excavation reached around RD 207m (Ch. 33.300 i.e., after the removal of slaty material), minor seepage took place from the right side and shearzone material started flowing down. Within a few minutes, about 200 Cum of sheared material accumulated in front of the tunnel heading along with sudden ingress of water measuring 50 to 60 lit./sec. Flowing muck covered the tunnel face and spread in front of the face. After a gap of about 24 hrs, water got reduced to 7 to 8 lit./sec. which has been flowing till date from the various locations of the tunnel. Tunnel face was blocked by putting bulk head of muck filled bags supported by steel girders.

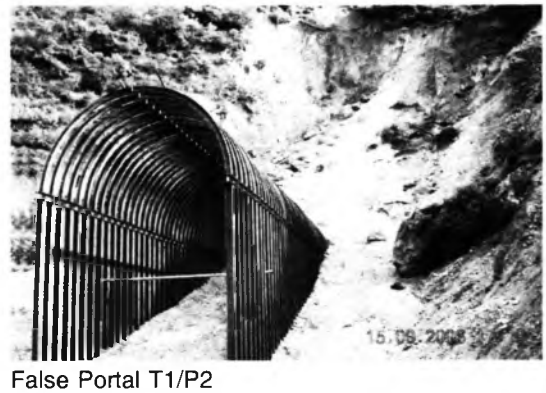
After some days, efforts were made to open Cael face with multiple drift method after consolidating loose material with grout lying in front of tunnel face and above the crown, but cement grouting did not help much. The tunnel work remained suspended between April 2005 and March 2006. During this period many Indian and Foreign experts visited this tunnel and suggested various methods to tackle the tunnel excavation. Finally it was decided to carry out Polyurethane (PU), colloidal silica, micro fine and OPC grout supported by lattice girders and shotcrete.

Methodology adopted (NATM)

Initially, the face was prepared by spraying 100mm SFRS or plain shotcrete with wire mesh to prevent loose flow. Then 50mm dia. 6m long S.D.A.'s (Self Drilling Anchors) were inserted along periphery at 250mm c/c and at inclination of 5º to 15º upwards. Total 50 to 55 no.s S.D.A. were used. Tunnel face was also consolidated by inserting 26 no.s S.D.A.'s at 1m c/c. Thereafter, crushed dolomite was consolidated by grouting through S.D.A.'s. After grouting through



Collapsed at Portal 2 of Tunnel No. 1



False Portal T1/P2

S.D.A.'s, 38mm dia. holes upto a length of 5m to 6m were drilled along periphery and tunnel face 1.5m c/c and pipes were inserted into the holes. All the drilled holes were then grouted with P.U. upto a pressure of about 150 bars until refusal, to make the 6m portion intact for excavation.

After the P.U. grout, again 8 to 10 holes were drilled at 1m to 1.50m c/c along periphery and at the face. All these holes were grouted with colloidal silica and micro fine cement till refusal.

After completing above works, tunnel face was opened with multiple drift method i.e., first crown portion, then left half and in the last right half and supported with 50mm SFRS, lattice girders and shotcrete with wire mesh (max. thickness upto 300mm). The lattice girders were placed at 250mm c/c. Out of 6m consolidated length only 4m was excavated and remaining 2m was left for overlap with new cycle.

With this methodology, only 22m tunnel heading was tackled within a period of about one year. The approximate cost of this work was coming out about one crore per meter. At present tunneling work has been suspended due to contractual problems.

Conclusions and Recommendations

The railway line between Katra and Reasi is mostly located either within thrust zone or near/along the thrust. The width of the Reasi thrust in the area varies from 300m to 450m. Reasi thrust has affected more Sirban dolomite as compared to Siwalik rocks which are soft. Thrust zone is made up of crushed dolomite with clay gouge. At places crushed and caught up Muree rocks are recovered. Crushed dolomite when charged with water starts flowing and creates cavities. Tunneling through crushed dolomite/thrust zone is costly, time consuming and difficult. Frequent cavity formation has been taken place in both the tunnels. Besides formation of cavities, at places water seepage is so high that work remained suspended for more than a year.

In view of the above problems, it is recommended that as far as possible tunneling should be kept away from thrust/ fault zone area.