International Research Journal of Earth Sciences _____ISSN 2321 – 2527
Vol. **6(12),** 22-28, December **(2018)** *Int. Res. J. Earth Sci.*

Review Paper

Geological and geotechnical challenges in road widening, national highway-44: Jammu-Udhampur-Banihal-Qazigund, J&K, India

Vinay Kumar Pandey
Consultant Geotechnical Engineer, Mumbai, MS, India
vinay78pandey@gmail.com

Available online at: www.isca.in
Received 24th September 2018, revised 10th December 2018, accepted 22nd December 2018

Abstract

Road construction in Himalaya is always challenging job. Himalaya is young mountain belt and tectonically active. National Highway-44 passes through mountain with varying topography and geological strata from Outer Himalaya to Central Himalaya. Not only geological and geomorphological structures but varying and critical climatic conditions have to tackled during the construction. Climatically area belongs to humid sub-tropical region of Jammu to temperate region of Banihal. Major geological challenges are Landslide, Hill slope, crossing of fault zones, tunnel construction and Hydro meteorological disaster. In this paper, I will discuss about the main geological challenges facing by road widening construction companies and will suggest precautionary measures for construction feasibilities.

Keywords: Geological strata, fault, thrust, landslide, slope failure, precautionary measures.

Introduction

Jammu-Udhampur-Banihal-Qazigund highway is part of Jammu-Srinagar National Highway (NH)-44 (NH-1A earlier) lifeline of Kashmir valley as well as Leh-Ladakh area. Distance between Jammu to Quazikund is 222km but normal travel time is about 7 hours due to narrow and zig zag road. Government of India (GOI) under the Ministry of Road, Transport and Highways has proposed the widening of NH-44 through National Highway Authority of India (NHAI), in view of security of border and connecting the people of Jammu and Kashmir to entire country.

Topographically area have highly variation; road elevation varies from msl 327m to 2400m (Jammu to Patnitop) and 1700m (Banihal). Road blockage due to landslide and snowfall is normal event along the highway. Climatically area belongs to humid sub-tropical region of Jammu to temperate region of Banihal. The area receives precipitation twice in year from January to March and very heavy rainfall between July and September. Average Precipitation from Jammu to Qazigund is 1500mm to 600mm. Two major rivers are flowing along this road, first Tawi (Jammu to Chenani) and second Chenab river (Peera to Ramban). Many small tributaries also crossed by NH-44.

For construction feasibility NHAI has divided whole 222 km stretch into five sections (Table-1).

Geological and Seismotectonic Setup along NH 44

Kashmir Himalaya is divided into three main physiographic divisions from south to north, the Siwalik Himalaya, the Middle Himalaya and the Greater Himalaya. The Siwalik Himalaya configures the foothills of the Himalayan Range which rise gently from the plains of Punjab and reaches an altitude of up to 2440m. The region forms a succession of narrow parallel ridges of the Tertiary rocks and is structurally bounded by the Main Boundary Thrust (MBT) in the north and the Main/Himalayan Frontal Thrust (MFT/HFT) in the south. The most prominent being the Main Boundary Thrust (MBT), Panjal Thrust (PT) or Main Central Thrust (MCT) and Zanskar Thrust[1,2]. Detailed geological setup given in Figure-1 and 2 and Table-2.

Geological Setup: The Siwalik Himalayan Belt (Foreland Basin) comprises of the Siwalik and Murree formation, which are overlying the buried surface of the northern fringe of the Indian shield. Lithologically these sediments constitute semi-consolidated to consolidated sandstones, siltstone, mudstone, shales, conglomerates and clay beds[6]. Structurally these rocks display broad anticlines and synclines[1,2,7].

A series of thrusts is a characteristic tectonic feature in the foreland strata. The most prominent among them are Main Boundary Fault (MBF) which delimits the Murree from the Siwalik strata. The Lower Murree strata display tight isoclinal folds and over folds with repeated local faults, whereas Upper Murree represents broad open type folds[1,2,7]. The outer Himalayas rise from the planes of Punjab, starting with a gentle slope from Jammu to an altitude of about 600m and then end abruptly in steep, almost perpendicular escarpments. Then, there is a section of narrow parallel ridges, separated by longitudinal valleys. These outer hills are formed entirely of Tertiary rocks like Sandstone, Mudstone and conglomerate. Range situated more inwards, and formed of older Tertiary rocks, reach higher

altitudes, about 1800m to 2450m. [Jammu to Peera Village in Nashri- Ramban road Section].

The Middle Himalayan belt is tectonically bounded by Murree thrust on the southern side and the Panjal Thrust on the northern side[2,8]. The Lesser Himalaya is composed of Late-Proterozoic metamorphosed rocks and unfossiliferous to fossiliferous Lower Paleozoic sedimentary rocks showing complex structural features such as folding and faulting. It is about 1300m thick rock sequence, with variable altitude of up to 4500m, and includes the PirPanjal Range. Lithologically this belt comprises mainly of slates, quartzites, volcanics, phyllites and subordinate metamorphic and sedimentary strata[6] in the sector between Peera to Banihal. Most of the rock types have a regional strike of NW-SE to WNW-ESE with moderate to steep dips towards the north or south[2,8].

The Greater Himalaya represents the highest mountains physiographically and comprises low to high grade metamorphic rocks like schists and gneisses and complete sequence of para-orthometamorphites with igneous intrusions of Proterozoic and younger age. [Some part of the Udhampur - Ramban road section (from Peera Village); Ramban – Banihal Road].

The lava flows are intercalated with pyroclastic material and intertrappean beds. The maximum thickness of these lava flows is up to 2300m and is well exposed in the northwestern and southwestern part, known as PirPanjal Trap. These rocks are Upper Carboniferous to Lower Permian in age.

The Tethyan Himalayan belt representing carboniferous to early Jurassic periods is the tectonic unit. The Jawahar Tunnel also lies in this sector around Banihal Pass area which transect through the Panjal Volcanics and Zewan Formation intersecting two local faults (Banihal to Qazigund Tunnel).

Seismotectonic setup: Apart from the major longitudinal thrusts i.e, the Murree Thrust and the Panjal Thrust in the study area, there are several minor transverse faults trending NNW - SSE to NNW-SSW e.g. Kistwar Thrust (KT), Kaurik Fault (KF), Ravi Tear (RT). Sundernagar Fault (SF) and tectonic lineaments[9,10]. These cut across the Murree Thrust and the Panjal Thrust at various locations in Jammu and Kashmir and Himachal Pradesh. Considering the seismotectonics, earthquake history, microseismicity and the presence of longitudinal and transverse thrust faults in the region, it is concluded that the study area is quite vulnerable to earthquakes. The Jammu and Kashmir partial comes under Seismic Zone IV and partial in zone V.

Geological and Geotechnical Challenges along NH-44

Geotechnical Investigations for widening of NH-44: For widening and avoiding of road curves as well as shorten the travel time on NH-44; topographical, geological, remote sensing and aerial imagery interpretation studies used in primary stage and finalized the road, tunnel and bridges alignment as well as basic civil construction details. Geological mapping along the project alignment was helpful in design the excavation and protection of slope, bridge foundation as well as geotechnical investigation provide the subsurface strata along the tunnel. Hydro geological and meteorological studies have done for mitigate the Highway from natural calamities such as landslide, flood, cloud burst etc. Rock burst study also preferred, as per requirement for construction of Tunnel.

Table-1: Summaries Project details from Jammu to Qazigund (NH-44)

Road Stretch	Length (km)	Tunnel	Geology/Rock strata	Geological Problem
Jammu to Udhampur	65	Including 4 Twin tube tunnels (2.77 Km)	Outer Himalaya:- Siwalik and Murree formation	Landslide, Slope failure
Udhampur to Ramban (Via Kud-Patnitop- Batote old route) consist of 3 section Udhampur to Chenani, Chenani to Nashri tunnel and Nashri to Ramban	88 km (Old alignments) 55 (as per new alignment)	One 888 m twin tunnel (Nashri to Ramban section crossing Murree thrust)	Murree and Panjal Formation Murree thrust passing in Nashri to Ramban section	Landslide, Slope failure, heavy snowfall (Kud-Patnitop- Batote)
Chenani to Nashri	12	One 9.2 km tunnel	Murree formation	Landslide, Slope failure
Ramban to Banihal	36	Six no's tunnels: - Total length 2.98 km	Panjal Formation and PirPanjal Thrust	Landslide, Slope failure and heavy snowfall
Banihal to Qazigund	15.25	One 8.45 km long twin tunnel	PirPanjal range	Heavy snow fall, landslide

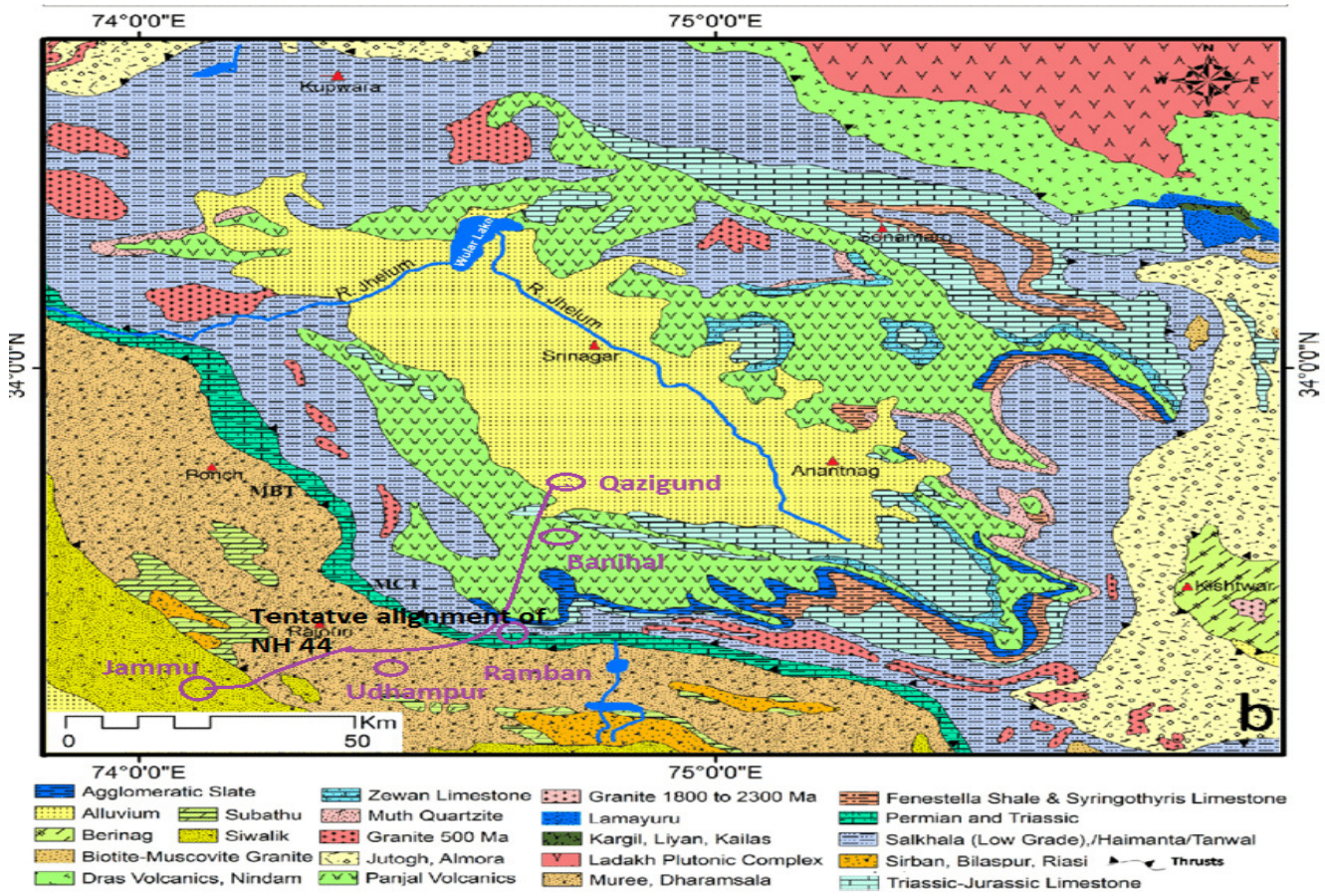

Figure-1: Geological map of Jammu and Kashmir along with tentative NH-44 alignment (Jammu to Qazigund)[3,4].

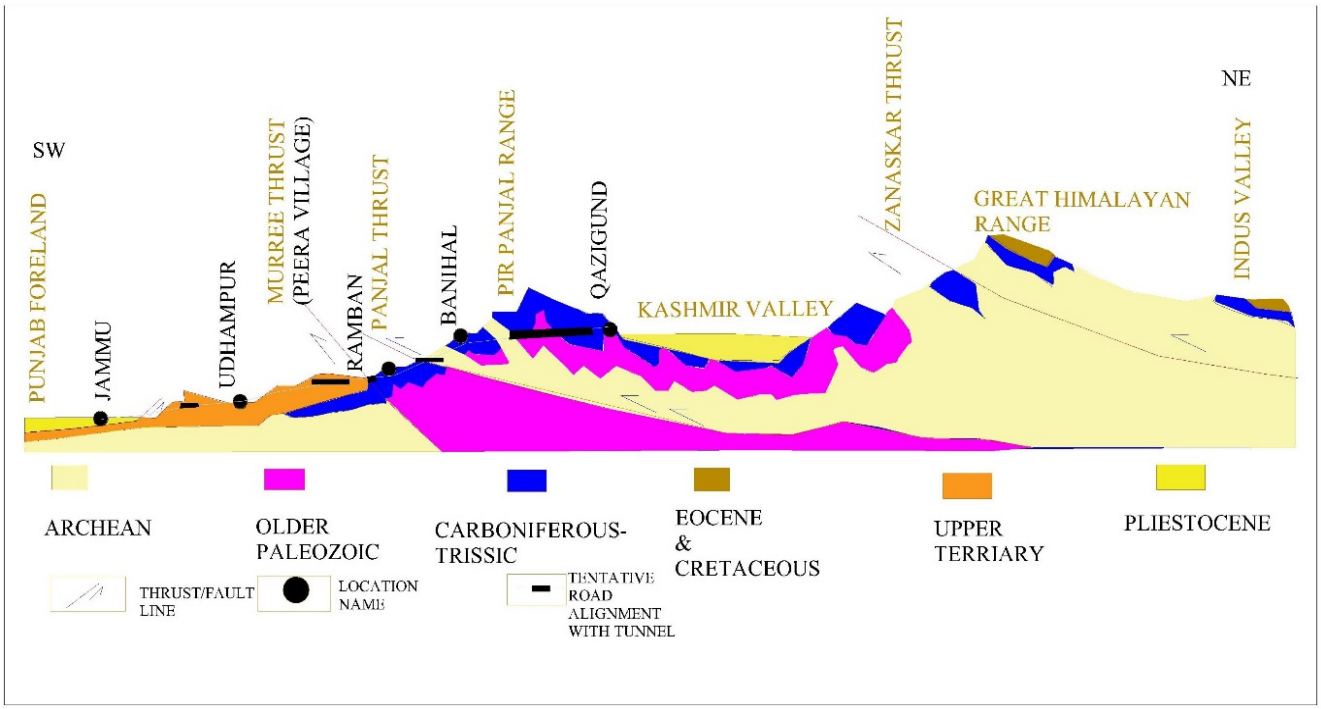

Figure-2: Geological Cross section of Jammu and Kashmir along with tentative NH-44 alignment (Jammu to Qazigund)[4,5].

Table-2: Stratigraphic Sequences from North to South direction (Qazigund to Jammu) along NH 44[6,11].

Group/Formation/Series	Lithology	Age
Karewa Formation	Conglomerates, Lignite, sand Clay, Glacial Morains, loess and Palesol.	Plio-Pleistocene
Vihi	Limestone, sandstone, Shale.	Triassic-Jurassic
Zewan	Limestone, Slate, Sandstone, Pumice and Conglomerate	Upper Permian
Panjal Volcanic (Panjal Traps and Panjal Agglomerate slates)	Shale, Quartzite, Limestone, Lava flow, Andisitic and Basaltic traps, Slates	Upper Carboniferous
Fenestella shale	Quartzite, Slate, basic Sill, Shale.	Middle Carboniferous
Ramsu Formation	Predominantly phyllities of various colors and composition	Palaeozoic
……Thrust……..		
Chamalwas Formation	Slate interbedded with thin bands of quartzite dark grey to grey greenish	Precambrian
……Unconformity…….		
Salkhala Formation	Various types of phyllites, schist gneiss and quartzite, crystalline limestone, gypsum lenses with granitoid intrusive.	Precambrian
……..Panjal Thrust……		
Rajapura (subathu) Formation	Limestone, Shale, patches of calc Paleocene-Shale over Sauni Volcanics	Palaeocene-Eocene
……Digdaul Thrust…….……..		
Dogra Formation	Alternating sequence of black slates, phyllitic slate and quartzite of varying thickness	Precambrian
……BalautFault (local)…….		
Sincha Formation	Quartzite, dolomite, limestone, phyllite, Slate	Proterozoic
……..…Murree Thrust…….		
Murree Formation	Red, brown and grey sandstone, claystone, shale, with inlier of limestone	Early Miocene to Oligocene
Siwalik Group	Sandstone, conglomerate, Mudstone	Miocene to Pliestocene

Before starting of construction activities, field geological mapping as well as various bore holes and geotechnical investigation have been done to get the engineering properties and actual subsurface strata. For verify the in-situ bearing capacity of bridge foundation; Plate load test/foot load test have performed. Apart from it; Hydro fracture test, Good man jack test, Pressure meter test, permeability test, geophysical tests have been done along the tunnel alignment. Laboratory test such as physical properties of materials, Unconfined Compressive Strength test, Point Load, Triaxial, permeability test etc. have been done on drilling core samples as well as on field soil and rock samples performed for better understanding of subsurface profile.

As NH-44 passing through outer Himalaya to Greater Himalaya, rock engineering properties and study of insitu joint orientation also considered during the preparation of geotechnical and geological report.

Geological and Geotechnical Challenges along NH-44: As NH 44 is passing through Siwalik Himalaya to Greater Himalaya, have different topography, variable hill slope, various rock conditions; creating huge construction problems. Geological problems during construction of NH-44 are broadly affected by following three factors: i. Geological and Geotechnical Factors, ii. Hydro-meteorological disaster, iii. Man Made factors.

Geological and Geotechnical Factors: As Himalaya is young mountain belt and tectonic active, various geological and geotechnical factors affect the construction of NH-44. Landslide, rock fall, ground subsidence, liquefaction, frost weathering are major natural hindrance faced by construction agencies. Apart from it; geological fault, shear zone, syncline, anticline, Seismotectonic factors playing the major role.

Landslide: Landslide along the NH-44 is normal phenomena. Several old landslide zones have observed along the existing highway. Landslide occurred due to various geological and hydrological process, combination of one or more factors which include geological, geomorphological, meteorological factors such as rainfall and snow; and the reduction of shear parameter due to an increase of pore water pressure by saturation during spells of torrential precipitation and undercutting/toe erosion by waterbodies. Rock falls occur along closely spaced and steeply dipping joints, while planar and wedge failures occur due to the intersection of adversely-oriented joint planes. Slides on the thick colluvium deposits have also observed. Colluvium deposit had made up of cobbles, boulders and Silty sand and clay sand soil which increase the chances of liquefaction in presence of water.

The most sensitive landslides zones along the highway are; Bali Landslide, Moudh, Samroli, Chenani, Nashri, Peera, Neera, Ramban, Ramsoo, Digdoul, Panthyal and Anokhifal landslide. Excavation activities for widening of NH-44 is also activating the silent/old landslide zone.

Outer Himalaya is made up of soft rock strata such as clay stone, silt stone, mud stone, lime stone, dolomite, slate and greater Himalaya comprises of weak metamorphic rock such as Phyllite, shale, schist, gneiss which are highly jointed and in presence of water, these shows liquefaction properties and landslide occurred.

Bali slide, Moudh slide, Samroli slide, Chenani slide, Nashri slide are covered with thick colluvium material and geologically synclinal structure with soft rock strata Mudstone, claystone, Silt stone. These area shows the wedge and planner failures and these are very old slide. Even starting of these slides are not documented. As in case of Nashri Slide, Geologist from Geological Survey of India at the request of the Commander, 32, Maintenance Task Force, Hq. Beacon, located at Verinag; had started the investigation works[12] in the late 50's. Nashri landslide had first documented in year 1965-66[13]. Mr R S Verma[12] observed heavy slides occurred in the month of March, soon after an abnormally heavy snowfall, which was preceded by minor earthquakes. Due to continuous sliding at Nashri location and blockage of National Highway (NH-44), government had prepared 18 km new bypass road connecting Peera village to Battot in year 1966. Sliding was continuous in this section and other researchers have also done lots of work regarding landslide in NH-1A[14-16]. But this slide is continuing activated and blocked NH time to time.

After crossing the river Chenab near the Chandrakot area, hill slope become high angle and made up of highly jointed and weathered metamorphic rock, which makes it landslide prone zone (Neera slide and Ramban Slide).

Peera slide, Digdoul slide and Ramsoo slide are situated along the tectonic active fault zone. Peera slide follows the Murree thrust (Main Boundary Thrust). Digdoul slide and Ramsoo slide are follow the Main Central Thrust (MCT) and local thrust zone. Mr R.S. Verma[12] had documents first time slide during his field visit in year 1966-67.

Digdoul slide, Ramsoo slide, Panthyal slide and Anokhifal slide are also affected by frost weathering and planner failure. Minor Earthquake would also enough for activate the slide. Earthquake capable of shacked the colluvium and weathered rock and landslide activated due to disturbance of hill slope.

Hill slope Protection: Hill slope angle is highly variable from Jammu to Banihal; from 30°-40° to vertical and again angular; covered with overburden colluvium and highly weathered rock. Rock joint orientation also unestablished the hill slope.

Hydro-meteorological Disaster: Climatically area is highly variable. During monsoon season landslide, cloud burst, flood is common and faced by local public every year. Jammu to Banihal whole area is affected by Hdro-Meteorological disaster in form of rainfall and heavy snowfall (Kud to Batote and beyond Ramban, Ramsoo, Banihal and Qazigund). For avoid

the road blockage and shortening the distance, NHAI has proposed the various tunnel. Frost weathering have an adverse influence on roads can cause serious damage to roads, leading to their break-up. Furthermore, the soil may become saturated when the ice melts, giving rise to thaw settlement and loss of bearing capacity. Repeated cycles of freezing and thawing change the structure of the soil, again reducing its bearing capacity.

Man Made Factors: Man made factors such as irrigation of agriculture land, deforestation and slope excavation for construction activities also disturbed the natural hill slope and generate temporary slide zone, sometimes activated the old landslide also. Construction of approch road, Preparation of Portal, water seepage, shear zone, rock settlement or rock bursting, vibration and noise, tunnel support system, joint orientation are major problem which likely to be faced. Sometimes actual geological condition is much differed from prediction, based on geological and geotechnical investigations. Change in rock class, water encounter, settlements are called geological surprises that affect the work progress. For long length tunnel ventilation is also an important factor. Proposed tunnel at Peera to Chandrakote will be crossed the Murree thrust and construction of tunnel in this section would be challenging.

Precautionary Measures: Precautionary measures for landslides zones which are situated along the NH-44, are different due to its originated causes. Different type of protection works applied according to geological strata and joint orientation. Step wise slope excavation, rock net, anchoring, shotcrete, retaining/breast wall, cladding wall, box type road cover, rock fall barrier, Bio-engineering methods are some important methods which may be used to protect the hill slope. Important landslide protection measures are recommended below: i. First go through the remote sensing data for identify the type of slide and its influence zone. ii. According to geological strata and geotechnical parameters of area, support system to be implemented. Such as if sliding happens due to toe erosion, protection of deep toe is important after that protect the whole slide as per bed rock condition. iii. If slide due to planner or wedge failure, protection measures to be applied from the highest and lowest point of failure. After that whole slide to be protected. iv. Stablished the soil slope by preparing the benches with create wall after the removal the loose colluvium materials and/or Bio-engineering methods to be adopted. v. Drainage hole/weep holes and diversion of water is important for free flow of pore water. vi. For smooth running of NH-44, construction agencies must avoid the sliding zone from highway. In my opinion tunnel is first best solution as per bed rock/insitu rock availability. Long span bridge is second best solution if stable foundation rock is in higher depth.

Conclusion

Widening of NH-44 is full of Geological and geotechnical challenges. Climatic and hydro metrological factors playing as catalyst in construction complications. Implementation of step wise precautionary measures will reduce the risk of landslide. Different type of issues should be tackled differently for smooth running of NH-44. Economically the protection measure cost may not be feasible at this movement but in long term about maintenance, blockage of highway and impact of day to day life; would be much cheaper.

References

1. Alam A., Ahmad S., Bhat M.S. and Ahmad B. (2015). Tectonic evolution of Kashmir basin in northwest Himalayas. *Geomorphology,* 239, 114-126.

2. Bhat M. Sultan (2017). Geomorphological Field Guide Book on Kashmir Himalaya. 9th International Conference on Geomorphology of the International Association of Geomorphologists (IAG), New Delhi (6-11 November, 2017). http://geoinfo.amu.edu.pl/sgp/LA/LA35/B4.pdf

3. Thakur V.C. and Rawat B.S. (1992). Geologic Map of Western Himalaya. Wadia Institute of Himalayan Geology, Dehra Dun, India.

4. Dar R.A., Romshoo S.A., Chandra R. and Ahmad I. (2014). Tectono-geomorphic study of the Karewa Basin of Kashmir Valley. *Journal of Asian Earth Sciences*, 92, 143-156.

5. Wadia D.N. (1976). Geology of India. *Macmillan and Co.,* London, fourth ed., 508.

6. Ravishanker (1989). Geology and Tectonics of India. *GSI. Sp. Pub*., 26, 1-60.

7. Alam A., Ahmad S., Bhat M.S. and Ahmad B. (2015). Response to the comment by Shah, A. A. (2015) and further evidence supporting the dextral strike-slip pull-apart evolution of the Kashmir basin along the central Kashmir fault (CKF). *Geomorphology,* 253, 558-563.

8. Ahmad S., Alam A., Ahmad B., Bhat M.I. and Bhat M.S. (2015). Geomorphic evidence of unrecognized Balapur fault segment in the southwest Kashmir basin of northwest Himalayas. *Geomorphology,* 250, 159-172.

9. Hussain A. and Yeats R.S. (2009). Geological setting of the 8 October 2005 Kashmir earthquake. *Journal of seismology*, 13(3), 315-325.

10. Thakur V.C., Jayangondaperumal R. and Malik M.A. (2010). Redefining Medlicott– Wadia's main boundary fault from Jhelum to Yamuna: An active fault strand of the main boundary thrust in northwest Himalaya. *Tectonophysics,* 489, 29-42.

11. Wadia D.N. (1975). Geology of India. *Tata McGraw-Hill Publishing Co*., New Delhi, 4th edition. (Tenth reprint).

12. Verma R.S. (1966). Geological report on the Landslides along the Jammu-Srinagar National Highway (1A), Jammu and Kashmir State. Geological Survey of India, Northern

region, Lucknow. *Field Season report* 1966-67.http:// www.portal.gsi.gov.in/gsiDoc/pub/NRO-JK_12925.pdf

13. Ashraf Z. and Nag R.B. (1966). A report on the detailed geological investigation of the Nashri Landslide on Jammu-Srinagar National Highway, J&K State. *(Unpublished report).* Geological Survey of India, Northern region, Lucknow.

14. Bhat G.M., Pandita S.K., Dhar B.L., Sahni A.K. and Haq Ihsan-Ul (2002). Preliminary Geotechnical Investigation of Slope Failures along Jammu-Srinagar National Highway between Batote and Banihal. Reprinted from *Aspects of Geology Environment of the Himalaya*, 275-288. http://www.scirp.org/ (S(351 jmbntvnsjt1aadkposzje))/ reference/ References Papers.aspx? ReferenceID=1417557

15. Singh Y. (2006). Geotechnical and Structural Evaluation of Tectonostratigraphic Units along the National Highway, NH-1A between Udhampur and Batote Jammu Himalaya. *(Unpublished doctoral dissertation*), University of Jammu, Jammu, India.

16. Chingkhei R.K., Shiroyleima A., Singh L.R. and Kumar A. (2013). Landslide Hazard Zonation in NH-1A in Kashmir Himayala, India. *International Journal of Geosciences*, 4, 1501-1508.