Journal of Research in Environmental Science and Toxicology Vol. 8(1) pp. 50-57, February. 2019
DOI: http:/dx.doi.org/10.14303/jrest.2019.029
Available online http://www.interesjournals.org/JREST

Full Length Review Paper

A case study of site investigation for Tunnel in North West Sub Himalayas (Pallandri area Azad Jammu and Kashmir)

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ABSTRACT

The study area is situated in the Sub-Himalayas of Azad Jammu and Kashmir in District Sudhnoti near Pallandri city. The main purpose of study is to give a research proposal to construct a short traffic tunnel project in realization Azad Jammu and Kashmir in Pakistan Himalaya and to reduce the route of cities that are located in Sudhnoti District. Untill recently, numerous hydro tunnels were leading Himalaya tunneling industry for last decades. Traffic tunnels now are being constructed with the collaboration of international contractors. The route from Islamabad to Rawalakot includes lots of mega and mini projects that are under construction. Azad pattan hydropower project, Azad Pattan landslide management and renovation of Gui Nala to Rawalakot road is one of them. Despite all these developments there is no appropriate source that could facilitate and link nearby cities and towns but this tunnel could be the reason for the mobility of people and equipment from Pallandari to Rawalakot, Azad Pattan and Islamabad. It will help urbanization and economical aspect of the region. Furthermore, this research is based on structural and stratigraphic exploration of study area. The project area is surrounded by Salt Range Thrust to the South, Jhelum Fault to the West, Riasi thrust to the East, and it lies in the south of Hazara Kashmir Syntaxes. The major folds in this area are Dhardarch Syncline, Pallandari Anticline and Chechhan Anticline.

Keywords: Himalayas, Tunnel

INTRODUCTION

Azad Jammu and Kashmir (Pakistan) is located inside the North West of the Himalaya, and it is surrounded by the two prominent countries of Asia that are China and India. Azad Jammu and Kashmir has total area of 13,297 square Kilometers, and a total population is 4,045,366 according to the 2017 census (Badr et al., 2018; Baig et al., 1987). The Himalayas are younger mountain belts and still under building processes having a high stress circumstance (Chapman; Hudson et al., 1993) and these stresses resulted into highly crushed and shear zone. Azad Jammu and Kashmir region is mostly comprised of sedimentary rocks that demonstrate the cover sequence of Indian plate (Wadia, 1928). The project area is the part of Sudhnoti district near Pallandri of Azad Kashmir, Pakistan. The research area is situated in Sub-Himalayas of Pakistan. Tectonically, It is surrounded by regional structures Riasi Fault to the East, Jhelum Strike Slip Fault to the Study Area West, Salt Range Thrust to the South and it lies in the south of Hazara Kashmir Syntax. The project area is connecting main places of District Sudhnoti. These are Azad Pattan, Checchan Sia with Pallandri city. This rote will be the only shortest way for connecting the areas. The project area is about 7 Sq.km and lies between longitudes 73°36'35"E to 73°52'6"E and latitudes 33°44'59"N to 33°33'43"N. The project area lies in the Geological Survey of Pakistan Toposheet no.43 G/10 and no.43 G/14 at 1:50,000 scale as shown in Figure 1.

Purposes of Research

Purpose of our research is to make a tunnel in the sub Himalayas of Azad Jammu and Kashmir near Pallandri city. The current situation of the road around the research area is unsatisfactory and requires significant demands on the need for the enhancement of existing road system. If this tunnel project is implemented, it will shorten the existing 23

Figure 1. Districts map of Azad Jammu and Kashmir.

kilometers long route from Azad Pattan to Pallandri city to only 14 kilometers, making it the shortest distance to the Pallandri city and it all nearby civilizations as shown in Figure 2.

Objectives of the Research Area

The main objectives of the research area are

- To find out the shortest route from Pallandri city and other areas near to Pallandri.
- To estimate the time that will reduce.
- Minimize the expenditures on the construction of road.
- To evaluate the weathering and erosion effects in the area.
- To minimize the travelling costs for the civilian communities.
- To set an example for the other researchers to investigate the Himalayas for Tunnel Routes.

LITERATURE REVIEW

General Review

This chapter illustrates the regional setting and stratigraphic aspects of the study are. It also demonstrates the tectonic settings and regional structures of study area. The study area is the part of the Kashmir Basin. According to Islam and Shah, The Precambrian to recent rock formations are exposed in Kashmir Basin. The project area consists of Murree Formation and Formation.

Regional Stratigraphy

The previous literature from (Lydekker, 1883; Wadia 1928; Islam 2006) have recognized the stratigraphy of the study area splendidly. The regional stratigraphic sequences is revealed in the Table 1.

Stratigraphy of Project Area

The project area is comprised of Early Miocene to late

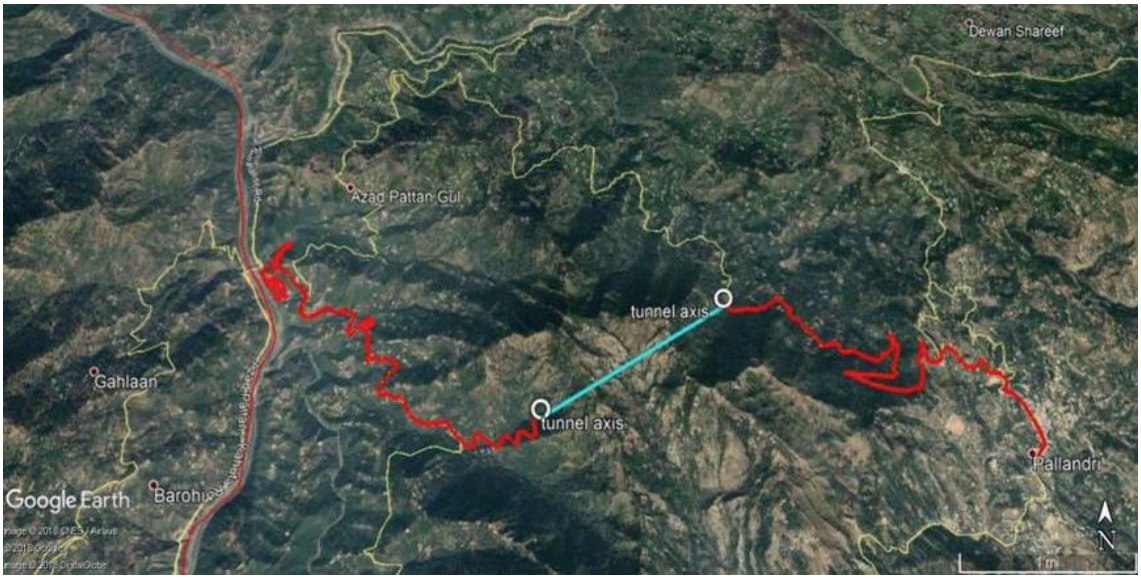

Figure 2. The new route of tunnel.

Table 1. The Stratigraphic sequence of the Kashmir basin Islam (2006).

Quaternary Alluvium	**Recent**	**Consist of silt, gravel and unconsolidated deposits of clay**
Formation	Age	Description
Mirpur Formation	Pleistocene	Consist of conglomerates having cobbles and pebbles of igneous, metamorphic and sedimentary rocks
Soan Formation	Pliocene	Consist of clay, claystone and grey sandstone. Clays are brown, yellowish grey in color.
DhokPathan Formation	Late Miocene	Dominantly consist of sandstone, siltstone, and clays. Sandstone is grey, fine to medium grained and medium to thick bedded.
Nagri Formation	Late Miocene	Dominantly it consist of greenish grey sandstone, siltstone and mudstone. Sandstone has massive beds and has medium to coarse grained texture. Sandstone alternates with clay and are 60 percent and 40 percent respectively.
Chingi Formation	Middle to Late Miocene	Red to purple, greenish grey, ash grey sandstone and siltstone and purple and redish brown mudstone. 70 percent clay and 30 percent sandstone.
Kamlial Formation	Early to middle Miocene	Mainly sandstone, clays and intraformational conglomerates.
Murree Formation	Early Miocene	Mostly clays, shales and sandstone. Sandstone is red purplered in colour and is fine to medium grained
Kuldana Formation	Middle to late Eocene	Variegated shales with subordinate sandstone. Shales are arenaceous
Chorgali Formation	Early Eocene	Mostly Calcareous shales, limestone and dolomitic limestone
Margalla Hill Limestone	Early Eocene	Main nodular fossiliferous limestone with shales
Patala Formation	Late Paleocene	Mainly shalesinterbedded with marl and limestone
Lockhart Formation	Early Paleocene	Grey to dark grey limestone with subordinate shales
Hangu Formation	Early Paleocene	Mainly Laterite, bauxite and fireclay
Muzaffarabad Formation	Cambrian	Mainly Dolomitic limestone with charty dolomite and chert bands
Dogra Formation	Pre-Cambrian	Slates

Miocene rock sequence. The sequence includes the Murree Formation and Kamlial Formation.

Murree Formation

The formation is comprised of cyclic beds of clastic sandstone, shales and siltstone of shallow marine origin with minor amount of conglomerates (Islam, 2006; Lydekker, 1883). Age of Murree formation is early Miocene (Wadia, 1931). The formation consist of calcareous sandstone of purple grey and greenish grey color and dark red to purple clay and with minor amount of conglomerates, (Madan, 2011; Nakata, 1991)

In project area the Murree Formation is exposed in Palandri, Sehr, Chhechhan and Sarsawah areas. It has transitional Upper contacts with Kuldana Formation and lower contact with Kamlial Formation as shown in Figure 3.

Kamlial Formation: Kamlial Formation mostly consists of sandstone and interbedded clay and mudstone sequences and the age of the formation is Middle to Late Miocene (Raza et al., 1978; Stix, 1981). The sandstone of coarse to medium grained and greenish to gray in color is found. Some sedimentary features like cross-bedding is also present in the formation. The formation is comprised of minerals that are quartz, muscovite, biotite and feldspar. Wood fossils and leaves prints are spotted inside the sandstone of kamlial formation near Tahlian.

Tectonic Settings of Project Area

Tectonic setting of the project area is highly distorted because of the Himalayan Orogeny. Southern part of study area is delimited by Salt range thrust, Hazara Kashmir syntax is present at the noth, Jehlum fault is to the west and Riasi fault to the east as shown in Figure 4.

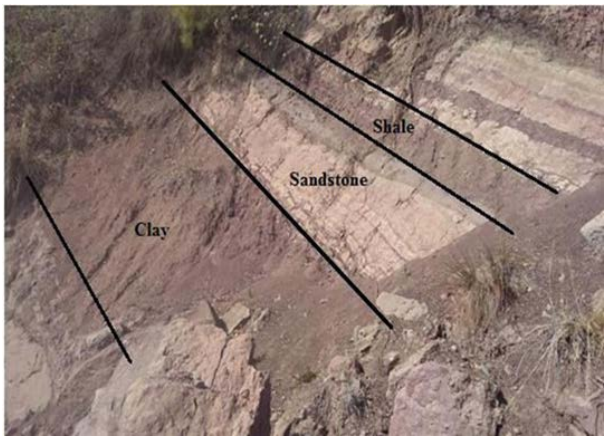

Figure 3. The cyclic sequence of clay, sandstone and shale.

STRUCTURAL STUDY OF PROJECT AREA

Pallandri Anticline

The nature of this fold is open fold. The trend of Pallandri Anticline is southeast or northwest regional anticline, ranges from the east of Sehr area and west of Jehlum River. This anticline is the reason behind the folding of murree

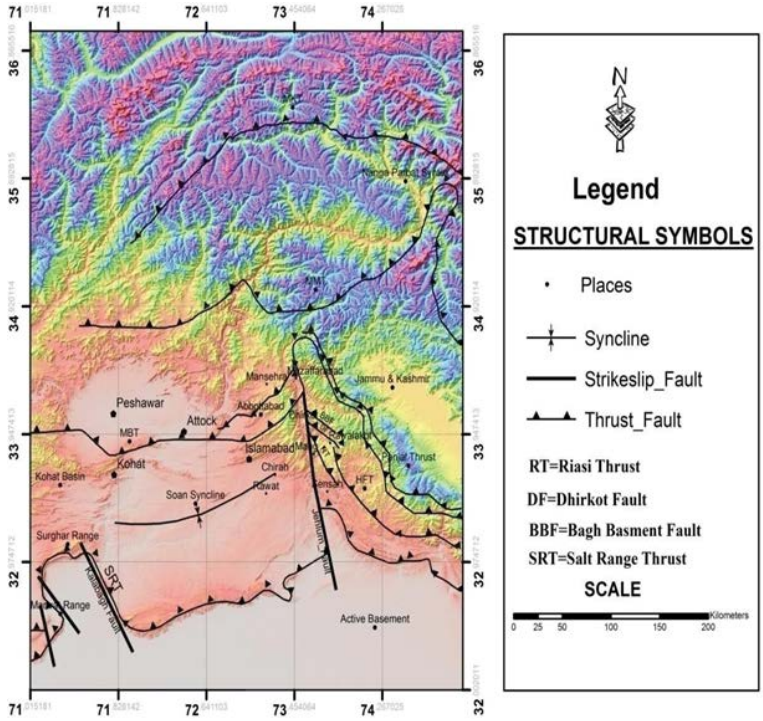

Figure 4. Regional tectonic map of northwest Himalayas of Pakistan. Modified after Kazmi and Aamir (2017).

and kamlial formations of research area. As the structure is anticlinal younger kamlial is found on the limbs and murree in the core of anticline. The interlimb angle of anticline diverges from 119.1° to 123.2°.

Dardarachh Syncline

The nature of this fold is open fold as well. The trend of syncline is northwest or southeast treding. Just like Pallandri anticline murree and kamlial are folded in research area . But in case of core and limbs it shows reverse behavior because of its synclinal nature murree formation lay on the limbs and kamlial in the core. The Interlimb angle of the syncline diverges from 139.8° to 95.1°.

Thickness of Bed Rock

The thickness of the bed rocks is always taken in term of length. The thickness of the bed rocks in the project area varies from 4 ft to 17 ft. These beds reveal the ancient shallow marine cyclic deposits.

Effects of Rock Structure on Tunnel

Folded rocks are always under high stresses, most of the times limbs of the fold occupy better physical conditions and axial region remains under high stresses. Crest and trough of the folded rocks contain highly deformed and jointed rocks because of compressional and tensional forces. As the tunnel is excavated through the folded strata the energy releases resulting into movement of rocks that could cause serious damage to the tunnel. In case of syncline tunnel experiences more hazards on its middle portion and lesser on portals. But the process gets reversed in case of anticline. In case of our research the tunnel has to passes through both syncline and anticline but the conditions are suitable because tunnel is supposed to be aligned away from the axial region. The rocks are not more likely to be deformed in deeper environment of a fold and more crushed and sheared on the top (Sassa et al., 2006; Wadia, 1928).

Methodology of Tunneling

Basics of Tunnel: Before excavation of a tunnel one should have the information of basic physical terminologies related to the it. Because tunnels bear high pressure from all sides due to overburden, the arch is an ideal shape to withstand against the pressure. The bottom or floor is the invert. The two opening ends of the tunnel are known as tunnel portals. The roof of the tunnel is the crown.

Excavation by Drilling and Blasting: Difference techniques are used for the excavation of a tunnel, TBM (Tunnel Boring Machine) is from one of them. But this method is economically beneficial for mega projects. The most common method for excavation of medium and hard rocks is drilling and blasting. Rocks are plugged by the help of drilling equipment and then blasted in order to clear the way an increasing the size of cavity. The commonly used explosives during drilling are Ammonia Dynamites, Ammonia Gelatin, Semi Gelatin and Straight Dynamites.

Geological Hazards along the Road

Himalayas are under high stresses since the Indian and Eurasion plate collision, so the roads in the region face problems like rock fall, landslide, mudflow, & several other geological hazards. Controlling the landslide is initial requirement at management plan (Sassa et al., 2016). The synclinal and anticlinal structure of the research area causes irregular topography that's why the development of roads is challenging. Regional tectonics are the reason behind the abundance of landslides & rock fall. Murree & Kamlial formations contain loose mudstone, siltstone, shales, and subordinate unconsolidated material that results into the mud-flow in rainy season.

Points of Tunnel Excavation by the help of Maps

Northeastern end

Survey showed that the northeastern face of the tunnel has the slope angle of 30-40° and constructed profile demonstrates the height of excavation point that is 3450 feet above in Pallandri anticline. Excavation points of northwestern end are described in Figures 5 and 6.

Western end: The western face of the tunnel is situated in Dardarachh syncline and height of excavation point is 3456 feet according to constructed profile. The profile also demonstrates proposed road. Because of the steep slope angle of 60° at this end the road is supposed to be made in zigzag manner that will overcome the slope effect as shown in Figures 7 and 8.

Contour Map of Project Area

The topographic map of the area indicates the height of terrain. By the help of this technique as well as GPS readings of research area it was concluded that the two

Figure: 5. The point of tunnel excavation through Pallandri anticline.

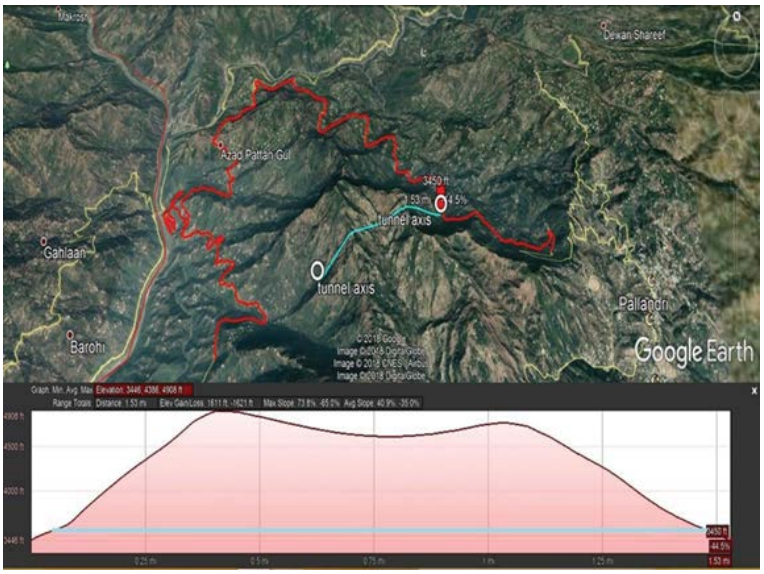

Figure 6. The constructed profile on satellite image showing the height of about 3450 feet.

portals of tunnel were meeting exactly at same height of 1052 meters with the accuracy of 10-15 meters as shown in Figures 9 and 10.

Aspect Map of Project Area

According to aspect map the one face of the tunnel trending to west and other face in the northeast. The Dip and strike study and GPS readings revealed that the slope angle on west face of the tunnel is greater than 60° and the Northeast face of the tunnel having slope angle between 30-40°.

GEOLOGICAL PROBLEMS

Different geological features like crushed zone, thrust zone, folded rocks, seismic events and water bearing layer cause problems during tunneling. These features are commonly used to be found in Himalaya.

Ground Water Inflow

Azad Jammu Kashmir is well known as tropical regions in the world resulting into the rivers, streams and tributaries. Rock layers of sandstone, clay and shale in project area are good source of accumulation of water because of the factors of porosity and permeability. Syncline is very good source of water access. Heavy inflow of water in rock layers act as a barrier in construction activities. Water swells the grains of the rock that result in weak bonding and weak cohesive forces within the saturated rock mass. This activity of water leads to the failure of rock mass from crown and walls.

Folded Rock Mass

Folded rocks are commonly found in Himalayas. Study area is also enriched by folded rocks. Folds behave differently

Figure 7. The point of tunnel excavation through Dardarachh syncline.

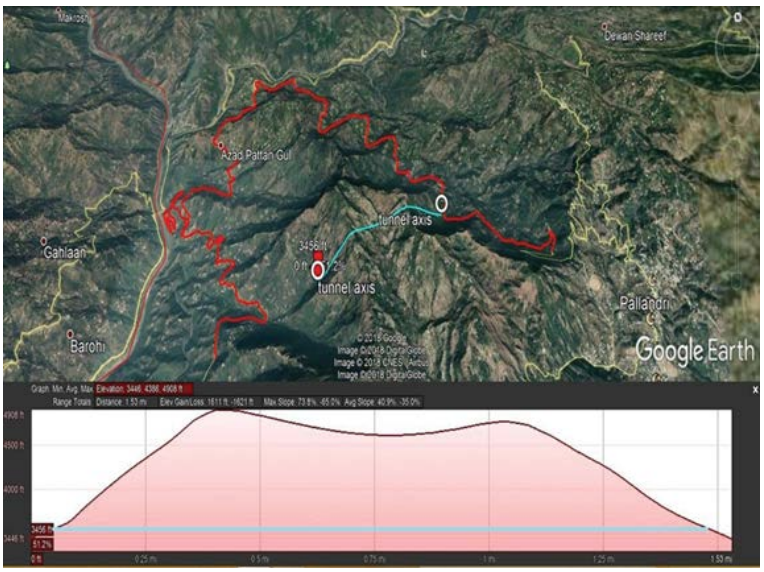

Figure 8. The constructed profile on satellite image showing the height of about 3456 feet.

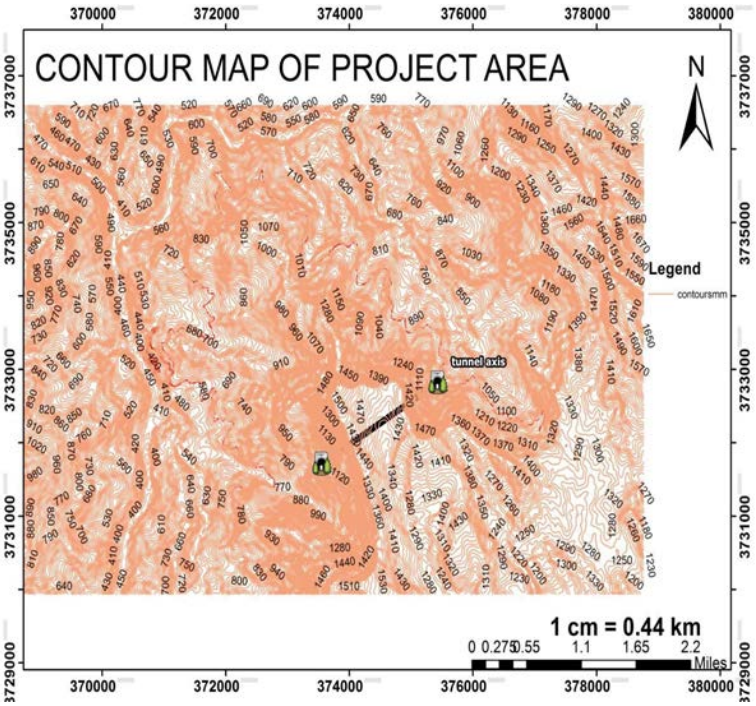

Figure 9. The contour map of the project area.

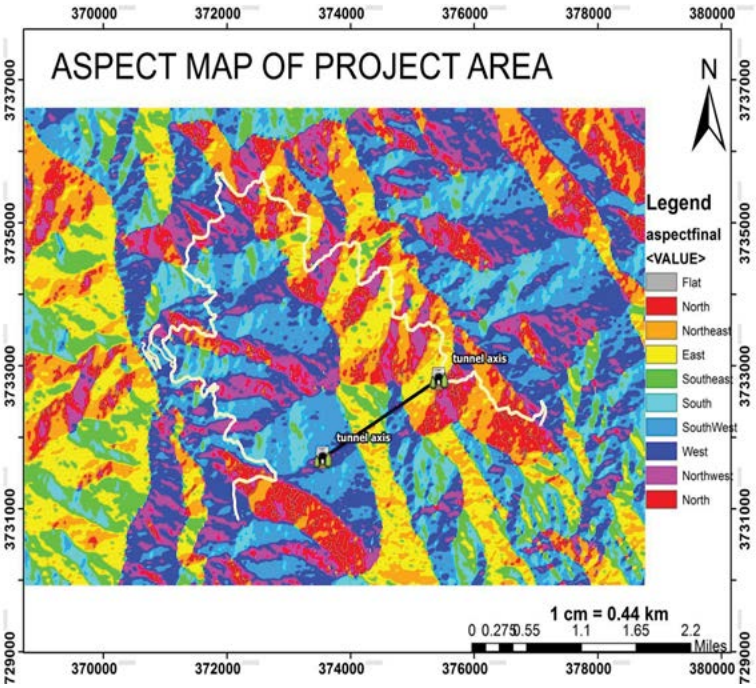

Figure 10. The aspect map of the project area.

throughout the tunnel alignment. In anticline rocks are highly fractured that results into the failure of crown of the tunnel. In synclines rock layers are highly charged with the water that act as water aquifers and also failure of consolidate rock mass.

Seismic Events

Northward movement of India plate toward Eurasian plate causes high storage of energy in crustal blocks of Indian plate and because of these forces the area is sensitive to seismicity. These seismic events are very

harmful for the tunneling. Movement of blocks can cause collapse of tunnel.

CONCLUSION

Travel method from Pallandri to all nearby cities of Azad Jammu Kashmir is not efficient for the people who travel every day for business and other purposes. This is because the road system is very outdated and time consuming as well as hazardous. A proposal to build a tunnel in Pallandri area is best solution to overcome all of the traveling barriers for the local people. The objective of this report is to find out the best travel solution from Pallandri to all nearby cities and vice versa. The travel system will be improved and time consumption will be shortened after the construction of tunnel.

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