Engineering geological considerations during construction stage of a Bridge- A case Study of Pannar Bridge, Moghul Road, J & K

L. N. Sharma
Department of Applied Sciences, PEC University of Technology, Sector-12, Chandigarh 16001.Email: lnsharma.pec@gmail.com

Received August 2013/Accepted August 2013

Abstract

Engineering geological considerations play a very important role during planning, construction and design stages of a bridge. Most often bridges fail as engineering geological considerations were not taken into account despite being best civil engineering practices adopted for the same. The paper deals with a problem encountered during the construction stage of a bridge being constructed at Pannar site, Moghul Road, Jammu and Kashmir during the 2012. A perusal of geotechnical investigations revealed fissure / cavities on the inclined base rock over which raft foundation has already been erected on the Srinagar end of the bridge location. It was felt necessary to take into account engineering geological considerations to avoid future failure / problems. A detailed visual reconnaissance survey along with ground truth verification was carried out. This involved geological settings, lithology, geomorphic features and existing information. The base of the abutment is comfortably placed at 9 m above from the river bed. Exposed rocks on the river side were found to be jointed and having weak bedding planes. The general strike of the rock strata is across the river and rocks are moderately inclined in the north direction. Weathering is quite active in this area. Soil cover is very less and grasses are present wherever small joints / fissures were found in the rocks. Prominent rock type included slates and phyllites common on the other side of the road, Bafliaz side of the bridge. The Karewa group, Quaternary in age, comprises of Sandstone, Siltstone and Conglomerates. Bafliaz formation lying below Karewa group comprises of Slates, Phyllites, volcanic and quartzites. In the absence of soil settling on this account is expected to be zero. Acid test had indicated absence of lime. The study area falls in the seismic zone five. Petrographic studies revealed the foundation rock being quartz rich meta sandstone**.** No ground water is encountered in the area while drilling till the depth at which abutment is laid. Highest flood static level is only up to 2 meters from the current level of flowing water (Photograph). No danger is posed to foundation due to groundwater and scouring. UCS indicates rocks beings strong but fissures and joints needs artificial methods of consolidating. It was recommended that i) construct plain cement concrete structure to cover exposed broken rock, ii) grouting under the abutment will seal openings and control uplift and pore pressure and iii) strengthen vulnerable right side of the bridge by rock bolting.

1. Introduction:

During Planning, design and construction stages of a bridge the importance of engineering geological considerations is a well established reality now. Despite best engineering practices adopted by the civil engineers during all the stages of the bridge, most of the bridges fail as engineering geological conditions are not considered seriously. The paper deals with a problem anticipated after raft foundation was already placed on the hard rock during the construction stage of a bridge. The bride is being constructed at Pannar site, Moghul Road, Jammu and Kashmir as shown in Figure 1 and both the ends are known by names as bafliaz side and Srinagar side. The problem in question is on the Srinagar side. The soil and geotechnical investigations were already carried out before selecting the site. However, during construction stage in view of the presence of fissures, joints and discontinuities observed in the borehole data it was decided to investigate engineering geological considerations so as to nullify effect of these structural features on the foundation laid for abutment on Srinagar side of the bride location. To overcome these difficulties what remedial measures are required had been attempted in this paper.

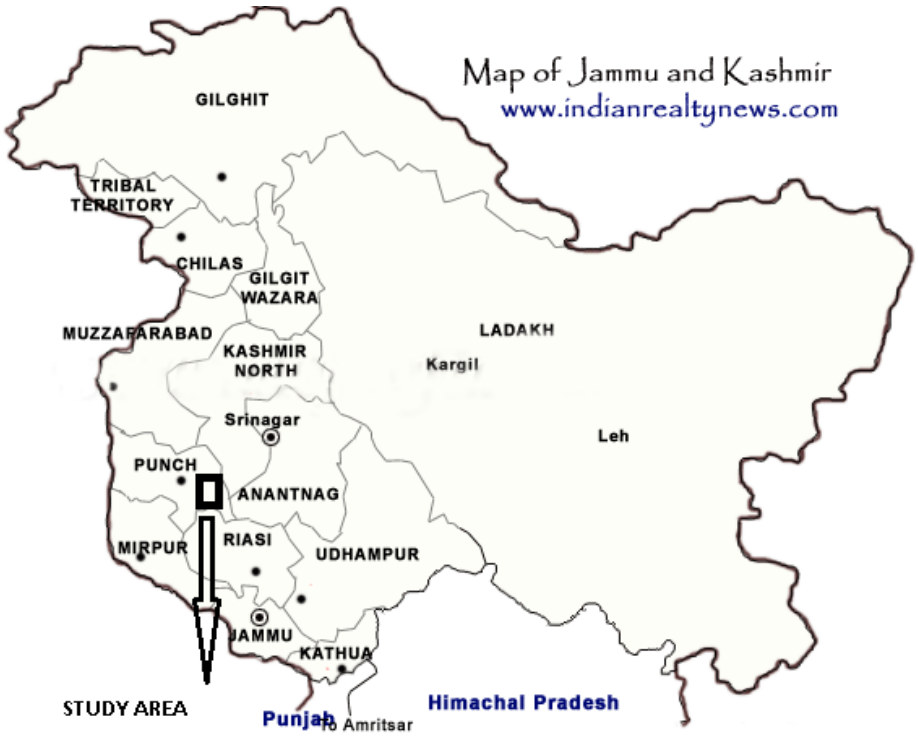


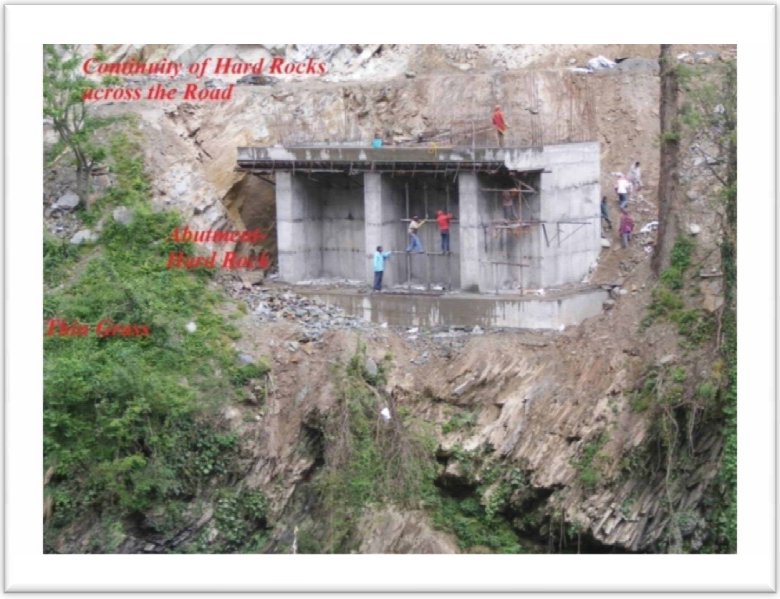
Figure 1 Location map of the Study Area

2. Ground Truth Verification:

The ground truth verification was carried out at the site included observation about height, width and location of the raft foundation vis-a vis rock type, structure, attitude of rocks- strike & dip, groundwater, static flood level and vegetation. All these studies helped in arriving at conclusions and recommendations.

3. Detailed Visual Reconnaissance Survey:

The visual reconnaissance included regional and local geology settings, tectonic setting, litho logy (rock types) of the location. Topographic details and other pre –existing information supplied were verified at the site. It was observed that abutment on the Srinagar side at Pannar is placed on the hard rock after cutting rocks vertically down almost 6m from the road side leaving weak terminal exposed rocks towards river side as untouched as shown in picture 1. The base of the abutment is comfortably placed at 9m above from the river bed as shown in photograph 3. Rock faces exposed on the western side i.e. towards river side clearly shows jointed and fractured nature of the rocks. Two prominent features i.e. yellow tinge on the exposed rock surfaces and grass was found to be present wherever jointed or fractured rocks are either directly exposed to rain water, exposed to atmosphere and water coming down from high regions due to sloping nature of the strata. The yellow colour is attributed to presence of iron in the parent rocks and reaction with water for prolonged period of time; thus colouration takes place. Grasses are seen grown only on the jointed / fractured rocks having either direct contact or indirect contact with water.



Picture 1 Field Photograph of the raft foundation on Srinagar side, Pannar Bridge

Grasses were found to be absent on either barren rocks having less slopes or devoid of any soil cover. The strike of the rocks runs across the river and rocks are dipping in the north direction (picture 2) with dip angle ranging between 35 to 45 degrees. Picture 1 is showing rocks dipping in the north with fissures and joints. It also shows prolong exposed jointed / fractured rocks broken from main body of the rock strata.

4. Analysis of Results and Discussion:

Taking in account investigations already carried out, visual reconnaissance survey and first hand information gathered about geology of the area it is clear that the area is suitable for construction of bridge at the specified location on the merit of following technical grounds.

4.1 Safety and Strength:

The unconfined uniaxial compression tests performed on the rocks ranges between 98kg/cm^2 to 177 kg/cm^2 indicate foundation being laid on not very strong rocks but sufficient to take such loads. This is further substantiated by field observations including scratching, fine to medium grained rock, hard in hand specimen and arenaceous nature.

4.2 Structural Features:

The beds at the site conformably lie over each other and dipping towards river. Since the strength values of in situ rocks are always significantly greater than their determined unconfined uniaxial compressive strengths, it holds good for this study, as the foundation is laid on barren exposed strong rocks. Jointing / fracturing mainly characterize the area investigated. The trends of joints/fracture exhibit geometrical relationship with the strike of the strata in the area. The superficial thin covers of grass support the evidence of these fractures / joints are being shallow in nature, hence of no consequence as far as exposed joints are concerned. However, for joints and fissure lying below the abutment as also pointed in the geotechnical report grouting is required to seal structure from possible threat side. Although foundation is on the hard rock, foundation material is found to be possessing fractures and joints reduce its bearing capacity. Hence, use of artificial methods of consolidating such material to improve its bearing capacity is desired in this case.

4.3 Geology:

The study area falls in Kashmir basin and immediately after Panjal Thrust. Litho logically predominant constituents of the area are carbonaceous rocks along with other metamorphic rocks such as slates and phyllites common on the other side of the road of the Bafliaz side of the bridge. Karewa group of Quaternary age comprising of Sandstone, Siltstone and Conglomerates. Other rocks are from Bafliaz formation lying below Karewa group comprising of Slates, Phyllites, volcanic and quartzites. The place where

structure is laid down (Srinagar side) is hardly having any soil cover either above or below; hence chances of settlement due to soil are negligible on the location of the foundation laid. It is also reported by the field engineer that while drilling was on no sudden gaps were observed. This point to no major cavity was encountered while drilling. Further, it was verified in the field was there a sudden loss of water when drilling was going on? No such incident was reported by the driller, thus pointing to no major cavity. However, fissures and jointed nature is evident from the core box photographs of the geotechnical report as well as observation made during field visit. This needs to be tackled. It is apparent to use grouting to prevent instability of the rocks lying under the structure and to strengthen hillside slope rocks. It is reported in the literature that more problem may occur wherein very tall piers are constructed on slopes in earthquake prone areas. However, this does not appear to be the case here as piers are not even tall, although area falls in seismic zone V and earth is subjected to periodic shocks of earthquakes.

4.4 Acid Test:

A fresh rock sample was collected for further laboratory tests from the Panner abutment area to find out the nature and type of the rock. Rock sample was broken in small pieces and concentrated hydrochloric acid was poured on the sample, no effervescence was seen. Further to confirm whether rock is dolomitic limestone, powdered sample was subjected to HCL test again and it was found that neither it is dolomite and hence not a carbonaceous rock. These clearly indicate that rock is not containing lime material.

4.5 Thin Section Studies:

In hand specimen through naked eyes and with the help of lenses quartz grains and biotitic grains can be seen very clearly**.** A thin chip of the rock sample was prepared and mounted on the glass slide using Canada balsam. This thin section slide was studied under microscope both in ordinary light and polarized light. It was found to be rich in quartz and low grade metamorphosed biotitic material, thus can be classified as meta-sandstone. This rock by virtue of being rich in quartz makes is hard rock.

4.6 Drainage:

No ground water is encountered in the area while drilling till the depth at which abutment is laid down and in the field also no evidence was found. Highest flood static level is only up to 2 meters from the current level of flowing water (picture 2). Thus, no danger is anticipated to the foundation site as far as groundwater is concerned. Scouring pose no problem in this area since it is not constructed across water ways and is placed on very safe height from the river bed.

5 Remedial Measures:

i) To seal open discontinuities i.e. joints and fractures and other openings in the host strata below the abutment curtain grouting need to be done through drilled holes under pressure as earmarked in figure 3. This will greatly improved / overcome characteristics of the mass and geological defects in foundation beds. Grouting will consolidate loose rock in the foundations to control uplift and pore pressure in rock slopes. This will increase the bearing capacity and stiffness of the rock mass.

Picture 2 Site showing spot needing grouting and concrete cementing

ii) Although joints / fractures made rock mass of the Pannar site facing river side appear weak, deformable and permeable, it is recommended to construct plain cement concrete structure as shown in the photograph 2. It should be planned in such a way (3-4 meters rectangular shape) that it covers exposed broken rocks and thereafter it should act as a single unit with main strata.

iii) In order to strengthen vulnerable right side of the bridge where a tall tree is seen (photograph 3) rock bolting comprising two rows of 2 meter centre to centre and 2.5 meter deep must be carried out. The second row holes may be staggered with respect to first row. The location of bolting is earmarked in photograph 3.

6 Conclusions:

Thus, collectively, all these investigations and field checks were in favour of continuation of construction of a bride by adopting above mentioned remedial measures.

References:

1. Chowdhury, F. & Sapkota, F. (2001)**,** Guidelines for geotechnical investigations of bridge and waterways structures, Pavements Engineering**,** Main Road, Western Australia
2. Handbook for bridge works, Rajasthan, Urban, Infrastructure Development Project, Avs Building, Jawahar Circle , Malviya Nagar, Jaipur- 17
3. Geology and Mineral resources of the States of India (2008), Part- X, Jammu and Kashmir, Miscellaneous Publication No 30, 2nd Edition.