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Site Selection and Geological Assessment of the selected Foot Bridge and Electric Cable Car Site at Bhyundar km across River Laxmananga, Chainage 10.00 Govindghat-Hemkund Sahib Foot Trek, Distt. Chamoli 17/07/2015

1- Introduction: - The Provisional Division, PWD, Gopeshwar has been entrusted for the construction of a ~170 m span foot bridge and a 112 m long electric cable car on Laxmanganga or Pushpawati river at Bhyundar village located along Ch Km 10.00 of Govindghat-Hemkund Sahib foot trek. During the site selection the site engineers noticed problems related to the slope failure in the area. In order to select the suitable construction site and for the geological assessment of the selected site along with remedial measures Er. G.C. Vishwakarma, Superintendent Engineer, Yatra Vyavastha, PWD Govindghat district Chamoli requested the under signed to make a site visit. Consequent to the request site visit was made on 10/07/2015. Er. Shiva Prajapati, Assistant Engineer, PWD Govindghat was present during the site visit.

2- Topographical Information/Location: The above said site is located near village Bhyundar on Govindghat-Hemkund Sahib foot trek in District Chamoli. The co-ordinates recorded by GPS at the right bank of the site on the foot trek with elevation, masl are as follows-

Latitude	: 30° 40' 41.20"
Longitude	: 79° 35' 31.12"
Approximate Elevation	: 2617 M

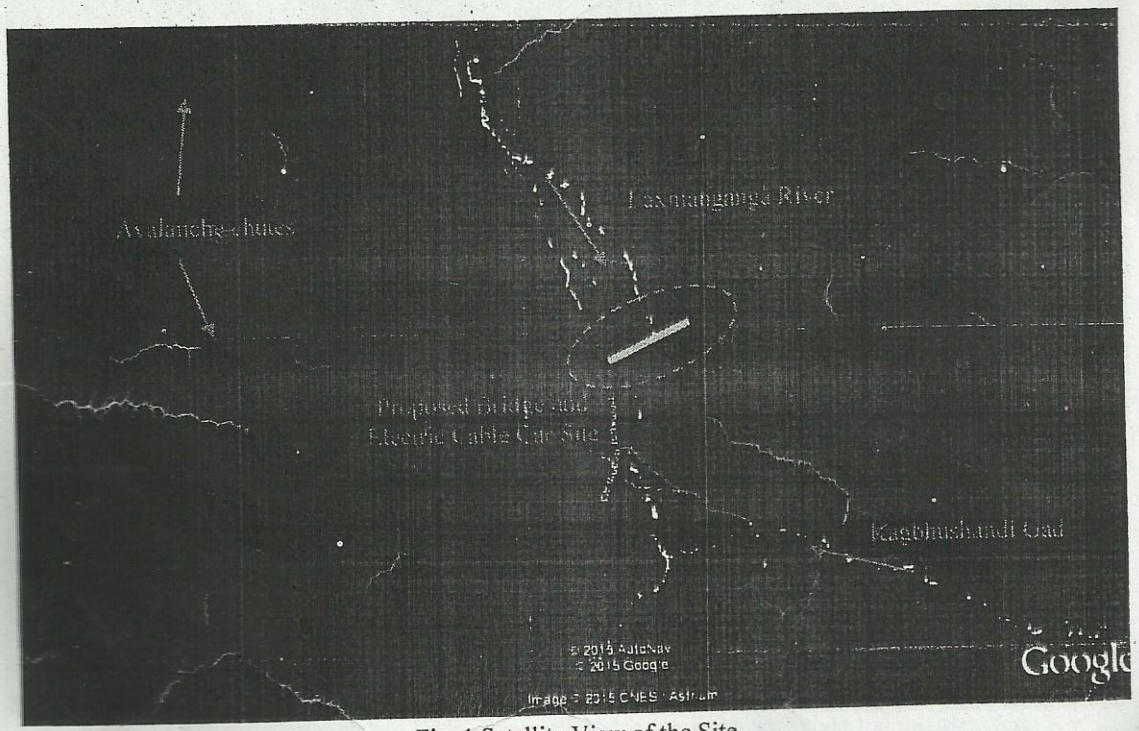

Fig: 1 Satellite View of the Site

3- Site Selection: - During the field visit it was observed that along the left bank of the river there is almost continuous exposure of sound and competent rock whereas on the right bank rock mass is concealed under thick overburden and talus material. It was also observed that the area upstream of the present site was unsafe for the construction of any structure due to the prevalence of avalanche chutes along which during the winter season snow, ice and rocks slide down the slope which will damage anything coming their way and also the gradient of the river is high in the upstream locations which will lead to the faster erosion of the toe especially of the right bank which constitutes almost entirely of overburden material therefore damaging the bridge and cable car components severely. Taking that into consideration three places were selected for the bridge site ie; 1A, 1B and 1C from upstream to downstream direction. Out of which site 1B was found to be appropriate for the construction of the bridge due to following reasons: the sites upstream and downstream (1A and1C) of 1B will have longer bridge spans, and on the right bank which has no bed rock exposure the sites 1A and 1B located along vertical cut slope faces consisting of thick overburden and slope material which consists of huge rocks embedded in the loose soil and mud which during the rainy season gets washed away leading to rock falls.

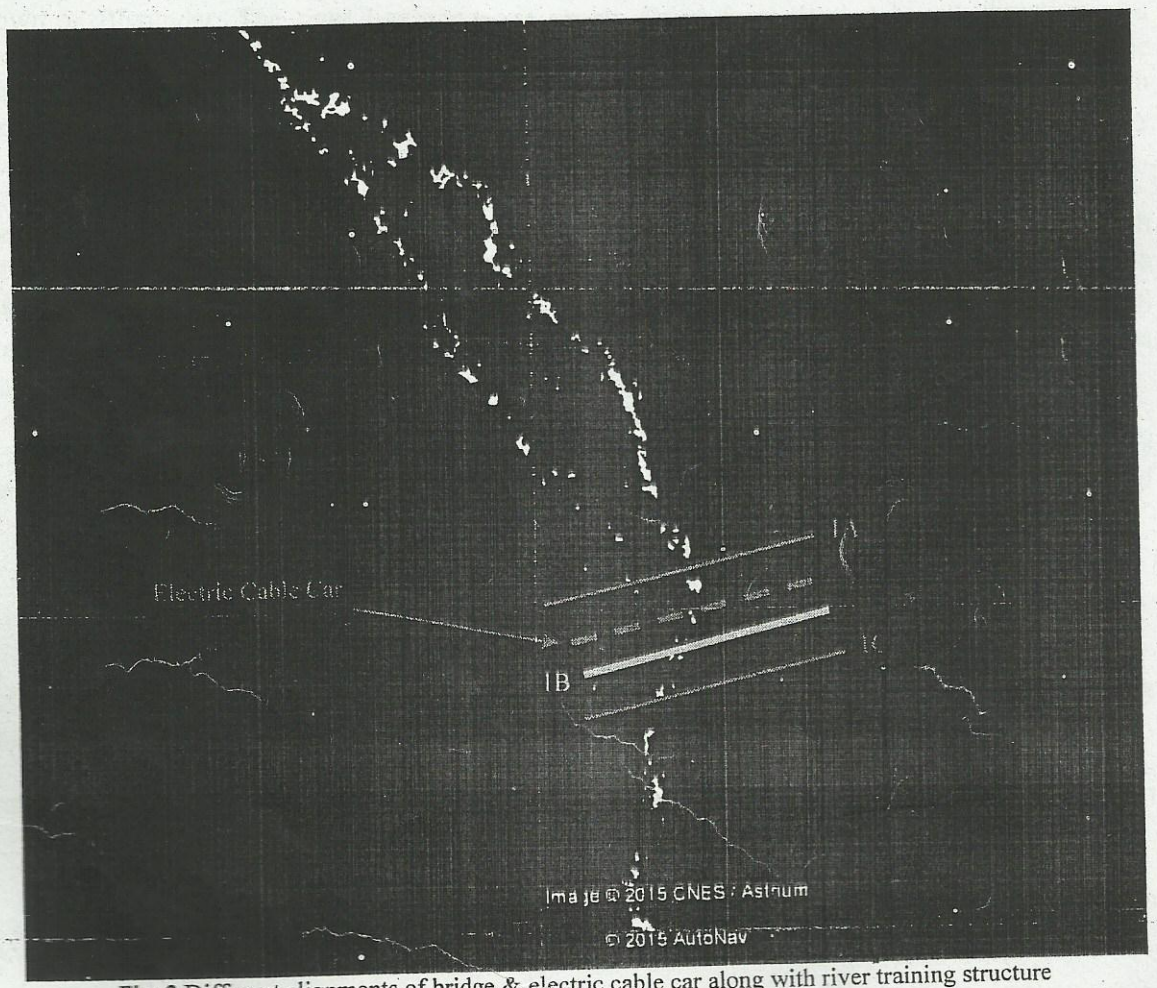

Fig: 2 Different alignments of bridge & electric cable car along with river training structure

Site for the construction of electric cable car is selected 15 m upstream of bridge site number 1B ie; between site number 1A and 1B.

The selected bridge and electric cable car sites on the right bank lie between two avalanche chutes, these chutes are 600 to 700 m upstream and downstream of the selected site. Hence the selected sites are safe in comparison to the other locations.

4- Geological Assessment: - Geologically, the area falls under the Higher Himalayan zone, described as the Himadri Complex by (Valdiya, 1973; Valdiya and others, 1999). Lithologically, the area is characterized by calc-silicates with sillimanite-kyanite-garnet-biotite gneiss and schist with tourmaline granite (pegmatite-apatite veins). The rocks around the site are variants of quartz biotite gneiss which are generally quartzitic.

The site lies in the Laxmanganga (or Pushpawati gad) valley 200 m upstream of the confluence of Laxmanganga river meets Kagbhushandi Gad at a chainage 10.00 km on Govindghat-Hemkund Sahib foot trek. Along the confluence of the two rivers lies a village known as Bhyundar. The river Laxmanganga nearly flows from north to south direction at a moderate gradient whereas Kagbhushundi gad roughly flows from east to west direction. The area receives heavy rainfall during the monsoons and during the floods of June 2013 both Laxmanganga and Kagbhusandi Gad rivers changed their courses (Fig: 3) due to which nearly the whole village of Bhyundar was washed away causing massive loss of property.

The right abutment site of the bridge consists of thick overburden and talus material which consist of huge boulders embedded in the loose silty clay and mud with no rock exposure in its vicinity. The hill slope of the right abutment declines towards **N 80°** direction, with slope having a vertical cut face of 10 to 30 m height initially, followed by a gentle slope of **30°** which gets steeper 150 m further up. The bearing of the bridge alignment from the right abutment is **N75°E**.

The left abutment site of the bridge consists of fresh, sound and competent bed rock which is quartzitic variant of Quartz Biotite Gneiss with an estimated UCS ~ 100 MPa. The hill slope of the left abutment declines towards **S85°W** direction, with a steep slope angle of **> 70°**.

The azimuths of the major discontinuity planes along the site are:

F: EW/55°/N, Rough Planar, 5 to 30 cm spacing, >250 cm persistence, tight to 1 mm opening with no filling.

J_2: N150°/60°/240°, Smooth to rough Planar, 30 to 45 cm spacing, ~50 cm persistence, 1 to 5 mm opening with no filling.

J_3: N205°/85°/295°, Rough Planar, 15 to 30 cm spacing, ~50 cm persistence, tight to 1 mm opening with no filling.

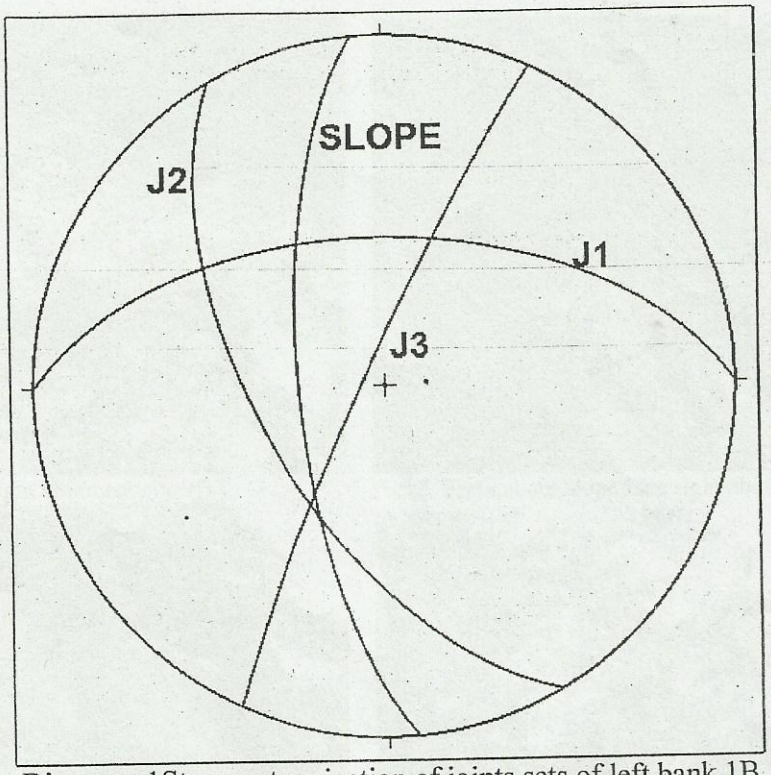

Diagram: 1Stereonet projection of joints sets of left bank 1B

The stereonet projection of the joint sets of left bank abutment site 1B shows the formation of a wedge between the joints J_2 and J_3. However, the wedge direction is oblique to the slope direction which does not favour the wedge failure along this slope.

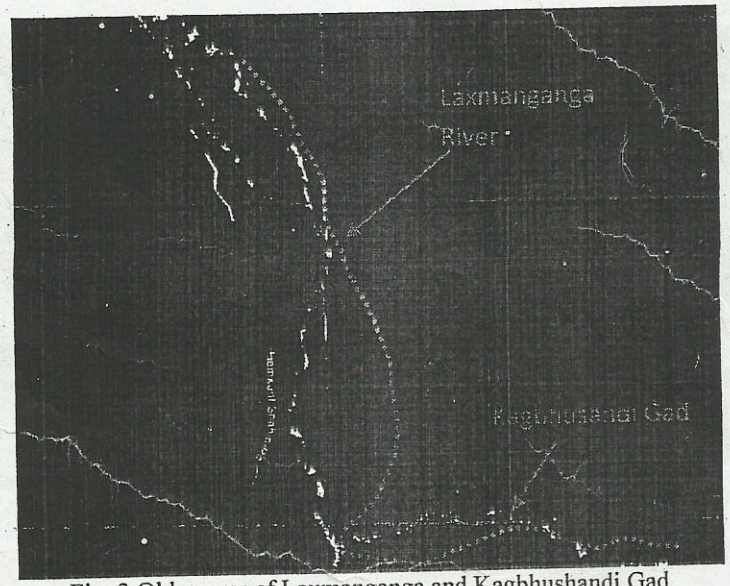

Fig: 3 Old course of Laxmanganga and Kagbhushandi Gad

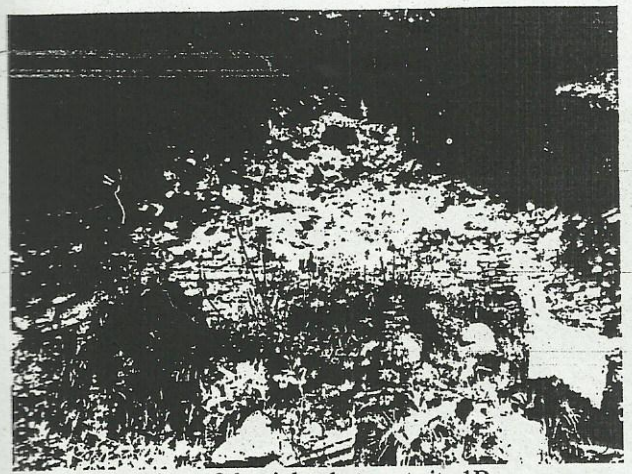

Fig: 4 Close view of the right abutment site 1B

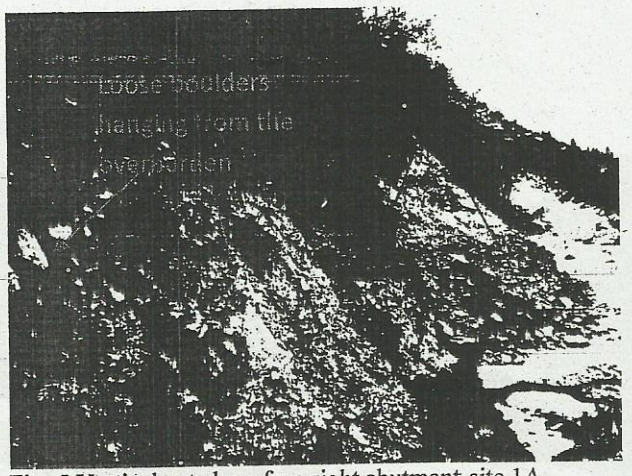

Fig: 5 Vertical cut slope face right abutment site 1A

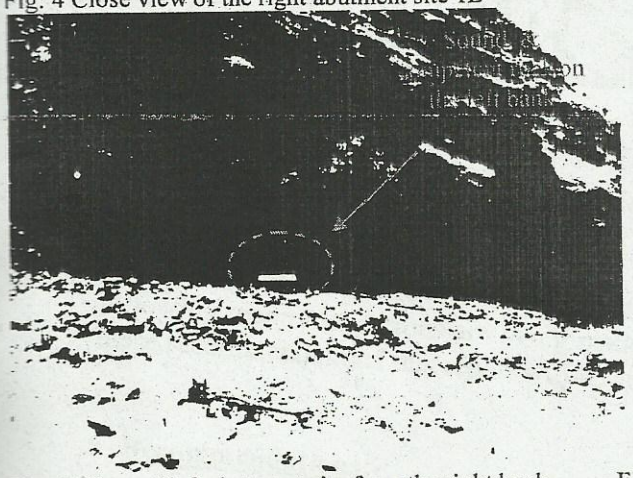

Fig: 6 View of left abutment site from the right bank

Fig: 7 Closer view of left abutment site 1B

Fig: 8 Loose boulders hanging near right abutment site 1C

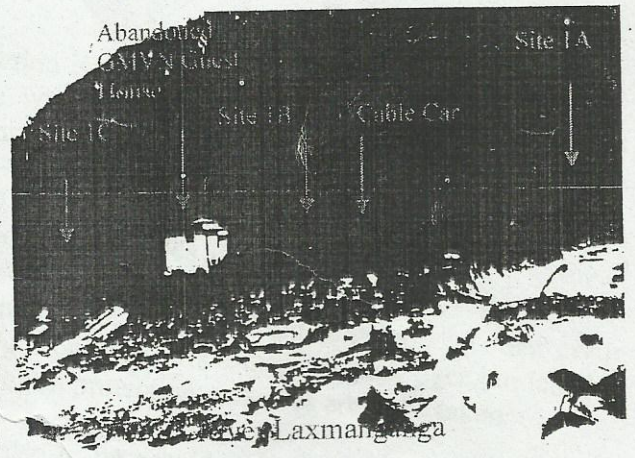

Fig: 9 View of different locations on left bank

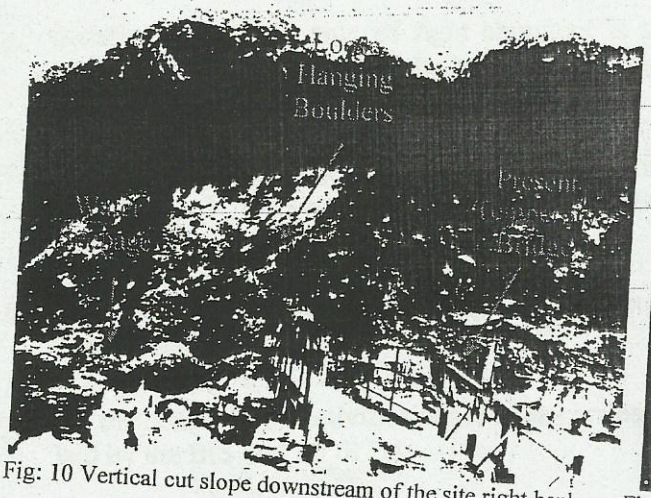

Fig: 10 Vertical cut slope downstream of the site right bank

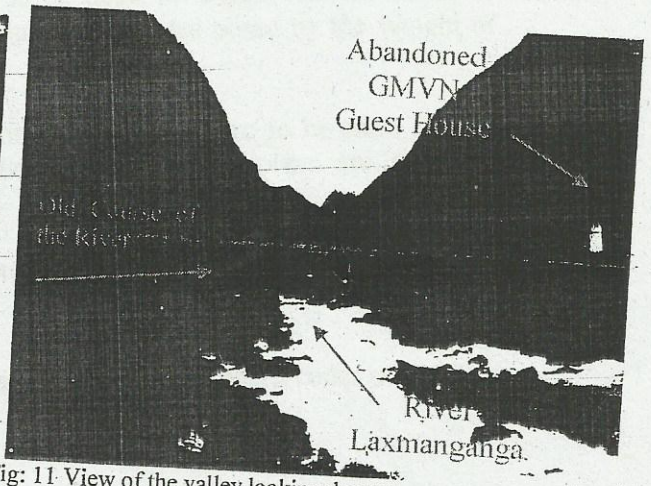

Fig: 11 View of the valley looking downstream

5- Seismicity: - According to the seismic zonation map of India the site falls under Zone V which corresponds to an intensity of IX on MM scale.

On the basis of the geological inspection of the site studies carried and the facts given above, the following recommendations are being made for the construction of the proposed road failing to these recommendations this report will be automatically treated as cancelled.

6- Recommendations:-

1. Blasting by explosives for the construction is to be avoided unless it gets very necessary, especially in the right abutment site where the there is thick overburden and talus material so the use of explosives can further aggravate the problem of rock falls and mass wasting.
2. It is advised to perform all of the construction activities after the rainy season.
3. The banks of the river are to be protected (Fig: 2) by the help of gabion or other civil engineering provisions especially the right bank in which there is thick over burden. In the areas where the river strikes directly extra protection measures are to be taken.
4. Weep holes or proper drainage should also to be provided on the support structures in order to allow water to pass through the overburden and loose material which will help in maintaining the shear resistance of the slope material.
5. River training has to be done (Fig: 2) especially on the right bank so that the river does not change it course during the season of high discharge.

6. Grouting in the hill side of right abutment is to be done in arched fashion so as to strengthen the left abutment site by equal distribution of stresses posed by the weight of bridge and electric cable car structures.

7. Prior to construction soil samples from the right abutment area are to be send for the evaluation of **'c' and 'ϕ'** values and construction and support plans are to made accordingly.

8. It is advised to dispose the muck on the pre-identified muck disposal site in the downstream area.

9. All the construction activities ought to be carried out as per the standard codes of practice laid by the BIS and MORTH.

6- **Conclusion:-** On the basis of the geological / geotechnical studies carried at the site and with the above recommendations, the proposed site at Govindghat-Hemkund Sahib foot trek Km 10.00 (Bhyundar Village) was found geologically suitable for bridge and electric cable car construction.

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14/07/2015

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