कार्यालय अधिशासी अभियन्ता,
सिंचाई खण्ड लोहाघाट

पत्रांक :– 424 /सिंखलो/फॉरेस्ट केस/कोलीढ़ेक दिनांकः– 17/5/2019।

विषय :– जनपद चम्पावत में लोहाघाट के समीप कोलीढ़ेक में बहुउद्देशीय कृत्रिम जलाशय (झील) के निर्माण हेतु 4.50 है0 वनभूमि का सिंचाई विभाग को प्रत्यावर्तन (ऑनलाईन सं0– FP/UK/IRRI 34614/2017)।

सन्दर्भः– कार्यालय भारत सरकार पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय क्षेत्रीय कार्यालय (उत्तर–केन्दीय क्षेत्र) के पत्र सं0–8 वी0/यू0सी0पी0/02/127/2018/एफ0सी0/305 दिनांक 10.05.2019।

अपर प्रमुख वन संरक्षक एवं नोडल अधिकारी, इन्दिरा नगर फारेस्ट कालोनी, देहरादून।

महोदय,

उपरोक्त विषयक सन्दर्भित पत्र के क्रम में अवगत कराना है कि जी0एस0आई0 देहरादून द्वारा भू–गर्भीय सर्वेक्षण का कार्य वर्ष 2009 में किया गया था, उक्त भू–गर्भीय सर्वेक्षण की रिपोर्ट आई0आई0टी0 रूड़की (ए0एच0ई0सी0) को हस्तान्तरित की गयी थी। उक्त भू–गर्भीय सर्वेक्षण को सम्मिलित करते हुए आई0आई0टी0 रूड़की द्वारा विस्तृत डिजाईन किया गया था।

वर्तमान में पुनः आई0आई0टी0 रूड़की की जियोलोजिकल टीम को साईट का स्थलीय निरीक्षण झील निर्माण से होने वाले Geological Effect के अध्ययन हेतु करवाया गया जिसकी रिपोर्ट संलग्न है।

उक्त रिपोर्ट को प्रमाणित कर आपको अग्रिम कार्यवाही हेतु प्रेषित है।

संलग्नकः– उपरोक्तानुसार।

अधिशासी अभियन्ता
सिंचाई खण्ड लोहाघाट

पत्रांक :– /सिंखलो/फॉरेस्ट केस/कोलीढ़ेक/तद्दिनांक।

प्रतिलिपिः– अधीक्षण अभियन्ता, सिंचाई कार्य मण्डल, पिथौरागढ़ को सूचनार्थ प्रेषित।

अधिशासी अभियन्ता
सिंचाई खण्ड लोहाघाट

भारतीय प्रौद्योगिकी संस्थान, रुड़की

वैकल्पिक जल ऊर्जा केन्द्र
रुड़की–247 667 (उत्तराखण्ड), भारत

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE
ALTERNATE HYDRO ENERGY CENTRE
ROORKEE - 247 667 (Uttarakhand), INDIA
Phone: (01332) 285213, 274254, Fax: (01332) 273517, 273560
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प्रो. एस. के. सिंगल
अध्यक्ष
Prof. S.K. Singal
Head

No. AHEC/C-1046/517
Dated: March 19, 2019

Executive Engineer
Irrigation Division, Lohaghat
Uttarakhand Irrigation Department,
Champawat – 262523

Sub: Engineering Deisgn of Kolidhek Dam

Ref: Your letter no. 852/Sinkhlo/Kolidhek dated Sept 20, 2018

Dear Sir,

The Kolidhek artificial lake project site was visited by our team of engineering geologist and hydraulic structure experts during March 08 to 11, 2019. Based on site visit and details collected from the Uttarakhand Irrigation Department officials a note on geology of the project site is enclosed herewith for your reference and necessary action please.

Yours faithfully,

(SUNIL KUMAR SINGAL)

CC:

Shri MC Pandey
Superintendent Engineer
Project Circle
Uttarakhand Irrigation Department,
Lohaghat, Champawat – 262524

(SUNIL KUMAR SINGAL)

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Note on Geological Aspects–Kolidekh Artificial Lake Project, Champavat (Uttrakhand)

1. Background

The Kolidhek Artificial Lake Project envisages a 21m high (above foundation) and 125m long (at top) concrete dam structure across Lohawati River, near village Kolidhek in Champavat District of Uttrakhand. The reservoir/ artificial lake formed will be utilized for the purpose of drinking water, minor irrigation and for the promotion of tourism. The project is accessible from Lohaghat Town through Lohaghat – Devidhura road and is about 2 km from Lohaghat. The project area falls in Survey of India toposheet No. 63 C/3. The weir site is defined by geographical coordinates; longitudes 80°04'50.5" and latitude 29°24'3.2". The proposed length of the reservoir/ lake will be approximately 1.64 km and the total submergence area by the lake would be about 8.10 hectares. The total reservoir capacity at FRL is estimated to be 0.45 MCM.

2. Geology of the dam site

At the proposed dam site rocks are mainly exposed at the river bed and on the both banks along the river. The exposed rocks are hard, massive dark to light colored phyllites which belongs to Manila Formation of Kumaon Super Group. On the left abutment hard and massive grayish phyllites are exposed upto a height of about 1.5 to 2m from the river bed. Above these rocks the left abutment slope is covered by overburden material upto a height of 10 – 12m. The slope in general is gentle and is a barren land. The sub-surface exploration on the left bank at lower and middle portion of the proposed dam abutment reveals that thick overburden material comprising yellowish brown silt and clay is present upto a depth of 3 to 4m followed by layer of boulders of phyllites with a thickness of 2 m. Below this layer bed rock is present which is characterized as hard massive compact phyllites. The bed rock is slightly weathered upto a depth of 6 to 9m. The foliation plane in general varies from 40 to 60°. Near the extreme end of the proposed left abutment of the dam thick overburden material comprising reddish brown clayey silt with fine sand is present up to a depth of about 9m. Further below bluish grey to grey hard compact phillites are present. These phillites are moderately to slightly weathered for initial 30 cm thickness, beyond which they are fresh. The foliation joint in this reach dips at 60° and the rock in general is moderately to closely jointed. The rock quality designation (RQD) varies between 9 to 40%. Further, along the right bank at the dam site rocks are exposed along the river bed upto a height of about 2 to 2.5 m. In the lower reaches right bank slope is steep and thereafter it is moderately steep to gentle. In the upper reaches slope is covered by thick vegetation. The overburden thickness is about 2m which comprises reddish brown color silty clay. The bed rock is present at a depth of about 2m which comprises grey hard compacted phyllite. The rock is moderately to slightly weathered up to a depth of about 11m, beyond which fresh rock is present. The foliation joints dips from 50 to 75°. The RQD in general varies from 5 to 25%.

3. Geology of the reservoir area

The rocks present in the reservoir area are mainly grey hard compacted phyllites which belong to Manila Formation of Kumaon Super Group. The rocks are mainly exposed along the river banks up to a height of 2 to 10m. The exposed rocks generally strike N40° to 60°W – S40° to 60°E and dips 30° to 70° in North easterly directions. The major joint sets present in exposed rocks in the reservoir area are; N-S/55°, E - W/Vertical, N60°E - S40°W/60°SE, N40°E - S40°W/50°NW, N70°E - S70°W/60°NW, N45°W - S45°E/15°SW and N40°W - S40°E/50°SW.

4. Geological hazard due to reservoir impoundment

The main geological hazard associated with the dam reservoir projects is related to the stability problems of the reservoir rim slopes under anticipated adverse conditions. Any catastrophic slope failure in to the reservoir may result into wave generation which may overtop the dam and may possibly damage the structure and may result into flooding in the downstream region. Stability of the slope is concerned with the relationship between driving and resisting forces. Some factors contribute

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट (चम्पावत)

for driving forces whereas others add to the resisting forces. Therefore, these governing factors are very important in defining the slope stability condition. The main internal governing factors are; geometry of the slope, slope material, potential failure plane/s characteristics, surface drainage and groundwater condition, whereas the external factors are rainfall, seismicity and manmade activities. These factors in combination will be responsible in defining the stability condition of the slope.

The main driving force acting on the slope is the gravitational force which is directly proportional to the slope inclination. Steeper slope will be more susceptible for instability. As the slope inclination increases, additional slope mass will add to the weight component, thus shearing stresses will increase and instability in the slope will be induced.

The proposed reservoir slopes of the Kolidekh project are mostly gentle along the left and right bank of the river (Plate 1). The slopes are mostly terraced and are covered by agricultural and barren lands. The right bank slopes near to the dam site and in the middle portion of the reservoir are partly covered by the forest land. The left bank slopes are relatively gentle, terraced and are covered by barren lands around the dam site, in the middle portion and in the uppermost portion of the reservoir (Fig.1).

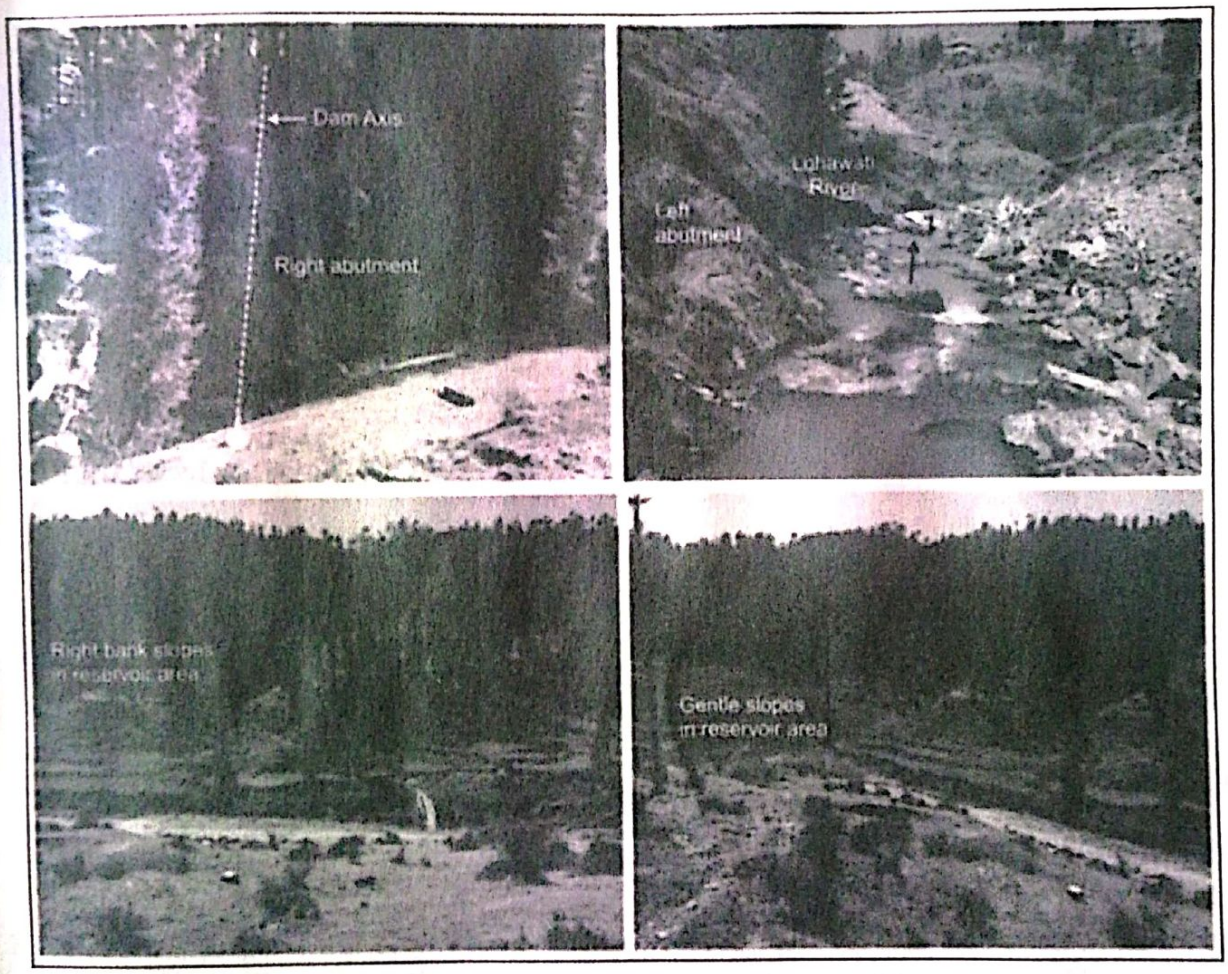

Plate 1 View of dam site and reservoir area

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

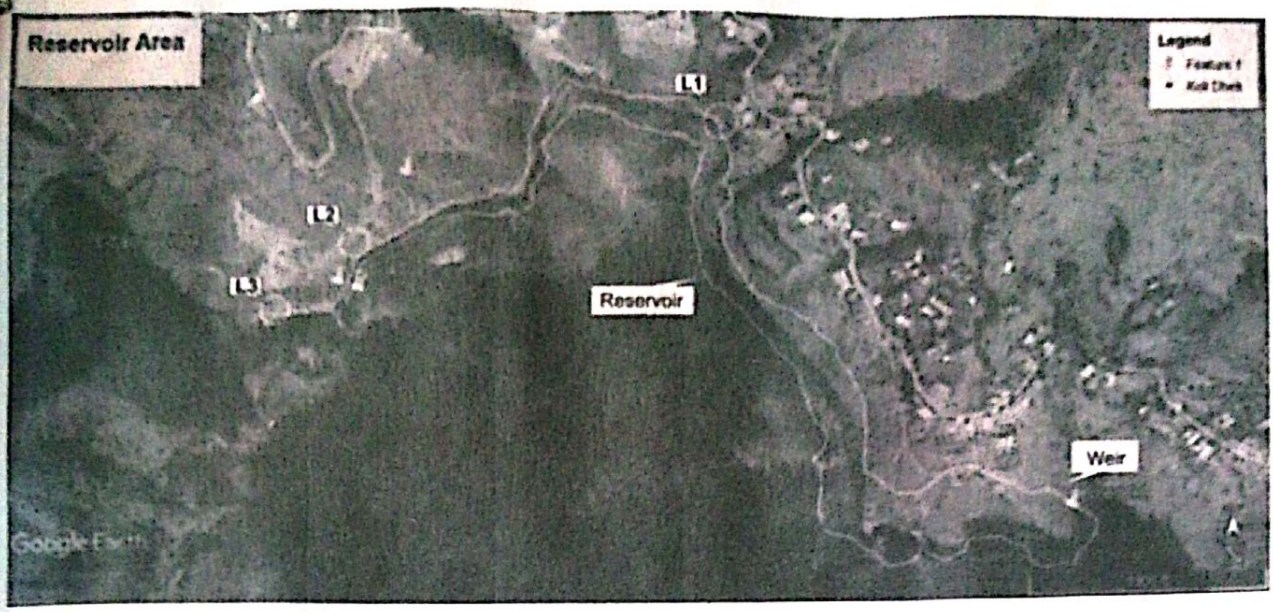

Fig.1 Reservoir area of Kolidekh artificial lake project as seen through Google Earth image

The middle portion of the left bank and the upper middle portion of the right bank slopes are covered by the agricultural lands. Since most of the lands on the either banks of the reservoir are terraced and gently inclined slopes, the slopes in general are considered to be stable under anticipated adverse conditions. The slopes along the river banks in the lower most reaches are generally rocky and form steep sections of low height. In these sections possibility of isolated rock failure may exist wherever kinematic conditions would be satisfied. However, such small failure may not have a potential to generate destructive waves that may adversely affect the stability of the project. Moreover, these steeper rock slope sections would be partially or fully submerged under reservoir water. A horizontal thrust would be exerted by the reservoir water which may improve the stability of the slope. Further, during reservoir operation rising and drawdown may bring changes in the material properties, particularly changes in the shear strength that may affect the stability of the slope section within the fluctuating zones. The rising of reservoir will saturate the overburden material and the rock mass sections and on the same time a horizontal thrust will also be provided by the reservoir. During drawdown minor changes are expected that may possibly destabilize the slopes. However, it will depend on the slope inclination, slope material, landuse, kinematic conditions and the shear strength properties of the slope material.

5. Conclusions

Finally, based on the topographical and geological considerations, prima facie, it may be concluded that the filling of the reservoir may not affect the stability conditions of the reservoir slopes. Thus, there seems to be no possibility of generation of destructive water wave in the reservoir due to any major slope failure under anticipated adverse conditions that may possibly affect the stability of the dam. Further, in the reservoir area along the left bank three slope sections, marked as L1, L2 and L3 (Fig.1) may require slope protection works. These locations have habitations and a road section well above the reservoir level. Slope protection at these locations will add to the safety of these features.

The inference drawn in this note is based on the review of the Geological and Geotechnical investigations, as presented in the DPR and through the satellite image interpretation. No systematic detailed studies were made to come up with quantitative evaluation of ground conditions. However, suggestions/ recommendations are forwarded on various aspects, as specified above, relevant to assess the slope stability condition in the reservoir area of the proposed project.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट/चम्पावत

भारत सरकार
Govt. of India

भारतीय भूवैज्ञानिक सर्वेक्षण, उत्तराखण्ड इकाई,
25/2, वसन्त विहार, देहरादून - 248006
उत्तराखण्ड
फोन नं0 - 0135-2762001, 2763004, 2762777(फैक्स)
Geological Survey of India, Uttarakhand Unit
25/2, Vasant Vihar, Dehradun-248006
Uttarakhand
Phone No - 0135-2762001, 2763004, 2762777(Fax)

2535

पत्रांक /630/यू/15/ऐ.एल.के/08-09 दिनांक 27.02.2009

27/2/09

प्रेषक

ऐ.के.जैन,
भूवैज्ञानिक वरिष्ठ
[illegible]
भारतीय भूवैज्ञानिक सर्वेक्षण,
जनपद-देहरादून । उत्तराखण्ड

सेवामें,

अधिशासी अभियंता,
सिंचाई निर्माण खण्ड,
लोहाघाट,
जनपद चम्पावत/ उत्तराखण्ड

विषय : कोलीढेक झील के भूवैज्ञानिक अन्वेषण पर एक निरीक्षण नोट ।

महोदय,

अधोहस्ताक्षरी द्वारा दिनांक 14, फरवरी, 2009 को लोहावती नदी के समीप कोलीढेक कृत्रिम झील परियोजना स्थल के अन्वेषण के संदर्भ में निम्न शीर्षक का निरीक्षण नोट आपको उचित कार्यवाही हेतु प्रेषित है।

"SECOND STUDY NOTE ON THE PROPSOED ARTIFICIAL LAKE ACROSS LOHAVATI RIVER, AT LOHAGHAT, DISTRICT CHAMPAVAT, UTTARAKHAND" by A.K.Jain

भवदीय,

संलग्नक : उपरोक्तानुसार

27/2/09

(ए.के.जैन)
भूवैज्ञानिक वरिष्ठ
भारतीय भूवैज्ञानिक सर्वेक्षण
(उत्तराखण्ड)

पत्रांक /यू/15/ऐ.एल.के/08-09 दिनांक 27.02.2009

प्रतिलिपि सूचनार्थ (संलग्नक सहित)
निदेशक, उत्तराखण्ड ईकाई, भारतीय भूवैज्ञानिक सर्वेक्षण, देहरादून ।

(ए.के.जैन)
भूवैज्ञानिक वरिष्ठ

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

SECOND STUDY NOTE ON THE PROPOSED ARTIFICIAL LAKE ACROSS LOHAVATI RIVER, AT LOHAGHAT, DISTRICT CHAMPAVAT.UTTRAKHAND.

By
A.K.Jain,
Geologist (Senior)
Uttrakhand Unit, Geological Survey of India, Dehradun.

On the request from the Executive engineer, Irrigation Construction Division, Lohaghat, District Champavat, geological investigation for the proposed artificial lake named as Kolidhek Lake across Lohavati River were under taken on 14th Feb. 2009. This is in continuation of the investigations carried out by this Department in the earlier field seasons also. The exploratory drill holes drilled on the left abutment on the two axes AA and BB and one hole in the river bed along AA axis were geologically logged in the last visit and drill hole no DH-7 to DH-10 were recommended and to be drilled after evaluation of the site by the design engineers . The summarized account of the geological logging is as under:

Drill hole No.DH- 7 :

This hole was drilled on the extreme end on the left side of the dam axis.

The hole was drilled for 26 meters and indicated 9m thick overburden comprising reddish brown colored clayey silt with fine sand. Further from 9m to 26m bluish grey to grey, hard and compact phyllites were encountered. The initial 30 cm depth of Phyllite is moderately to slightly weathered thereafter the rock is fresh. The rock is moderatey to closely jointed. The prominent joint plane is foliation joint dipping at 60^0. The core recovery varies from 40% to 70% and RQD values are between 9% and 40%.

Drill hole no. DH-8 :

This hole was drilled along the dam axis on the right bank.

The hole was drilled for 26m and indicated 2m thick overburden comprising reddish brown silt/clayey silt. The bed rock comprises bluish grey to grey hard and compact phyllite. The Rock is rich in mica content and moderately to slightly weathered from 2m to 11m. The rock contains staining and coating of silt/soil along joint planes in the upper zone. The rock below 11m depth is hard, compact and fresh. The rock is moderately to closely jointed. Foliation joints are the prominent joint planes. These foliation joints dip at 70^0 to 75^0 up to 17m depth and below 17m depth foliation joints dip ranges from 50^0-60^0. The core splits along the foliation joins. The other steep joint dips at 80^0 and is rough planer, was recorded between 20m and 23m depth. The core recovery is below 15% up to 17m and beyond 17m it is up to 35%. The RQD is between 5% and 25% only.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Drill hole no.DH-9:

This hole was drilled in top portion along the proposed spillway alignment.

The hole was drilled for 26m depth and has indicated Bluish grey to grey, hard and compact phyllites. The rock is moderately weathered up to 15m depth and slightly weathered from 15m to 18 m depth, beyond 18m the rock is fresh. Brownish colour in weathered rock zone and ferruginous coating along joint planes in fresh rock was also observed. The rock is closely jointed. The foliation dips varied 60^0 to 70^0. The core at many places splits along foliation joint. The core recovery up to 15m is below 20% and beyond this depth it is up to 38%. The RQD values ranges from 5% to 19% only.

Drill hole no DH-10 :

This hole was drilled in the middle portion along the proposed spillway alignment.

The hole was drilled for 26m depth and indicated 2m thick overburden comprising clayey silt with fine sand. Bluish grey to grey, hard and compact, phyllites were encountered in the entire depth. The rock is slightly weathered up to 18m depth and contains high degree of ferruginous staining/coating. Fresh rock with fine grained and at times slaty in nature was encountered from 18m depth onwards. The core recovery is below 20% up to 24m depth and in the last two meter zone it was 49%. The RQD values were below 15% only.

Drill hole no .DH-11:

This hole was suggested by the Design engineers.

The hole was drilled for 12m depth only. The hole has indicated 5m deep overburden comprising reddish brown clayey silt with fine sand. The bed rock was encountered below 5m depth. In the top one meter zone the rock is hard, compact, flaggy quartzitic phyllites, below this grey to bluish grey, hard and compact phyllites with quartz vein up to 2 cm thick were encountered. The rock is slightly weathered up to 8m depth below this rock is fresh Distortion of the foliation planes due to intrusion of quartz veins was noted in the cores. Pyrite specks were also observed in some core pieces. The foliation joints dipping around 70^0 are prominent one. The core recovery varies from 18% to 45% and RQD values were below 20%.

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27/2/09

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

भारत सरकार
Govt. of India

भारतीय भूवैज्ञानिक सर्वेक्षण, उत्तराखण्ड यूनिट,
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Geological Survey of India, Uttarakhand Unit
251/2, Vasant Vihar, Dehradun-248006
Uttarakhand.
Phone No.- 0135-2765097, 2763094, 2765097(Fax)

1007 पत्रांक 624 /अक/कुमाऊँ झील/2007 दिनांक 5.8.2008

प्रेषक

ऐ.के.जैन.
भूवैज्ञानिक वरिष्ठ
दल प्रमुख, कुमाँऊ परियोजनायें,
भारतीय भूवैज्ञानिक सर्वेक्षण,
जनवद-देहरादून । उत्तराखण्ड

सेवामें.

अधिशासी अभियंता.
सिंचाई निर्माण खण्ड.
लोहाघाट.
(जनपद चम्पावत) उत्तराखण्ड

विषय : कोलीढेक झील के भूवैज्ञानिक अन्वेषण पर एक निरीक्षण नोट ।

महोदय.

अद्योहस्ताक्षरी द्वारा दिनांक 22 से 27 जुलाई, 2008 को लोहावती नदी के समीप कोलीढेक कृत्रिम झील परियोजना स्थल के अन्वेषण के संदर्भ में निम्न शीर्षक का निरीक्षण नोट आपको उचित कार्यवाही हेतु प्रेषित है।

"STUDY NOTE ON THE PROPSOED ARTIFICIAL LAKE ACROSS LOHAVATI RIVER, AT LOHAGHAT. DISTRICT CHAMPAVAT. UTTARAKHAND" by A.K.Jain

संलग्नक : उपरोक्तानुसार

भवदीय,

(ए.के.जैन)
भूवैज्ञानिक वरिष्ठ एवम्
दल प्रमुख, कुमाँऊ परियोजनायें

पत्रांक /अक/कुमाऊँ झील/2007 दिनांक 5.8.2008

प्रतिलिपि सूचनार्थ (उपलब्ध सहित)
निदेशक, उत्तराखण्ड इकाई, भारतीय भूवैज्ञानिक सर्वेक्षण, देहरादून ।

(ए.के.जैन)
भूवैज्ञानिक वरिष्ठ एवम्
दल प्रमुख, कुमाँऊ परियोजनायें

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

सिंचाई निर्माण खण्ड लोहार
पत्रांक 1552
दिनांक 13/8/08
फाईल नं०

STUDY NOTE ON THE PROPOSED ARTIFICIAL LAKE ACROSS LOHAVATI RIVER, AT LOHAGHAT, DISTRICT CHAMPAVAT.UTTRAKHAND.

By
A.K.Jain,
Geologist (Senior)
Uttrakhand Unit, Geological Survey of India, Dehradun.

On the request from the Executive engineer, Irrigation Construction Division, Lohaghat District Champavat, geological investigation for the proposed artificial lake named as Kolidhek Lake across Lohavati river were under taken between 22nd July 2008 and 27th July2008.This is in continuation of the investigations carried out by this Department in the earlier field seasons also. The exploratory drill holes drilled on the left abutment on the two axis AA and BB and one hole in the river bed along AA axis were geologically logged. The summarized account of the geological logging is as under:

Drill hole no DH-.1 was drilled for 27m depth, on the left abutment of the river at the lower most portion along the proposed barrage axis. The hole revealed the presence of 5.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter in the upper three meter and another two meter depth comprises boulder of hard phyllitic rock. The bed rock comprises hard and compact massive phyllites. This rock is slightly weathered up to 9 meter depth below which the rock is fresh and contains thick quartz vein the upper portion of the fresh rock. The dips of foliation \bedding planes are between 40^0 and 50^0. The core recovery ranges from 20% 78%.

Drill hole no. DH-2 was drilled for 28 m depth, on the left abutment of the river at the middle portion along the proposed barrage axis. The hole revealed the presence of 5.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter in the upper three meter and another two meter depth comprises boulder of hard phyllitic rock. The bed rock comprises hard and compact massive phyllites. This rock is slightly weathered up to 7 meter depth below which the rock is fresh. The dip of foliation \bedding planes varies from 50^0 to 60^0 core recovery ranges from 33 to75%.

Drill hole no. DH-3 was drilled for26m, on the left abutment of the river at the upper middle portion along the proposed barrage axis. The hole revealed the presence of 4.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter. The bed rock comprising hard and compact, jointed. phyllites. This rock is slightly weathered up to 6 meter depth below which the rock is fresh.. The dip of foliation \bedding planes varies from 50^0 to 60^0 core recovery ranges from30% to 60%.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Drill hole no. DH-4 was drilled for27m. on the left abutment at BB axis in the lower middle portion along the proposed barrage axis. The hole revealed the presence of 3.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter.. The bed rock comprises grey hard and compact, jointed, phyllites. This rock is moderately to slightly weathered up to 7 meter depth below which the rock is fresh.. The dip of foliation \bedding planes varies from 50^0 to 60^0 core recovery ranges from 30% to 45%. A shear zone was interpreted between 21m and 24 m depth on the basis of fine grey sludge.

Drill hole no. DH-5 was drilled for27m, on the left abutment at BB axis in the upper middle portion along the proposed barrage axis. The hole revealed the presence of 8.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter.. The bed rock comprises grey hard and compact, jointed, phyllites. This rock is moderately to slightly weathered from 8 meter to 16 meter depth below which the rock is fresh.. The dip of foliation \bedding planes varies from 50^0 to 60^0 core recovery ranges from 16% to 28%. A shear zone was interpreted between 21.5 m and 23 m depth on the basis of fine grey sludge.

Drill hole no 6 was drilled for 15 m depth in the river bed portion on the AA axis. The bed rock comprising grey, hard and compact, massive phyllites were met in the entire drilled depth.. The dips of the bedding plane vary from 40^0 to 60^0. The core recovery ranges from18% to 48%.

The preliminary analysis of the drilling data indicate that the overburden thickness ranges from 4 to 5 meters and 2 to 4 meter weathered rock zone above the fresh bed rock along AA axis on the left abutment . The overburden thickness on the left abutment along BB axis varies from 3 meter to 8 meters and 4 meter to 8 meter weathered rock zone lies on the fresh bed rock and a shear zone was also interpreted between 21 meter and 24 meter depth. In the river bed section around AA axis hard fresh bed rock was encountered from the start of the hole.

On the basis of the present subsurface data Axis AA appears to be more suitable for weir as the fresh bed rock on the left abutment will be available at 7 to 9 meter depth in comparison to BB axis where it will be available between 7 and 16 meter depth. From engineering point of view the civil design engineers should also evaluate the site after physical inspection. If found suitable from engineering side also it further required exploring over burden and weathered rock thickness on the left abutment extreme end portion by one drill hole. Right abutment and spillway structure on the right side also required to be explored by three drill holes. The location of the holes have been shown to the project engineers at site as well as also marked on the contour plan.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोसाघाट /चम्पावत

- At the time of site inspection the location of the reference pillars on the ground as well as on contour plan and the precise location of the drilled holes on the contour plan were not marked.

- The contour plan with grid reference and axis reference pillars should be prepared and marked at site a copy of such plan is supplied to this department also.

- The details of the drilled holes as per the enclosed proforma are to be supplied.

- The water percolation test in the bed rock should be carried out and minimum three reading should be taken for each pressure.

(डी० के० जैन)
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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

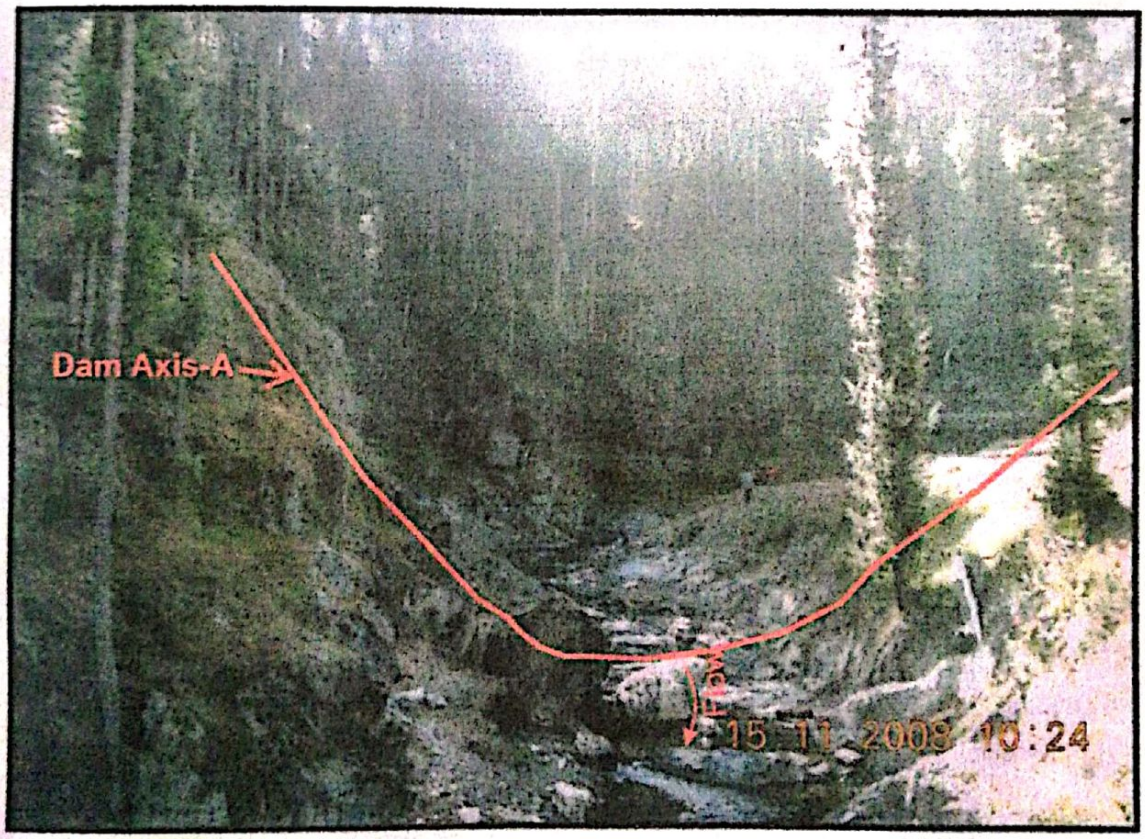
Irrigation Construction Division,

Lohaghat, Champavat (Uttarakhand)

Detailed Project Report

Kolidhek Artificial Lake Project

District : Champavat (Uttarakhand)



Prepared by:

Alternate Hydro Energy Centre
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March, 2009

CHAPTER – 2

PRELIMINARY GEOLOGICAL INVESTIGATIONS

2.1 INTRODUCTION

The project envisages creation of an artificial Lake by constructing a concrete/ gravity dam of 15 m high and 65 m in length across the river Lohawati near village Kolidhek in District Champavat in Uttarakhand State. to promote tourism, minor irrigation and drinking water supply to town and its vicinity. The project site is located about 2 km from Lohaghat Town on Lohaghat-Devidhura road. The area of investigation falls in survey of India toposheet No. 63 C/3. The project area falls under seismic zone-V of seismic zoning map of India.

The detailed geological mapping of the project site was carried out during the period between 30th May and 4th June 2005 in pursuance of GSI field season programme 2004-05 where in the item of investigation was included as an additional item. An inspection visit was also paid to the project site at the request of the District Magistrate, Champavat and the Executive Engineer Irrigation Construction Division, Lohaghat, on 24th Feb 2005.

The area experiences tropical climate with seasonal variation. Rains are common throughout the year; however, regular monsoon starts from June and continue upto October. The area is generally covered by thick forest but at places, few barren hills also seen. The main flora consists of Chirr, Deodar, Nashpaati and Chameli. The area around dam site and reservoir area are covered with thick forest of Deodar trees.

This report deals with the geological investigations carried out at dam sites and part of reservoir area of Kolidhek Artificial Lake Project in the FS 2004-05. The investigation taken includes detailed geological mapping of dam sites and part of reservoir area to delineate different lithological units, structural units, overburden rock contact, assess general rock mass conditions and to finalise the dam axis.

2.2 GENERAL GEOLOGY OF THE PROJECT AREA

In the area alternating sequences of Sandstone, Siltstone and Shale, of the Siwalik Group are exposed upto Sukhidong. The Bhimtal Formation sandwitched between Main Boundary Fault (MBF) in the south and Ramgarh thrust in the North comprises purple to pale green quartzite with phyllite and chlorite schist and metavolcanics. The formation close to the thrust is sheared and pulverized, at places.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Ramgarh Group of rocks, bounded by South Almora Thrust (SAT) in the North and Ramgarh thrust in the South, consists of phyllite, gneiss, porphyries, quartzite and chlorite schist. Further north, these are followed by the Almora Crystalline Group, comprising garnetiferous mica schist carbonaceous phyllite, slates, augengneiss, granite and granodiorite. Near Ghat the Crystalline Group of rocks separated by shale, phyllites, limestone and dolomite of Garhwal Group are exposed. Quanternary deposits occur in the form of river terraces, flood pain and riverbed deposits, debris/ talus deposits and reworked debris in the area.

2.3 GEOLOGY OF DAM SITE AND PART OF RESERVOIR AREA

The detailed geological mapping (Fig. 1.2) on 1:1000 scale, using total station, was carried out at the proposed dam site area and its reservoir area (upto chainage 700 m). An area of 1,25,000 m^2 was covered. Geological mapping in the current season was taken up with the aim to delineate different lithological units, structural units, overburden, rock contacts, assess general rockmass conditions and to finalise the dam axis.

At the proposed dam axis 'A' and 'B', grayish coloured, hard and massive phyllites are exposed. On the right bank, insitu rocks are exposed with in vegetation upto an elevation ± 1718 m from the riverbed, (± 1694). The rock are also exposed in the riverbed section on the both sites. The width of river at these sites ranges from 10 to 15 m (Fig. 1.2).

On the left bank, along the dam axis 'B' the rocks are exposed upto an EL. ± 1706 m from the riverbed. Beyond this, the area is occupied with overburden material/ soil cover upto a considerable distance. The river section at this site is covered with massive phyllite rocks, which are very hard and compact in nature.

On the left bank, along the dam axes 'A', the rocks are exposed between riverbed level (±1699) and EL. ±1700m. At this site the area between EL. ±1700 and ±1710 is covered with soil/overburden materials. Beyond EL. ±1710 the scanty outcrop of insitu rocks area seen exposed with in cover of overburden material and soil.

The foliation of rocks at these sites, in general, trends N 60° – 70° W – S 60° – 70° E direction with 30° and 60° dip in north easterly direction. The following sets of joint have been observed. The foliation joints are the prominent joints in the area.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

S. No.	Strike	Dip/amount and direction	Description
1	N60°W-S60°E	30°NE	Spacing 2 to 5 cm tight, moderate smooth.
2	N65°-70°W-S65°-70°E	60°NE	Smooth and tight, iron stained
3	N-S to N 10°W-S10°E	50°-60°W to S 80°W	Smooth, tight, spacing 5 cm to 20 cm
4	N 55°E-S55°W	75°NW	Smooth, tight
5	N70°E-S70°W	15°SE	Smooth, tight
6	N40°W-S40°E	27°SW	Spacing 2 cm to 5 cm, rough, tight, iron stained.

In absence of any subsurface data, it is not possible at this stage to comment on the depth of acceptable foundation rock on the left bank for both the alternative sites. However, on the basis of available surface data and the tentative geological section drawn along dam axis it is anticipated that the overburden material would be upto a depth of 2 to 6 m. But this needs confirmation by putting few drill holes down to fresh rock level in consultation with geologists.

The reservoir area, which will have a 1.6 km^2 spread, is located mainly on grayish coloured hard and compact phyllites of Manila Formation. The rocks in the reservoir area generally strike N 40° to 60°W – S 40° to 60° E and dip 30° to 70° in northeasterly direction. Variation in attitude of rocks have also been observed at places. The following joint sets are observed in the area. The foliation joint are the prominent joints in the area.

i.	N-S/55°E°	Tight, rough, spacing 2 to 5 cm, 0.5 continuity
ii.	E-W/Vertical	Spacing 5 to 10 cm, tight, rough 0.5 m continuity
iii.	N 60° E-S40° W/60°SE	Spacing 2 to 10 cm tight rough iron stained, 0.5 cm continuity
iv.	N 40° E – S 40°W/50°NW	Rough, stained, spacing 5 to 25 cm, continuity 20 cm
v.	N 70° E – S 70° W/60° NW	Tight, rough.
vi.	N 450 ° W – S 450 ° E/150 ° SW	Spacing 5 to 20 cm, moderately smooth, continuity 0.5 m.
vii.	N 40 ° W – S40 ° E/50 ° SW	On 5 to 0.5 m spacing, stained, tight, rough

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट / चम्पावत

The entire area of reservoir is devoid of any overburden materials except at certain location where few rolled blocks of quartz vein associated with host rocks and RBM are seen in the river bed section. The exposures of rocks are observed in riverbed section on proposed reservoir area upto a height of 3 to 10 m on the either bank. Scanty outcrops are also seen exposed on left bank of reservoir area.

The slopes on the right and left banks of the proposed reservoir area are largely terraced, gentle and occupied by barren agriculture lands. The hill slopes on both the banks of the proposed reservoir area, are stable except at few locations where the vertical slope with thick vegetation exist and dips towards the valley. The Dam is located in known seismically sensitive Himalayan Region and it would be necessary to adopt a suitable seismic factor in the design of the dam.

2.4 CONCLUSIONS AND RECOMMENDATIONS

2.4.1 Detailed geological mapping on 1:1000 scale at dam site area was completed in this field season and contacts of different rock types and of rock and overburden mass were delineated. In the area mainly phyllites of Manila Formation are present. As the thickness of overburden/soil material is tentative, it is recommended to explore the left bank area of the proposed dam sites by fiver drill holes (location is given in the plate-I) to know the subsurface geological condition and decide about acceptable foundation medium and dam axis. Water percolation tests may also be conducted as per BIS codes is the holes. These holes should be drilled for a depth 25 m each (at least 5 m in bed rock).

2.4.2 The rock types present in and around dam site and reservoir area are phyllites (Manila Formation) of Kumaon Super Group. Regionally, these rocks are intruded by granodiorities of Champavat, dipping 30° to 60° in northeasterly direction. The left bank area of dam sites is covered with overburden materials and bedrock is expected to be at the depth of 2 to 6 m. This need to be confirmed by subsurface exploration by mean of drilling at suitable locations.

2.4.3 The left bank area of dam site 'A' and 'B' should also be explored by drilling followed by water percolation tests with a view to decipher the subsurface geological

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

condition and acceptable foundation medium; albeit both the sites, prima facie, appear to be feasible.

2.4.4 On the basis of the desired subsurface data, final decision would be taken up as regard to the choice of dam axis and height of the dam and also to comment on the acceptable foundation level.

2.4.5 Geomechanical properties like compressive strength, modules of elasticity, shear parameters and other laboratory/insitu tests should be conducted, for evaluation of rock mass parameters.

2.4.6 The Dam is located in a known seismic region and it would be necessary to adopt a suitable seismic factor in the design of the dam.

2.4.7 Project authorities are also advised to workout the layout of dam and other appurtenant structures in consultation with designers for taking up further engineering geological investigations.

2.5 EXPLORATORY DRILL HOLES

As per the recommendations of the geologist above, the investigations of the subsurface strata were carried out by GSI through drill holes suggested by GIS and design engineers. The exploratory drill holes drilled on the left abutment on the two axis A and B and one hole in the river bed along axis A were geologically logged. The locations of these drill holes are shown in Fig. 1.2. The detailed observations of geological logging as recorded during drilling are given in Appendix-2.1. The summarized account of the geological logging is as under:

Drill hole no. DH-1 was drilled for 27 m depth, on the left abutment of the river at the lower most portions along the proposed barrage axis. The hole revealed the presence of 5.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter in the upper three meter and another two meter depth comprises boulder of hard phyllitic rock. The bed rock comprises hard and compact massive phyllites. This rock is slightly weathered upto 9 meter depth below which the rock is fresh and contains thick quartz vein the upper portion of the fresh rock. The dips of foliation / bedding planes are between 40° and 50°. The core recovery ranges from 20% to 78%.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Drill hole no. DH-2 was drilled for 28 m depth, on the left abutment of the river at the middle portion along the proposed barrage axis. The hole revealed the presence of 5.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter in the upper three meter and another two meter depth comprises boulder of hard phyllitic rock. The bed rock comprises hard and compact massive phyllites. This rock is slightly weathered upto 7 meter depth below which the rock is fresh. The dip of foliation / bedding planes varies from 50° to 60° core recovery ranges from 33 to 75%.

Drill hole no. DH-3 was drilled for 26 m, on the left abutment of the river at the upper middle portion along the proposed barrage axis. The hole revealed the presence of 4.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter. The bed rock comprising hard and compact, jointed, phyllities. This rock is slightly weathered upto 6 meter depth below which the rock is fresh. The dip of foliation/bedding planes varies from 50° to 60° core recovery ranges from 30% to 60%.

Drill hole no. DH-4 was drilled for 27 m, on the left abutment at BB axis in the lower middle portion along the proposed barrage axis. The hole revealed the presence of 3.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter. The bed rock comprises grey hard and compact, jointed, phyllites. This rock is moderately to slightly weathered upto 7 meter depth below which the rock is fresh. The dip of foliation/bedding planes varies from 50° to 60° core recovery ranges from 30% to 45%. A shear zone was interpreted between 21 m and 24 m depth on the basis of fine grey sludge.

Drill hole no. DH-5 was drilled for 27 m, on the left abutment at BB axis in the upper middle portion along the proposed barrage axis. The hole revealed the presence of 8.0 meter thick overburden material comprising yellowish brown silty soil with clayey matter. The bed rock comprises grey hard and compact, jointed, phyllites. Thick rock is moderately to slightly weathered from 8 meter to 16 meter depth below which the rock is fresh. The dip of foliation/bedding planes varies from 50° and 60° core recovery ranges from 16% to 28%. A shear zone was interpreted between 21.5 and 23 m depth on the basis of fin grey sludge.

Drill hole no. DH-6 was drilled for 15 m depth in the river bed portion on the A axis. The bed rock comprising grey, hard and compact, massive phyllites were met in the entire drilled depth. The dips of the bedding plane vary from 40° to 60°. The core recovery ranges from 18% to 48%.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Drill hole no. DH-7 This hole was drilled on the extreme end on the left side of the dam axis. The hole was drilled for 26 meters and indicated 9 m thick overburden comprising reddish brown colored clayey silt with fine sand. Further from 9 m to 26 m bluish grey to grey, hard and compact phyllites were encountered. The initial 30 cm depth of Phyllite is moderately to slightly weathered thereafter the rock is fresh. The rock is moderately to closely jointed. The prominent joint plane is foliation joint dipping at 60°. The core recovery varies from 40% to 70 and RQD values are between. 9% and 40%.

Drill hole no. DH-8 This hole was drilled along the dam axis on the right bank. The hole was drilled for 26 m and indicated 2 m thick overburden comprising reddish brown silt/clayey silt. The bed rock comprises bluish grey to grey hard and compact phyllite. The Rock is rich in mica content and moderately to slightly weathered from 2 m to 11 m. The rock contains staining and coating of silt/soil along joint planes in the upper zone. The rock below 11 m depth is hard, compact and fresh. The rock is moderately to closely jointed. Foliation joints are the prominent joint planes. These foliation joints dip at 70° to 75° up to 17 m depth and below 17 m depth foliation joints dip ranges from 50°-60°. The core splits along the foliation joins. The other steep joint dips at 80° and is rough planer, was recorded between 20 m and 23 m depth. The core recovery is below 15% up to 17 m and beyond 17 m it is up to 35%. The RQD is between 5% and 25% only.

Drill hole no.DH-9 This hole was drilled in top portion along the proposed spillway alignment. The hole was drilled for 26 m depth and has indicated Bluish grey to grey, hard and compact phyllites. The rock is moderately weathered up to 15 m depth and slightly weathered from 15 m to 18 m depth, beyond 18 m the rock is fresh. Brownish colour in weathered rock zone and ferruginous coating along joint planes in fresh rock was also observed. The rock is closely jointed. The foliation dips varied 60° to 70°. The core at many places splits along foliation joint. The core recovery up to 15 m is below 20% and beyond this depth it is up to 38%. The RQD values ranges from 5% to 19% only.

Drill hole no. DH-10 This hole was drilled in the middle portion along the proposed spillway alignment. The hole was drilled for 26 m depth and indicated 2 m thick overburden comprising clayey silt with fine sand. Bluish grey to grey, hard and compact, phyllites were encountered in the entire depth. The rock is slightly weathered up to 18 m depth and contains high degree of ferruginous staining/coating. Fresh rock with fine grained and at times slaty in

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट / चम्पावत

nature was encountered from 18 m depth onwards. The core recovery is below 20% up to 24 m depth and in the last two meter zone it was 49%. The RQD values were below 15% only.

Drill hole no. DH-11 This hole was suggested by the design engineers. The hole was drilled for 12 m depth only. The hole has indicated 5 m deep overburden comprising reddish, brown clayey silt with fine sand. The bed rock was encountered below 5 m depth. In the top one meter zone the rock is hard, compact, flaggy quartzitic phyllites, below this grey to bluish grey, hard and compact phyllites with quartz vein up to 2 cm thick were encountered. The rock is slightly weathered up to 8 m depth below this rock is fresh distortion of the foliation planes due to intrusion of quartz veins was noted in the cores. Pyrite specks were also observed in some core pieces. The foliation joints dipping around 70° are prominent one. The core recovery varies from 18% to 45% and RQD values were below 20%.

2.6 CONCLUSIONS

The preliminary analysis of the drilling data indicate that the overburden thickness ranges from 4 to 5 meters and 2 to 4 meter weathered rock zone above the fresh bed rock along A axis on the left abutment. The overburden thickness on the left abutment along B axis varies from 3 meter to 8 meters and 4 meter to 8 meter weathered rock zone lies on the fresh bed rock and a shear zone was also interpreted between 21 meter and 24 meter depth. In the river bed section around axis-A, hard fresh bed rock was encountered from the start of the hole.

On the basis of the present subsurface data axis-A appears to be more suitable for weir as the fresh bed rock on the left abutment will be available at 7 to 9 meter depth in comparison to axis-B where it will be available between 7 to 16 meter depth. From engineering point of view the civil design engineers should also evaluate the site after physical inspection. If found suitable from engineering side also if further required exploring over burden and weathered rock thickness on the left abutment extreme end portion by one drill hole. Right abutment and spillway structure on the right side also required to be explored by three drill holes. The location of the holes have been shown to the project engineers at site as well as also marked on the contour plan.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
गोहाघाट /चम्पावत

Geologist
GSI, Dehradun

DESIGN OF NON-OVER FLOW SECTION OF CONCRETE DAM

The concrete or gravity dam is proposed for Kolidhek lake. The design data are as follow:

DESIGN DATA

1.	Top of dam	= El. 1714.0 m
2.	Top width	= 5.0 m
3.	River bed level at dam site	= El. 1694.0 m
4.	Rock level in deeper river course at dam axis	= El. 1693 m
5.	Maximum water level/FRL in lake	= El. 1712 m
6.	Crest level of spillway	= El. 1708 m
-	Tail water level	= El. 1698 m

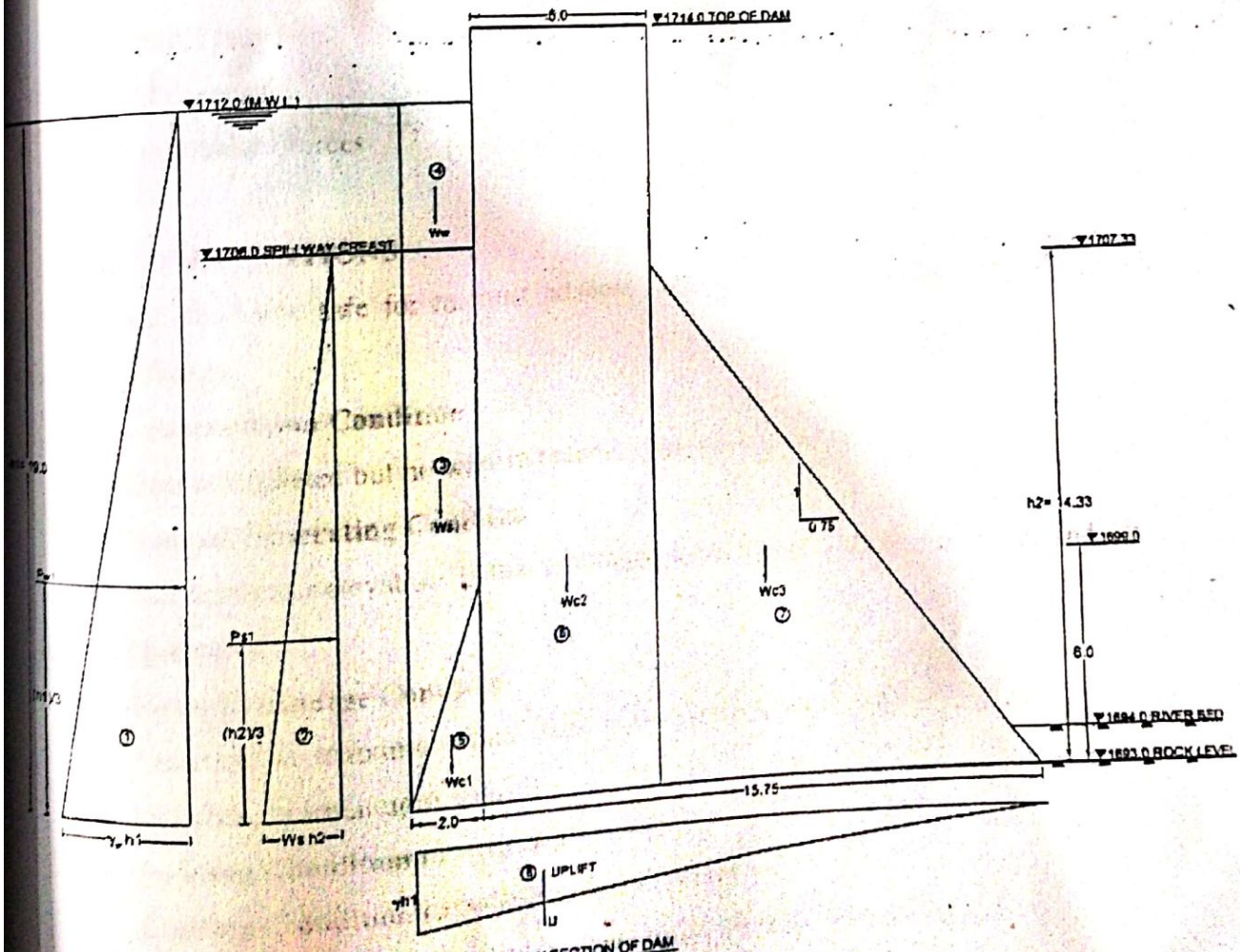

FIG - 1 MAXIMUM NON-OVER FLOW SECTION OF DAM

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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट/चम्पावत

STABILITY REQUIREMENT

Consider the maximum section of non-over flow portion of dam as shown in above Figure. esign shall satisfy the following requirements of stability as per IS 6512-1984.

a) The dam shall be safe against over turning at any plane within the dam or at the base.

b) The dam shall be safe against sliding on any plane within the dam, at the foundation or within the foundation.

c) The safe unit stresses in the concrete of the dam or in the foundation material shall not be exceeded the permissible limit.

FORCES CONSIDERED IN THE STABILITY ANALYSIS

Following forces are considered for the design of dam:

a) Dead load of concrete dam (W_c)

b) Water Pressure in u/s (P_{w1}) and Water Pressure in d/s (P_{w2})

c) Uplift Pressure

d) Silt Pressure

e) Earthquake forces

LOAD COMBINATIONS

The design shall be safe for the most adverse loading condition given below using the vable safety factors:

a) **Construction Condition**

Dam completed but no water in reservoir and no tail water.

b) **Normal Operating Condition**

Full reservoir elevation, normal dry weather tail water. normal uplift, ice and silt (if applicable)

c) **Flood Discharge Condition**

Reservoir at maximum flood pool elevation, all gates open, tail water at flood elevation, normal uplift and silt.

d) **Loading Condition (a) with Earthquake**

e) **Loading Condition (b) with Earthquake, but no Ice**

f) **Loading Condition (c) with extreme uplift (drains inoperative)**

g) **Loading condition (e) with extreme uplift**

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सह... ...i अथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

NALYSIS FOR SAFETY – UNDER NORMAL OPERATING CONDITION (b)

he dam section shall be designed for normal operating condition and will be checked in ading conditions. Different loads and bending moment acting on the dam section are d and tabulated below:

Loads (T/m)		Eccentricity from dam toe (m)	Moment about dam toe (T.m/m)		Remarks
Horizontal	Vertical		Clockwise	Anticlockwise	
180.50	-	6.33	1142.57	-	Factor of Safety against over turning $= \frac{5812.45}{3339.96}$ = 1.74
40.5	-	5.00	202.5	-	
-	32.00	16.81	-	537.92	
-	22.20	16.83	-	373.63	
-	14.40	16.42	-	236.45	
-	252	13.25	-	3339	
-	184.86	7.17	-	1325.45	
-	(-) 168.63	11.83	1994.89	-	
ΣH = 221.0	**ΣW = 336.83**		**Σ 3339.96**	**Σ 5812.45**	

In Fig. 1, we have following loads

(i) Horizontal Pressure (P_{W1})

$$= \frac{1}{2} \gamma_w h_1 h_1$$

$$= \frac{1}{2} \times 1000 \times (1712.0 - 1693.0)^2 \text{ kg/m}$$

$$= 180.5 \text{ T/m}$$

(ii) Horizontal Silt Pressure (P_s)

$$= \frac{1}{2} W_s h_2 h_2$$

$$= \frac{1}{2} \times 360 \times (1708 - 1693)^2 \text{ kg/m}$$

$$= 40.50 \text{ T/m}$$

(iii) Vertical Water Load (W_w)

$$= 1000 \times \frac{(13+19)}{2} \times 2 \text{ kg/m}$$

$$= 32 \text{ T/m}$$

(iv) Vertical Silt Weight (W_{s1})

$$= 925 \frac{(9+15)}{2} \times 2 \text{ kg/m}$$

$$= 22.20 \text{ T/m}$$

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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

(v) Vertical Concrete Load (W_{c1}) $= \frac{1}{2} \times 2.0 \times 6 \times 2400$ kg/m

$= 14.4$ T/m

(vi) Vertical Concrete Load (W_{c2}) $= 2400 \times 21 \times 5$ kg/m

$= 252$ T/m

(vii) Vertical Concrete Load (W_{c3}) $= 2400 \times \frac{1}{2} \times 10.75 \times 14.33$ kg/m

$= 184.86$ T/m

(viii) Uplift Vertical Load (u) $= \frac{1}{2} \times 1000 \times 19 \times 17.75$ kg/m

$= 168.63$ T/m

Stability Against Over Turning

A gravity dam is considered safe against overturning if the criteria of no tension on the u/s re satisfied. The stresses at heel and toe are given by:

$$\sigma_{1,2} = \frac{\Sigma W}{T}\left(1 \pm \frac{6e}{T}\right)$$

Stresses with uplift

Let $\bar{x}$ be the distance of resultant from toe where it cuts the base, then

$\bar{x} \times 336.83 = 5812.45 - 3339.96$

or $\bar{x} = 7.34$ m

Now eccentricity of resultant force from the centre of base

$$e = \frac{17.75}{2} - 7.34$$

$= 1.535$ m (thus eccentricity lies within two third of base width)

$$\sigma_{1,2} = \frac{336.83}{17.75} \pm \frac{336.83 \times 1.535 \times 6}{17.75^2}$$

$= 18.97 \pm 9.85$

$= 28.82$ T/m^2, 9.12 T/m^2 (within safe limit and no tension at heel)

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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Stresses without uplift

$\Sigma W = 505.46$ T/m

$$\bar{x} = \frac{5812.45 - 1345.07}{505.46} = \frac{4467.38}{505.46}$$

or $\bar{x} = 8.84$ m

$$e = \frac{17.75}{2} - 8.84 = 0.035 \text{ m}$$

$$\text{So, } \sigma_{1,2} = \frac{505.46}{17.75} \pm \frac{505.42 \times 0.035 \times 6}{17.75^2}$$

$= 28.48 \pm 0.34$

$= 28.82$ T/m^2, 28.14 T/m^2

Since there is no tension developed at u/s face and the bearing stresses on the rock tion is also within safe limit. Hence, the dam section is found safe against over turning. The f safety against over turning is given by:

$$\text{F.O.S.} = \frac{5812.45}{3339.96} = 1.74 > 1.0 \text{ (O.K.)}$$

Stability Against Sliding

The tendency of sliding the dam section at any horizontal plane is resisted by the frictional ear resistance of the concrete or the foundation. The factor of safety against sliding (F_s) may culated as:

$$F_s = \frac{\frac{\Sigma W \tan \phi}{F\phi} + \frac{CA}{F_c}}{P}$$

Where,

ΣW = algebrical sum of all vertical forces = 336.83 T/m

$\tan \phi$ = coefficient of internal friction of the material

C = Cohesion of material

A = Area under consideration for cohesion = 17.75 m^2

F_ϕ = Partial factor of safety in respect of friction = 1.5 for load condition (b)

F_c = Partial factor of safety in respect of cohesion = 3.6 for load condition (b)

P = Total horizontal force = 221 T/m

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सहायक अभियंता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

The value of ϕ and C for concrete to rock at foundation level may be taken 36^0 and 20 t/m^2 respectively. Thus,

$$F_s = \frac{\frac{336.83 \tan 36}{1.5} + \frac{20 \times 17.75}{3.6}}{221}$$

$$= \frac{261.76}{221}$$

$$= 1.2 > 1.0$$

(safe against sliding)

CHECKING IN CONSTRUCTION CONDITION (a)

The dam is completed and no water in u/s & d/s of dam. Here,

$\Sigma W_c = 14.40 + 252 + 184.86$

$= 451.26$ T/m

ΣM about dam toe $= 236.45 + 3339 + 1325.45$

$= 4900.9$ T.m/m

Stability Against Over Stressing at Foundation

Let $\bar{x}$ be the distance of resultant of vertical load, from toe where it cut the base.

$$\bar{x} \times 451.26 = 4900.9$$

$$\bar{x} = 10.86 \text{ m}$$

$$e = \frac{17.75}{2} - 10.86 = 1.985 \text{ m}$$

$$\sigma_{1,2} = \frac{451.26}{17.75} \pm \frac{451.26 \times 1.985 \times 6}{17.75^2}$$

$= 25.43 \pm 17.06$

$= 42.49$ T/m^2, 8.27 T/m^2 (within safe limit)

CHECKING UNDER FLOOD DISCHARGE CONDITION

Here the maximum water level during flood condition is same as FRL and tail water depth ve foundation level will be 5.0 m. Hence the section designed under normal operating dition will also be safe under flood condition.

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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट / चम्पावत

8.0 CHECKING UNDER LOADING CONDITION (b) WITH EARTHQUAKE

Earthquakes impart accelerations to the dam which usually increase the effective loadings on the dam. The u/s movement of foundation due to earthquake increases the downstream force of water and silt loads, similarly d/s movement of foundation due to earthquake, decreasing the effective weight of the water & silt above a sloping face and of concrete in the dam. Both increasing the horizontal loads in a d/s direction and decreasing the effective weight tend to decrease the stability of the dam. Therefore, in the design of concrete dam, the earthquake forces shall be considered in addition to hydro dynamic pressure due to reservoir.

(i) Horizontal Earthquake Forces

The project site lies in seismic zone-IV. As per IS 1983-1984 the hydro dynamic pressure (P_e) due to horizontal earthquake at any depth 'y' below reservoir surface is given by the equation:

$p_e = C_s \cdot \alpha_h \gamma h$

$= 0.726 \cdot 1.5 \cdot 0.15 \cdot 1.0 \times 19 = 3.10\ T/m^2$

Total hydro dynamic horizontal force due to earthquake

$P_e = 0.726 \cdot p_e \cdot h$

$= 0.726 \times 3.10 \times 19 = 42.76\ T/m$

and over turning moment due to earthquake (horizontal)

$M_e = 0.299 \cdot p_e \cdot h^2$

$= 0.299 \times 3.1 \times 19^2$

$= 256.27\ T.m/m$

(ii) Vertical Earthquake Forces

The seismic coefficient in vertical direction $= 0.75 \times \alpha_h$

$= 0.75 \times 0.15 = 0.1125$

The effect of vertical earthquake is to reduce the weight of the concrete by the vertical seismic factor.

$\Sigma(W_e) = 0.1125 \times \Sigma W_c$

$= 0.1125 \times 451.24$

$= 50.76\ T/m$

This force will act at C.G. of the section i.e. at 10.86 m from toe. Thus moment due to vertical earthquake about toe.

$= 50.76 \times 10.86$

$= 551.25\ T.m/m$

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सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट/चम्पावत

8.1 Checking Against Over Turning

a) **In downward and u/s earthquake accelerations**

$\bar{x}$ (336.83 – 50.76) = 5812.45 – 3339.96 – 256.27 – 551.25

$\bar{x}$ (286.07) = 1664.97

$\bar{x}$ = 5.82 m

$$e = \frac{17.75}{2} - 5.82$$

= 3.05 m

$$\sigma_{1,2} = \frac{286.07}{17.75} \pm \frac{286.07 \times 3.05 \times 6}{17.75^2}$$

= 16.11 ± 16.62

= - 0.51 T/m^2, 32.73 T/m^2 (Tension is allowed upto 2% of compressive strength of concrete). Hence safe.

b) **In upward and u/s earthquake accelerations**

$\bar{x}$ (336.83 + 50.76) = 5812.45 – 3339.96 – 256.27 – 551.25

$\bar{x}$ = 2767.47 / 387.59 = 7.14 m

$$e = \frac{17.75}{2} - 7.14$$

= 1.735 m

$$\sigma_{1,2} = \frac{387.59}{17.75} \pm \frac{387.59 \times 1.735 \times 6}{17.75^2}$$

= 21.84 ± 12.81

= 34.65 T/m^2, 9.03 T/m^2 (under safe limit)

8.2 **Checking Against Sliding**

$$F_s = \frac{\frac{286.07 \tan 36}{1.2} + \frac{20 \times 17.75}{2.4}}{(221 + 42.76)}$$

$$= \frac{321.12}{263.76} = 1.22 \text{ (O.K.)}$$

Thus, the dam section shown in Fig. 1 is found safe under all the critical load combination conditions, hence it may be adopted.

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

Drinking water Calculation

1- Capacity of reservoir = 0.45 mcm=4.5 lac m^3

2- So rain water store = 4.5 Lac m^3

3- Water required for drinking per day = 3.375 Mld

=3.375 m^3 per day

= 0.03375 Lac m^3 per day

4- So for 25000 population form march to june Month = 0.03375 Lac m^3 x 120 days

= 4.05 Lac. m^3

This Much of water will be met for drinking from reservoir in above 04 months.

5- In remaining 08 Months 3.375 Mld water requirement will be met for drinking from Incoming water in the reservoir.

6- so in the worst case if we assume that there is no inflow in the reservoir from March to june then the remaining water in reservoir after ginning required water for drinking will br 4.05 lac m^3

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत

सहायक अभियन्ता प्रथम
सिंचाई उप खण्ड
लोहाघाट /चम्पावत