Pre-feasibility study of Dras – Suru link hydro-electric projects, Kargil District, Jammu&Kashmir

Ajay Kumar
Geological Survey of India (NR)
Jammu & Kashmir
ajaygsiangu@gmail.com

N. K. Nayak
Geological Survey of India (CHQ)
Kolkata

Abstract:-The Jammu & Kashmir State Power Development Corporation (JKSPDC) is contemplating for construction of different run of the river schemes on Dras – Suru Rivers to harness the power potential of these rivers. The Pre-feasibility Stage geotechnical and geological investigation of three hydroelectric projects across the Dras and Suru Rivers were carried out. These proposed projects, named as Dras-Suru link HEP Stage-I, Dras-Suru link HEP Stage-II and Karkit Hydro Electric Project, are all run of the river schemes. The Dras-Suru link HEP Stage-I envisages construction of a low height dam near Dras Town across the Dras River downstream of the bridge connecting the road to Sanko with the Srinagar – Leh national highway and an underground powerhouse near Dongchik village. The length of the proposed HRT is 8 km. and the estimated power potential is 45 MW with 110 m head and 50 cumecs designed discharge. The Dras-Suru link HEP Stage-II envisages construction of a low height dam / barrage across Dras River upstream of Dandal village and an underground powerhouse at village Pheruna along Suru River. The length of the HRT is 9.36 km. and the estimated power potential of the project is 70 MW with 150 m head and 50 cumecs designed discharge. All the project components of these two projects are located within Dras Volcanic Formation comprising mainly basalt and andesite in association with geosynclinals sediments. The proposed Karkit Hydro Electric Project envisages construction of a dam 1 km downstream of the confluence of Dras and Shingo Rivers with an underground powerhouse near Harka Bahadur Memorial upstream of the confluence of Shingo and Suru Rivers. The length of the HRT is 11 km and the estimated power potential is 180 MW with 124 m head and 126 cumecs designed discharge. The project components of this project are located within Ladakh Granitoid Complex comprising heterogeneous rock association of granite, gabbro, basic dykes, meta-volcanics and meta-sediments. During the course of the Pre-feasibility geotechnical investigation, one new project site was identified and height of the dam in one project was suggested for enhancement based on the geotechnical considerations. This led to revision of aggregate power potential of these projects from 172 MW to 305 MW, i.e. an addition of considerable 133 MW power potential.

Keywords:- Pre-feasibility; Hydroelctric; powerhouse

I.INTRODUCTION

The Jammu & Kashmir State Power Development Corporation (JKSPDC) is contemplating construction of different run of the river schemes on Dras – Suru Rivers to harness the power potential of these rivers. JKSPDC approached CWC in this regard and CWC, in turn, requested Geological Survey of India for the preparation of PFR of two hydro-electric projects across the Dras – Suru Rivers. The authors were deputed to undertake the reconnaissance geological investigation in the Dras – Suru basins and Indus basin. The field investigations were carried out by the authors during August 2011 accompanied by the technical team of CWC and JKSPDC.

II.GEOLOGY AND TECTONICS OF THE AREA

The central portion of the Dras valley is occupied by the volcanic suit of rocks called Dras Volcanics (Plate – I), which have an intrusive contact with the hornblende-biotite granite belonging to Ladakh Granitoid Complex in the north and a thrusted contact (Sanku Thrust) with the slate-phyllite-limestone sequence of Batal ≡ Phe Formation of Neo-Proterozoic age in the south [4]. The valley of Suru River between Kargil and Sanku is also occupied mostly by the Dras Volcanics with intrusive tongues of granites. The southern part of the volcanic belt towards Sanku has a faulted contact with a group of highly folded and metamorphosed rocks resting over granitic gneiss.A generalised regional geological / tectono stratigraphic sequence worked out for Dras valley and Kargil – Sanku area has been given in Table – 1[3].

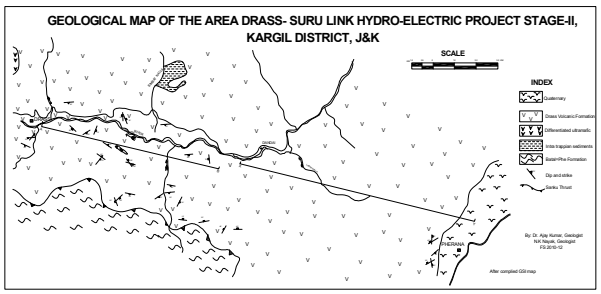

Fig. 1. Geological map of Dras-Suru Link hydroelectric project Stage-II

Tectonically, the proposed Dras – Suru link HEP Stage-I, Stage-II and Kirkit HEP lie on the south-western edge of the Indus-Shyok Belt. This belt is sandwiched between Karakoram Belt in the north and Main Himalayan Belt in the south. It comprises Cretaceous and Tertiary sediments and associated mafic, intermediate and acid magmatic rocks with imprints of Upper Palaeozoic and Early to Middle Mesozoic

sediments in the Shyok Belt. Wakha, Pashkyum and Shyok Thrusts are the major tectonic planes from south to north.Seismotectonically, the Projects are located in the Trans-Himalayan Indus Suture Zone (ISZ) in Central Ladakh falling in the Seismic Zone-IV and V of the Seismic Zonation Map of India[1,2,4].

TABLE – 1: GENERALISED REGIONAL GEOLOGY / TECTONO-STRATIGRAPHIC SEQUENCE.

Group	Formation	Lithology	Age
Quaternary		Glacial moraines, scree and recent alluvium	Pleistocene to Recent
Ladakh Granitoid Complex		Hornblende-biotite granite with dioritic enclaves	Cretaceous to Oligocene
----------Intrusive----------			
Sangeluma Group	Dras Volcanics	Basalt, Andesite, Ultrabasics, intratrappean sediments with Orbitolina limestone.	Cretaceous to Eocene
----------Sanku Thrust----------			
Haimanta Group	Batal ≡ Phe Formation	Pyritiferous dark slate, phyllite, crystalline limestone / marble and meta-basics	Neo-Proterozoic

III. GEOTECHNICAL APPRAISALS

A. Geotechnical Appraisal of Dras-Suru Link HEP – I

Dras-Suru link HEP Stage – I is a run of the river scheme. This is a new project suggested by the authors based on the current investigation. The project authorities did not have this proposal when they had approached the GSI. The proposed dam site (34° 25' 37" N : 75° 45' 59" E) is located downstream of bridge on Dras river heading towards Sanko in J&K. At this location Dras River is forming deep and narrow gorge of 40 m width. The project envisages construction of low height dam across Dras River and an underground powerhouse (34° 24' 53" N : 75° 51' 12" E) near opposite to the village Dongchik (Plate – I). The total length of the Head Race Tunnel will be 8 km. The water level at proposed dam site is 3080 m and at powerhouse site the tail water level is 3000 m. A 30 m high dam is proposed to get additional head. The power potential of this project is estimated to be of 45 MW with 110 m head and 50 cumecs design discharge.The project components are located within the Dras Volcanic Formation that mainly comprises basalt and andesite in association with geosynclinal sediments. The main subdivisions of Dras Volcanic Formation are as under [3, 5].

1. Volcanic suite of rocks
2. Pyroclastic materials
3. Differentiated ultramafite bodies within the Dras Volcanics
4. Sediments of the geosynclinal belt.

The volcanic suite is mainly represented by basalt in the Dras valley and andesite in the Suru valley. Bedded flows of basaltic lava are conspicuously developed in this area. The most common rock type of the volcanic suite is basalt which is medium to fine grained, greenish coloured and highly jointed in nature. Vescicles are also recorded at a few places in the basalt which are filled with calcite as secondary mineral, while andesite is greyish or greenish in colour having cryptocrystalline aggregate of feldspar and ferromagnesian minerals with little silica.Two small outcrops of volcanic agglomerate have been noticed on the left bank of Bhimbat nala. These pyroclastic beds comprise fragments of limestone, basic rock and chert.

Differentiated ultramafite bodies are occurring at several places within the Dras Volcanics at Dras and Thasgam area. The ultramafite bodies constituting "Brown Hill" are exposed along western slope of Tololing Hill and north of Gosan village. They mainly comprise monomineralic rock, Dunite, which is medium to coarse grained in texture, pale green in colour and greasy in luster [3].There is widespread distribution of chert within volcanic belt which is greyish, bluish and reddish in colour. Interbedded outcrops of limestone and shale occur within the volcanics in Dras valley. It comprises alternate bands of grey and purple shale, calcareous siltstone and orbitolina limestone.These rock units are highly jointed with multiple set of joints trending in all directions. Four set of joints recorded in area are tabulated below.

TABLE-2: DETAILS OF JOINT SETS.

Sl. No.	Dip & Strike of Joint set	Spacing (in cm)	Continuity (in m)	Remarks
1	N80W-S80E / 65 SW	50 – 200	Continuous	Bedded flow joint, smooth and tight.
2	N10W-S10E / 30SW	10 – 100	20-25	Open at places filled with clay and grass roots, slightly rough
3	N25W-S25E / 70 NE	10 – 100	20-25	Open at places filled with clay and grass roots, slightly rough
4	N50E-S50W / 80 NW	Close spaced	Discontinuous	Open at the surface, rough.

Along the head race tunnel (HRT) minimum cover is 50 m at the intake point and maximum cover over HRT is 600 m towards proposed powerhouse location. One perennial nala namely Watakul Nala at km 5.900 is crossing over the tunnel alignment (Plate-II). The overhead cover is sufficient all along the tunnel alignment but due to freezing and thawing, most of the joints are open in the area and remain under snow cover for a maximum period. The area is highly charged with water and due to shattered nature of

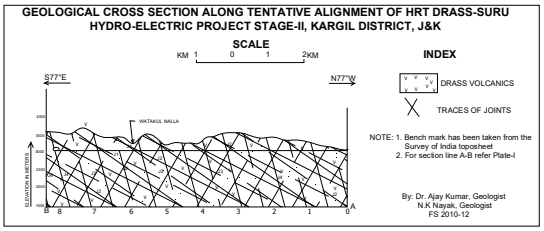

Fig. 2. Geological cross section along tentative alignment of HRT Dras-Suru hydroelectric project stage-I

rocks, heavy seepage is anticipated in this section. J2 and J3 are also forming wedges of different sizes. The alignment of the head race tunnel can be finalized at the DPR stage investigation of the project.The geotechnical appraisals are based on the reconnaissance survey of the area on 1:50,000 scale. The detailed geotechnical investigation is very much essential before taking up the project for construction.

B. Geotechnical Appraisal of Dras-SuruLink HEP – II

The proposed Dras-Suru link HEP is a run of the river scheme. The proposed dam / barrage site (34° 24' 48" N: 75° 51' 59" E) is relocated upstream of Dandal Middle School. The project envisages construction of low height dam / barrage across Dras River and a underground powerhouse (34° 25' 28.5" N : 75° 58' 25.7" E) at village Pheruna along Suru River (Plate-I). The total length of the Head Race Tunnel will be 9.36 km (Plate – III). The power potential of this project is estimated to be of 70MW with 150 m head and 50 cumecs design discharge.

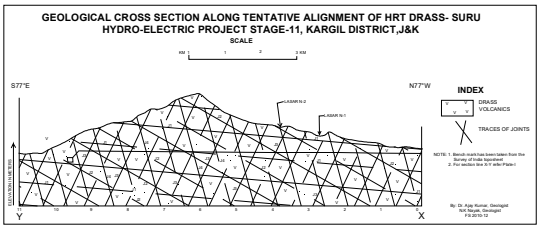

Fig. 3. Geological cross section along tentative alignment of HRT Dras-Suru hydroelectric project stage-II

The project components are located within the Dras Volcanic Formation that mainly comprises basalt and andesite in association with geosynclinal sediments. Since Dras – Suru Link HEP Stage – I & II are located in the same geological set up. The geological part for Stage – II refer under Stage – I to avoid reputation. Along the head race tunnel (HRT) minimum cover is 100 m at the intake point and maximum cover over HRT is 1650 m in its central portion. Two perennial nalas namely Lasar nala-I at km 2.650 and Lasar nala-II at km 3.850 are crossing over the tunnel alignment. The overhead cover is sufficient all along the tunnel alignment but due to freezing and thawing, most of the joints are open in the area. The area between km 2.5 and km 6 along HRT remains under snow cover throughout the year. The area is highly charged with water and due to shattered nature of rocks, heavy seepage is anticipated in this section. J2 and J3 are also forming wedges of different sizes.The geotechnical appraisal is based on the reconnaissance survey of the area on 1:50,000 scale. The detailed geotechnical investigation is very much essential before taking up the project in construction.

It was also proposed to construct a canal from the tail water to irrigate the command area in the downstream of Pheruna village. After visiting site it has been assessed from the topography of the area that irrigation canal from tail water is not feasible. Three set of canals at different contour levels already exist in the area. But these canals are not successful to meet the actual requirement of the area as they are fed by the snow melt water and remain dry for most part of the year.Instead of constructing new canal from the tail water which cannot irrigate the entire area, it is recommended to the project authority that the already existing canals in the area may be charged from Suru river water by simply diverting the river water upstream of Pheruna village to meet the actual requirement of the area.

C. Geotechnical Appraisal of Karkit Hydroelectric Project

The proposed Karkit HEP is a run of the river scheme located 1 km downstream of confluence of Dras river and Shingo river near Kargil (34°35'29.4 N: 76°00'12.4" E)and a underground powerhouse near Harka Bahadur Memorial (34°35'34.9" N : 76°06'40.6" E) upstream of the confluence of Shingo river and Suru river. The project envisages construction of low height dam of 30 m across Shingo River. After seeing the feasibility of the area, along both the abutments where competent rock which is hard, fresh and less jointed granite is exposed, the height of the dam has been revised upto 60 m. The total length of the head race tunnel will be 11 km along the right bank of Shingo River (Plate-IV). The power potential of this project is estimated 180 MW with 134 m head and 126 cumecs design discharge.

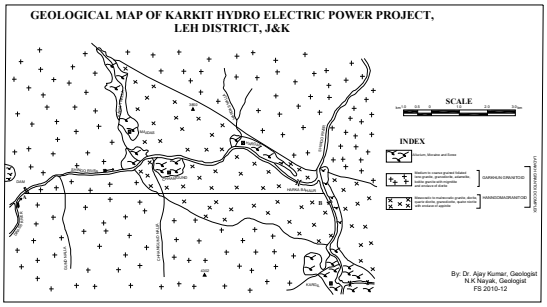

Fig. 4. Geological map of Karkith hydroelectric power project

The project components are located within Ladakh Granitoid Complex (LGC). The valley appears to be narrow and suitable for concrete structure. However, proper assessment thickness of river borne material in the river bed, stability of left abutment and topography of the site will ultimately be the deciding factors in the finalization of the actual structure and type of the diversion structure.At the

TABLE-3: DETAILS OF JOINT SETS.

Sl. No.	Dip & Strike of Joint set	Spacing (in cm)	Continuity (in m)	Remarks
1	N4°W-S4°E / 85° E	50 – 200	Continuous	Foliation joint, smooth and tight.
2	N80°W-S80°E / 50° SW	10 – 100	20-25	Open at places filled with clay and grass roots, slightly rough and in dry condition.
3	N35°W-S35°E / 60° SW	10 – 100	20-25	Open at places filled with clay and grass roots, slightly rough and in dry condition.
4	E - W / 55° N	Close spaced	Discontinuous	Open at the surface, rough.

TABLE - 4. A COMPARATIVE STATEMENT OF THE INITIALLY PROPOSED POWER POTENTIALS AND REVISED POWER POTENTIAL OF ALL THE PROJECTS.

Sl. No	River	Location of dam / barrage	Lithology exposed (Dam site)	Dam height (m)	Average discharge (cumec)	Length of tunnel (in km)	Location of power house	Lithology exposed (PH site)	Total head (m)	Power potential (MW)
1	Dras	Dras	Basic volcanics	30	50	8	Dongchik	Basic volcanics	100	40/45
2	Dras	Dandal	Basic volcanics	Barrage	50	13	Pheruna	Basic volcanics	140	65/70
3	Dras - Shingo	1 km D/S of confluence of Dras & Shingo	Granite	30 / 60	126	11	Harka Bahadur Memorial	Diorite	94 / 124	107 / 180

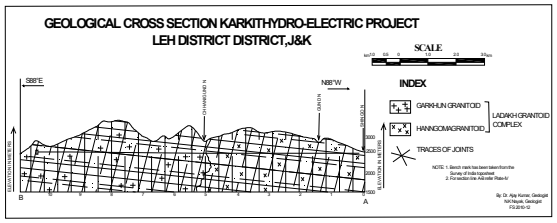

Fig. 5. Geological cross section of Karkith hydroelectric power project

proposed dam site, hornblende – biotite granite is exposed. Two sets of basic dykes are emplaced in the granite. Whereas, the proposed underground power house site diorite belonging to LGC is exposed which cuts across the HRT alignment in Chhanigund nala near Channigund village.

These rock units are traversed by four set of joints. These joint sets are forming the rock blocky in nature which requires minor treatment in the form of rock bolting and head ward excavation in the HRT and power house cavity with fore polling method. The dip and strike of these joint sets vary frequently due to circular nature of the joint pattern in granite terrain. Four set of joints recorded in the area are tabulated below.

The geotechnical appraisal is based on the reconnaissance survey of the area on 1:50,000 scale. The detailed geotechnical investigation is very much essential before taking up the project for construction.

IV. CONSTRUCTION MATERIAL

River terraces and shoals having sufficient quantity of natural aggregate along the rivers Dras and Suru have been observed at a number of places in the vicinity of the project. Basic volcanic rock of massive and strong nature and granites exposed along the banks of the Shingo and Suru Rivers within the reasonable distance from the dam sites and power house locations are the other prospective sources of construction material.

A comparative statement of the initially proposed power potentials and revised power potential of all the projects is given in annexed table, Table-4

V. CONCLUSION

- Dras-Suru link HEP Stage - Ia low height dam upto 30 m at this location and an underground power house with an 8 km long HRT has been proposed. The roughly calculated discharge in the Dras River at this location is 50 cumecs and the power generation is estimated upto 40 MW. All the components of this project are located in the basic volcanic rocks of Dras Volcanic. The overall rock quality is very good for the construction of HEP.
- Dras-Suru link HEP Stage - II is a run of the river schemeenvisaging construction of low height dam / barrage across Dras River near Dandal village and an underground powerhouse at village Pheruna along Suru River with a HRT of 9.36 km. The power potential of this project is estimated to be of 70MW with 150 m head and 50 cumecs design discharge.The project components are located within the Dras Volcanic Formation that mainly comprises basalt and andesite in association with geosynclinal sediments.It was also proposed to construct a canal from the tail water to irrigate the command area in the down stream of Pheruna village. But after site assessment, it was recommended that instead of constructing new canal from the tail water whose level is very low and inadequate to irrigate the entire area, the existing canal system in the area may be charged by diverting water of Suru River upstream of Pheruna which will serve the purpose better.
- The proposed Karkit HEP is a run of the river scheme located 1 km downstream of confluence of Dras River and Shingo River near Kargil and an underground power house near Harka Bahadur Memorial.The project originally envisaged construction of low height dam of 30 m across Shingo River but after assessing the feasibility of the area and studying both the abutments where good quality granites are exposed, revision of height of the dam upto 60 m has been recommended.The project components are located within Ladakh Granitoid Complex (LGC).The estimated power potential of this project is 180 MW with 134 m head and 126 cumecs design discharge.
- The proposed dam height of one projects and identification of one new site in addition keeping in view the geotechnical considerations, the power potential of these projects were considerably revised. Earlier projected aggregate power potential of these projects was 172 MW, considerably revised to 295 MW. Thus, as a result of the modifications suggested during the feasibility stage study of these projects a total 123 MW

power potential was added which is equivalent to Rs. 815.5 crore of yearly revenue (based on the current market rates of electricity, i.e. Rs 7.00 per unit).

- The geotechnical appraisals are based on the reconnaissance survey of the area on 1:50000 scale. The detailed geotechnical investigation is very much essential before taking up these projects for construction.

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