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GEOLOGICAL REPORT ON 13.225KM. LONG NAUDKHAL-MALA KOTA TO SIRASU MOTOR ROAD ALLINMENT IN DISTRICT PAURI GARHWAL UNDER PRADHAN MANTRI GRAM SADAK YOJANA.

1. INTRODUCTION:

A 13.225 km long road has been proposed named as Naudkhal-Mala Kota to Sirasu motor road in Yamkeshwar Block. Distt. Pauri Garhwal under the supervision of MAGOT Engineering Consultant Pvt Ltd. Tapovan Enclave. Nalapani Road, Dehra Dun. For this work geological investigation has been done by KainGeotech Dehra Dun. This work has been awarded by the General Manager of the project MAGOT Engineering Consultant Pvt Ltd Dehra Dun. During the field investigation Mr. Surjan Singh Survey of MAGOT was also present.

2. LOCATION:

The road is proposed from left bank of river Ganga. The proposed road starts from km. 20 Chalusain to Ghattugad of km. 7 Naudkhal - Mala Kota to Sirasu LVR Motor Road in Block Yamkeshwar. Pauri Garhwal and covers the distance of 13.225 km.

3. PHYSIOGRAPHY AND GEOMORPHOLOGY:

The proposed road starts from km. 20 from Chalusain to Naudkhal to Mala Kota to connect the Sirsu village.The given road alignment lies in the rugged mountaineous topography of Lesser Himalaya. In this region the ground elevation vary generally from 1400m to 1100m above ms!. Mountain peaks over 1442m and 130Sm in heights are present. Villages close to the proposed road alignments are Mala, Kota, Sirsu, Seramala,Basani,Chauri and Malakhuti. Steep cliffs hundreds of meter high are common features of topography. Generally features of colluvial and fluvial origin are found in the region. Boulders are embedded in the superficial deposits in this region.

Hiyuni river which is a major tributary of river Ganga drains this region flowing southern direction. Numereous small tributaries of these river form generally a dentritic and redial pattern. Valleys are narrow and decp but at places they are widen. The region is prone to rockfall and debris flow due t9 high relief prcsence of fault overburden and prescipitation. Middle and lower valley slopes are generally col\'ercd by colluvial and fluvial overburden and scattered outcrop. Upper slopes are mostly rocky and s~cep with lillle overburden. This region experiences a moderate climate, It has moderately dry winter hot summer followed by heavy rain. Montane subtropical and montane temperate types of vegetation are found in this area. Forest and open shrubs are present in this region.

4. REGIONAL GEOLOGY:

Rocks of Subathu, Tal and Krol Formations are occurred in this region. Krols are dominantly carbonate formation constitutes the upper part of sy11clinal mountain range. It is divisible into three distinct members Lower Kro!. Middle Krol and Upper Krol. Tal occurs in syncline disposed fOffi1ing the Mussoot;e and Lansdowne hills. In Lansdowne region it forms and elliptical fringe around the over thrust sheets of Bijni and Amri Between Dugadda and Rathwadhab. The Tal is split into two belts separated by a narrow strip of synclinally folded Subathu in between. Subathu and Tal are mixed up and crushed at many places suggests thrUStj'i1g of the northern belt of Tal over the Subathu along a thrust. Subathu is the youngest lithostratigraphic unit of the Lesser Himalaya occun'ing unconforn1ably upon Tal and Krol Thrust comprises alternating maroon or red and grey-green grey wackes siltstone ɳudstone with

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intercalation of nummulitic and Shelly limestone of Eocene. The tectonic succession of the area is as follows:

Group/Formation	Lithology
---------- Thrust ----------	
- -	
Subathu Formation	Maroon or red and gray-green greywackes siltstone, mudstone, nummulitic and sdelly limestone.
Tal Formation	Mudstone, chert, limestone, greywackes, sandstone, slates and quartzite.
Krol Formation	Limestone, Slates, shales.

The area around Nilkanth is structurally a complicated region, where Amri, Bijni, Krol, Tal and Subathu rocks are exposed in juxtaposition. These rocks can closely be traced if one follows the course of the river Ganges and the Hiyuni.

Ameri Nappe rock. The crystalline rocks of this unit comprises quartzites, quartzose micaschists,garnet mica-schists and chlorite mica schist. These rocks fonn the Amri hill and then extend further south and southeast. In the field these rocks are thrusted over the younger Krol-belt rocks.

Bijni Nappe rocks. The rocks of this unit comprise quartzites and schistose phyllites which represent another strually complicated region south of river Ganges and east of river Hiyuni comprising the Mala hills Bijni village and further extends eastsouth, east and southeast. These rocks are the detached and far travelled frontal part of the Nathuakhan Formation of the Ramgarh group.

Krol Belt rocks. These rocks comprises Blaini-Krol-Tal-Subatu units.Extensive development of these rocks can be found in the north,northwest, northeast, southwest and southeast of Nilkanth.The Blaini and Krol rocks show moderate effects of metamorphism by the development of sericite-muscovite in slaty rocks while the younger Tal and Subathu rocks have escaped such effects.

Blaini rocks. These rocks include grey-green diamictites, dark grey laminated slates, grey massive sandstones, pink limestines, shales and siltstones. The only exposure of this unit grey-green diamictities (l"OjJU~:::rl)' known as "boulder bed") are located around Lakshmanjhula.

Krol rocks. The Krol rocks arc charactcrised by a sequencc of interbedded quartzites and slates and dolomitic limestones. Exposures of these rocks are found in the north of Laxmanjhula and northwcst of Nilkanth. T\vo episodes of folding are confirmed in these rocks. The Fl folding (=£2 folds of Amri rocks) in the quartzites and slates (east of Laxmanjhula on the northern bank of Ganges) show the folds whose axes trend WNW-ESE. This folding is related to the folding of the Amri and Bijini thrust, on a WNW-ESE trending Garhwal synform in this region. The F2 fold found in these rocks are fairly broad and open, trending NE-SW (=F3 fold of Amri rocks).

Tal rocks. The Tal rocks occupy a major portion of the study area and comprise orthoquartzies, shales and limestones. Good exposurers of the Upper Tal rocks can be seen around Manikot hill just north of Nilkanth These rocks further are found around Hiyuni river in south eastern region forming an antifonnal structure between the two major synforms i.e. Bijni in the northeast and east and Almi in the west and southwest.These rocks contain fossils of foraminifera, ostracoda, bryozoa, corals, algal fragments, gasteropoda, and pelecypoda. Various types of sedimentary structure including cross and parallel beddings can be found in these rocks .

Subathu rocks. The Subathu consists of green and purple shales. limestones and intercalations of calcareous sandstones (Calc-arenites). The Calc-arenites are marked by fine lamination and low angle cross bedded structures. At places the Sub.atl1U rocks are highly crumpled and traversed by calcite

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veinlets. Due to shearing along the fault the contact between Tal and Subathu is not very sharp. Good exposures of Subathu rocks located south of Nilkanth towards the Amri thrust zone. These rocks are also found to contain the three types of oolites including the iron oolites as in the Tal rocks.

GEOLOGY OF NAUDKHAL - MALA KOTA TO SIRASU AREA

Limestone, slates, quartzite and greywackes of Tal Formation is found in this area. These are covered by overburden comprises of colluvial materials. A number of prominent discontinuities developed in these rocks have been grouped into following sets:

Dip	Dip Direction	Strike	Remark
66°	S40°W	NSOuW-SSOuE	Bedding
60°	S800E	NI0°E-SI00W	Joint
S4°	N40°E	NSOuW-SSOuE	Joint
46°	N80°E	NI0°W-SI0°E	Joint
ISO	S80°E	NI0°E-SI0°W	Joint

Quartzite is the main rock types in this area. Quartzite is medium to fine grained and hard & compact. Bedding is moderate to high and southwasterly dipping. The rockmass is thinly to thickly layered and moderately to highly jointed. Weathering is generally moderate at surface. Slope around project is gentle to moderately steep / steep. First half of length of aligned is on same hill slope. Nature and behavior of overburden and rock are same as described in Km.1.0. km. Here slopes have been converted into small terraces for agriculture purpose. In the proposed alignment two nalas are crossing the alignment at different chainage. During monsoon high discharge of water may damage the structures at these location.

GEOLOGY ALONG ROAD ALINGMENT:

Both overburden and rocks are occurred along the proposed road alignment. The overburden is comprising of colluvial material consist brown to grey silty clayey matrix with angular fragment of Slate,quartzite and limestone. Generally slopes are moderate to steep and stable except initial length. At the ential reach slopes are moderately steep to steep and vegetated with trees (Banj,pine) and bushes. The proposed road from Naudkhal to Mala Kota having the steep slope in initial reach (up to km 1). At this reach slope is steep and rock is highly jointed to crushed. Seepage/spring are noticed at places with low to medium discharge. Slope at this reach is moderately steep to steep. At the reach rock are weak, jointed, weathered and weak at surface and dipping southwesterly. Around km 4 hard grey quartzite is present with steep slope along the alignment.

From km. 1 to km. 4 the proposed alignment is passing through the cultivated land of village Basani. Slope along this length is moderate to gentle and fairly stable. After km *4.S* to km. *9.S* the proposed alignment is crossing through both cultivated as well as barren land of village Chauri. Two low to medium discharged perennial nala crossing the alignment at km *8.S* and km *9.S*. Between km. *9.S* to km 10 outcrop of quartzite is exposed along the alignment. This rock is grayish white, medium grained and slightly weathered. Slope around this location is moderately steep / steep. From km 10 to km13.22S the alignment of proposed road is almost parallel to the river Ganga and laying on overburden comprising colluvial material. From km. 10 to km. 12 the proposed road is almost straight. The hill side slope is rocky and very steep to steep and fairly stable. From km 12 to village Sirsu (km 13.22S). In this reach the slope is gentle and passing on colluvial material. End part of the alignment is proposed on colluvial mixed river borne material. This section of the alignment appears stable.

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SLOPE STABILITY:

This total length of 13.225 km long road is proposed between two perennial nalas and left bank of river Ganga. A bridge on rock is existed to cross this nala. The slope on rock is steeper. Slope both on rock and overburden appears stable after initial1.0 km. along road alignment. The qualitative assessment of litho logy, relationship of structural discontinuities with slope, relative relief, landuse, landcover and groundwater condition have been done for stability of slope. The plan of the area shows that there are at least eight streams draining the slopes along road alignment. These are not unifonnly distributed in the area.

The area is sparsely to moderately vegetate with varying cover of sandy- silty soil deposit. Land in km 0.0-1, km- 4.2, km.5.5- 6.5, km.7- 9.2, km.9.7- 13.225 are not being used for agriculture or horticulture. The surface manifestation with a few cross drains shows that area is dry and shows some locations for development of spring water and hydrostatic pressures in slopes.

In overburden, slides occur where the material has appreciable proportion of fine particles of silt and clay sizes and due to increase in weight of soil (material) itself caused by the infiltrated water during rainfall, and lowering of shearing resistance caused by soil saturation and the development of excess pore water pressure. At the proposed alignment site, though overburden material has some fines, the slope wash material derived form weathering of quartzite and are pervious. Therefore there is little chance of overburden slides occurring is the area particularly in initial 1.0 km.

The entire Himalayan terrain lies in the seismically active belt. The project area falls in seismic zone IV of the seismic zoning map of India. Regionally the project lies in a tectonic block bounded by NW-SE trending and northeastward dipping regional thrust. A thrust is also passing close to the project area.

RECOMMENDATION AND CONCLUSION:

(a.) The general bedding dips 60°-66° towards S 40° W.
(b.) Grass should be grown on the open slope for prevention of deep weathering and enrichment of micro-environment of the road.
(c.) The depth of the water table was not kt10wn.
(d.) The foundation of the structures (RIW & B/W) be laid on the sound/acceptable bedrock, discarding the OB material. The bearing capacity of the foundation grade be determined in the light of present geological assessment.
(e.) The slopes in the first 1.0 km have a tendency of planar failure due to highly jointed and parting with low friction angle and the condition is worse when these partings and joints are saturated with water. It is advised to provide a properly designed retaining wall, breast wall and other important structure all along the northern/northeastern slopes, back filling with free drawing material and with the provision of weep holes.
(f.) The rock exposed, around the site and along the road section' consists of quartzite and slate of Tal, Formations. The rocks are generally jointed and develop bedding plane.
(g.) Quartzite's are hard and strong in fresh condition and can be used a construction material for road.
(h.) As the area falls in high seismic zone, it is advised to take adequate seismic coefficient in the design of the structures.
(i.) Suitable structure should be constructed on sloppy overburden area and weak/weathered rocky zones. Due consideration should be given in initial 1:0 km. So the foundation of the structures (R.W, B.W etc.) to De laid on the sound/acceptable bedrock, discarding overburden material.

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(j.) The surface drainage should be properly planned to drain away rain water from road alignment through lined drains/pipes and release at safe place at down hill along a gully. It will prevent the erosion of hill of hill surface.

(k.) Wherever weak zones and nalas are encountering on the proposed road alignment particularly at chainage km.8.4, km.9.3 suitable structures like supper, causeway, culvert, etc. should be constructed.

(1.) The area in question is geologically favorable for the construction of the proposed road provided the above measures are adopted.

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