CHAPTER - 3

GEOLOGY OF UPPER TUNGA PROJECT
3. **Introduction**

A complete foundation investigation and analysis shall consist of an adequate program of field sampling, laboratory testing, and engineering properties analysis. The investigation and analysis shall be performed in compliance with the procedures outlined in this document and generally accepted principles of sound geotechnical engineering practice.

The equipment used shall be hand operated and power drilling, driving equipment and other tools equipment considered suitable for necessary to determination of the limits and conditions of the various soil strata, and for obtaining samples for examination field classification and laboratory analysis.

3.1. **Stratigraphical Succession**

Geologically the area around the dam site for a distance of 300 km radius taking the dam as center forms the part of the Indian shield and comprises variety of rock formations ranging in age from greater than 3200 million years to less than 5 million years viz., A narrow coastal strip of Tertiary and Quaternary sediments, the Deccan traps of Cretaceous Paleocene age in the northern part; under formed to slightly deformed sedimentary rocks of kaladgi, badami and Bhima groups immediately to the south of the Deccan traps and their equivalents the Cuddaph and Kurnool group of rocks in the eastern part belonging to the middle to late
Proterozoic age and Vast granitoid -green stone belt terrain (> 70%) made up of Peninsular Gneiss (Archean) with high grade schist enclaves (Sargurs), Charnockites and Granulites, several long, linear low grade volcano- sedimentary piles or greenstone belts of Dharwar Super Group (Archean of lower Proterozoic age) and intrusive granites (Closepet and related granites, upper proterozoic age, and younger Chamundi and related granites) and mafic and ultra mafic complex.

On the basis of the metamorphic facies, lithological association and tectonic setting and the type of supracrustal belts of Dharawar crater can be divided into two blocks viz., Eastern and Western and the schist belts can be differentiated into three broad techno-litho stratigraphic groups viz., ancient supracrustal (Sargur Groups). Archean to Lower Proterozoic basins and geosynclines (Dharawar Super Group) and Greenstone belts (Kolar Group).
The Stratigraphic succession of the various rock formations as worked out by GSI is given below in the following table.

**Table 8. Stratigraphic succession of the various rock formations**

<table>
<thead>
<tr>
<th>Era/ Eon</th>
<th>Period</th>
<th>Epoch</th>
<th>Age (Million Years)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenozoic</td>
<td>Quaternary</td>
<td>Recent to Pleistocene</td>
<td>&lt;2</td>
<td>Residual soils, colluvium and alluvium</td>
</tr>
<tr>
<td></td>
<td>Tertiary</td>
<td>Pliocene</td>
<td>2.5</td>
<td>Laterite</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Miocene</td>
<td>5-23</td>
<td>Shell limestone, clay, thin lignite layers</td>
</tr>
<tr>
<td>Cenozoic to Mesozoic</td>
<td>L- Cretaceous to Paleocene</td>
<td>60-100</td>
<td></td>
<td>Deccan trap ( tholeitic basalt )</td>
</tr>
<tr>
<td>Upper Proterozoic</td>
<td></td>
<td></td>
<td>800</td>
<td>Chamundi, Madapura, HD Kote granites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; 1000</td>
<td>Kurnool Group, Bhima Group</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1000</td>
<td>Cuddaph, Super group, Kaladgi super group</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2200-2400</td>
<td>Basic dykes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Layered anorthosite-gabbro complexes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2500-2600</td>
<td>Closepet, chitradurga, Hosadurga, JN Kote, Arasikere, Banawar, patna and Karwar granites</td>
</tr>
<tr>
<td>Archean-L-</td>
<td></td>
<td></td>
<td>2500-3000</td>
<td>Dharawar Super Group</td>
</tr>
<tr>
<td>Archean</td>
<td></td>
<td></td>
<td>2600-3000</td>
<td>Charnockite</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3000</td>
<td>Proterozoic Peninsular Gneissic complex (2600-3200)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;3000</td>
<td>Sargur Group</td>
</tr>
</tbody>
</table>
Sargur Group

The medium to high grade schistose rocks underlying the basal unconformity (base of Dharawar Super group) and usually occurring as narrow bands, fold remnants, scattered enclaves and tectonic slices within the Peninsular gneisses comprise the Sargur Group.

Peninsular Gneissic Complex (PNG)

The vast expanse of gneisses and migmatites that cover the greater part of the area consists of an unclassified polyphase complex of migmatites, gneisses, and granitoids of tonalitics, adammilitic and granodioritic composition.

Charnockite

Geochronological studies indicate a main Charnockite phase of 2600 M.Y with vestiges of earlier Charnockites around 3000 m.y. The age of transformation of gneiss is to Charnockite is around 2700 m.y at Kabbaldurga.

Dharawar Super Group

The regional basal unconformity marked by uraniferous, pyratiferous oligomictic quartzite conglomerates marks the base of the Dharawar Super Group exposed in Bababudan and Chitradurga etc, belts.

The lower Bababudan Group is characterized by basinal cycle with lava-quartzite-iron ore association and typical uraniferous oligomictic conglomerates, rarely or absence of limestone/dolomite and absence of manganese formation.
The upper Chitradurga Group represents a typical geosynclinal to eugeosynclinal association, marked by polymict/oligomict conglomerate, quartz-carbonate-pelite shelf facies with transitional persistent limestone–managanese–iroinestone horizon and a eugeosynclinal regime represented by thick pile of greywacke-argillite-greenstone suite.

**Clospet Granite**

The prominent linear batholiths of Clospet granites separate the two tectonic regimes, the eastern and the western blocks. Clospet Granite is considered to be an younger granite of magmatic origin intruding the Dharawaras and PGC, pictographically ranging from adamelite to alkali granite with a distinct gneissic fabric that parallels the host rock though the other equivalent granites are especially massive.

**Cuddaph Super Group**

It rests on a basement consisting of gneisses and schists with a distinct unconformity, consisting of a thick pile of predominantly sedimentary rocks comprising quartzite, shale and limestone. Kaladgi Super Group is equivalent to these with a similar but less deformed sedimentary rocks.

**The Kurnool Group and their equivalent Bhima Group**

The Kurnool Group and their equivalent Bhima Group resting over the Cuddaphs and kaladgi respectively consist entirely of underformed sedimentary rocks viz., quartzite and limestone.
**Deccan trap**

Deccan trap are exposed between 380 and 987 m above MSL and overlap all the older rocks. The estimated maximum thickness of the flows in this area is of the order of 300 m. The flows essentially comprise quartz normative tholeiite consisting of labradorite and pigeonite.

### 3.2. Structures of Upper Tugna Project

The most striking feature of the granite-green stone, terrain is the disposition of the green stone formations as sub parallel, curvilinear belts, whose regional trend swings from N-S in the southern part of NW in the northern part.

**Folds**

Three phases of folding are recognizable in the green stone, belts, the earliest folds, F₁, are right, isoclinal with thickened hinges and thin drawn out limbs and general rockless. This event was accompanied by the development of cleavage / foliation / schistocity (S₁), the second deformation folds (F₂) is denoted by close to open, inclined to upright folds, which have rotated earlier folds resulting in the development of crenulation cleavage (S₂). Most of the major fold havinges with N-S to NW-SE trending axial planes are due to F₂, F₁ and F₂ are nearly co-axial, the third phase of folding (F₃) was of milder intensity producing broad open folds and warps on transverse axial planes, i.e., ENE to WNW direction, crenulation cleavage and widely spaced joints (S₃) striking in the above direction are due to F₃, the N-S to NW-SE swing in the run of greenstone belts and the gulminations and depressions along axial traces of F₂ folds are due to F₃ folding episode.
Joints, shears and faults

Joints and shears parallel to axial planes, particularly of F₂ and F₃ folds, traverse the green stone belts, shear zones parallel to F₂ axial planes have hosted the Au mineralization at Kolar, Hutti, Gadag and Ajjanahalli, 440 km long NNW-SSE trending shear zones parallel to S₂ in the east central part of Chitradurga belt has localized Cu-Pb-Au-Ag-Sb mineralization.

Shear zones and faults trending

The shear zones and faults trending ENE-WSW to WNW-ESE have affected the green stone belts, gneisses, younger granite and N-S to NNW-SSE trending dolerite dykes. The precipitous scarps of Western Ghats and the straight coastline are the products of a series of step faults trend in NNW-SSE direction. These faults are probably of post tertiary age as they displace the late tertiary laterate cover.

3.3. Detailed Geology of the Dam Site

Schistose rocks belonging to the Shimoga schist belts, in contact with granite to its east are exposed in and around the project site.

The Shimoga schist belts and its extensions in a NNW-SSE direction over a strike length of about 250 km with a maximum width of about 150 km constitute the most extensive greenstone belt in India.

This belt is the northern extension of the Bababudan belt, both the belts having been separated by the Peninsular Gneiss of the Tarkere valley.
This belt has a highly irregular configuration caused by numerous, broadly arcuate NNW-SSE trending folded structures, most of them related to island like domal masses of gneiss and granitoids.

About 200 m downstream of the existing anicut an outcrop of granite is seen. The contact between granite and schistose rocks, however, could not be seen. The granite at this place is high in quartz and also contains garnet possibly because of the admixture of the garnetiferous chlorite-schist near the contact zone.

Subsurface Exploration

An examination of the cores of some of the boreholes shows that greenish grey fresh and hard quartz chlorite with quartz is the predominant rock types right from the top with minor granite gneiss in a few boreholes.

The quartz chlorite schist is garnetiferous and micaceous at places and shows idioblastic magnetite at some other places.

Rarely quartz-sericite-chlorite schist is also seen as observed at right embankment where drilling is being carried out presently.

The core recoveries are good, more than 80% especially if the first one or two runs (top 1.5 to 3 m) are not considered, where the recoveries range from 43 to 80%. The Rock Quality Design (RQD) is fair to good ranging from 51 to 91 % and mostly above 70 %.

The foliation trends N 30° W-S 30° E and dips 80° towards N 60° E. The chlorite schist shows minor folds at Ch. 585 m 112 m downstream of the existing
anicut, with the axial plane cleavage trending N 20° W-S 20° E and dipping 80° due S 70° W. Other joints observed are N 50° E-S 50° W with a dip of 65° due S 40° E and N 10° W-S 10° E with a dip of 77° due S 20° E.

In order to ascertain the stability of the foundation of the spillway portion, series of boreholes have been drilled in different location as given below.

Table 9. Left side and Right side Flanks

<table>
<thead>
<tr>
<th>Location/Component</th>
<th>Chainage (M)</th>
<th>Borehole Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>Left side Flanks</td>
<td>0</td>
<td>360</td>
</tr>
<tr>
<td>River course</td>
<td>360</td>
<td>530</td>
</tr>
<tr>
<td>Right side flanks</td>
<td>530</td>
<td>780</td>
</tr>
</tbody>
</table>

**Left side Flanks**

In left side flank, 21 boreholes have been drilled between Ch. 45 m and 360 m upto a depth ranging from 1.5 m to 18 m. The ground level of these boreholes varies from 584.75 m to 577.3 and whereas bottom level of these boreholes ranging from 574.45 to 569.85 m. In all these boreholes, the litho units have been classified into 4 groups based on their physical characteristics as given below.
Symbols & Litho units

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Code</th>
<th>Litho unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>S</td>
<td>Soil</td>
</tr>
<tr>
<td>B</td>
<td>WCSCT</td>
<td>Weathered Chlorite schist</td>
</tr>
<tr>
<td>C</td>
<td>HCSCT</td>
<td>Hard Chlorite schist</td>
</tr>
<tr>
<td>D</td>
<td>HGNS</td>
<td>Hard Granite Gneiss</td>
</tr>
</tbody>
</table>

Soil

From Borehole numbering from 1 to 16, the soil cap is available with a thickness of 0.5 m to 2 m from their respective ground levels.

Weathered Chlorite Schist

Weathered Chlorite schist is available below the soil, having thickness ranging from 2.5 m to 13 m is encountered in these boreholes. When compared to hard rock thickness, the depth of weathered chlorite is more. Among these boreholes, the borehole No. BH-8 is having 11 m of weathered chlorite schist.

Hard Chlorite Schist

Hard Chlorite schist is underlying from weathered chlorite schist having thickness ranging from 1.5 m to 2.00 m. However, this Hard chlorite is not met with. In borehole No 7, 9 and 13
Hard Granite Gneiss

Hard Granite gneiss is available below the Hard Chlorite schist in borehole number viz., BH-7, 9,13 and from BH 17 to 21. The thickness of this hard strata is varies from 1.5 m to 2.00m. The boreholes bearing Nos. 17 to 21 drilled in river portion is encountered only hard granite gneiss.

Since the hard granite gneiss is available at shallow depth he river bed (3-18 m), the foundation grade rock levels has been fixed sat depth of 566.00 m.
Fig. 3. Geology of Tunga River Basin
Fig. 4. Soil Map of Tunga River Basin