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Study of Suspended Sediment and Its Mineral Content Analysis with Impact on Hydropower Design: A Case Study of Rahughat Hydroelectric Project

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Abstract: Rahughat Hydroelectric Project is an ROR (run of river) project with the installed capacity of 40 MW. The suspended sediment study was carried out in 2008 and 2015 AD. The present study is concentrated on the study carried out in 2015 AD. The suspended sediment samples were collected in the headworks site and its analysis was done in Hydro Lab Pvt. Ltd. Concentration analysis, PSD (particle size distribution) analysis and mineral content analysis were carried out. The minimum and maximum sediment concentration is 54 PPM and 3,759 PPM respectively. The PSD analysis shows that 52% of the suspended sediment contained sand fraction and 48% is fine sediments. The mineral content analysis shows presence of quartz, feldspar, mica, kyanite, garnet, carbonates, chlorite, clay and some fragments of shale, phyllite and slate with few unidentified sediments. The proposed desander in RGHEP is designed to settle particles of size 0.2 mm and above. The sediments lesser than 0.2 mm size that reach the turbine may affect the loss of turbine material due to erosion.

Key words: Suspended sediments, mineral content, quartz, turbine.

1. Introduction

The main objective of the study was to conduct the laboratory analyses of suspended sediment samples which will effect in the turbine material of the Rahughat Hydroelectric Project. The suspended sediment has different parameters as size, shape, hardness which have direct effect on the turbine. The study was carried out in 2008 and 2015.

The suspended sediment data collection from the gauging station at Galeshwor (near powerhouse site of the project) was taken from May to September, 2008 and two types of sediment samplings were performed. The maximum daily concentrations recorded from D-74 sampler and bucket samplings are 12,482 PPM and 13,549 PPM respectively which were analyzed in the SRCL (Soil Rock and Concrete Laboratory), Nepal Electricity Authority, Swoyambhu, Nepal.

In 2015, the suspended sediment samples were collected from the headworks site of the Rahughat Hydroelectric Project and its concentration, PSD (particle size distribution) and mineral content analyses were carried out in Hydro Lab Pvt. Ltd.

2. Sediment Study

Geologically, the Nepal Himalayas are considered to be young and active in the mountain building process which has led to many rock and slope instabilities. These instabilities are the primary source of sediment for the river system in Nepal. Also the regional geological map (Fig. 1) of Rahughat Hydroelectric Project area (DMG 2002) shows a thrust that runs almost parallel to sub-parallel on both sides of Rahughat River which have led to many slope instabilities.

Hydrologically, Nepal has rainy season or monsoon period for four months from June to September. About 70-80 % annual precipitation occurs over the monsoon season and the peak flow and sediment transport in most rivers occur during this monsoon period.

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3. Methodology

The standard filtration method is used to analyze the suspended sediment concentration. For filtration analysis, Whatman filter paper of 11 micron porosity was used.

PSD analyses were carried out by using Beckman Coulter Particle Size Analyzer (Fig. 2). This equipment analyses the particle size within a range of 0.4 micron to 2,000 micron by using Laser Diffraction method. The principle of Laser Diffraction method is that when particles of different sizes are exposed to a beam of light, the pattern of scattered light is observed. This analyzer analyses the particle sizes by using those patterns of scattered light. A standard procedure specified by the equipment manufacturer was adopted to analyze the particle size.

A Zoom Stereo type of microscope (Fig. 3) was used to identify the minerals. The identification of minerals was based on the visual observation method. The carbonate percent was determined by acid wash technique. Representative samples within the sampling period were selected and the mineral content analyses have been carried out. Each sample was divided into three sets and analyzed separately. Finally, the results of each set were averaged for the good representation of minerals.

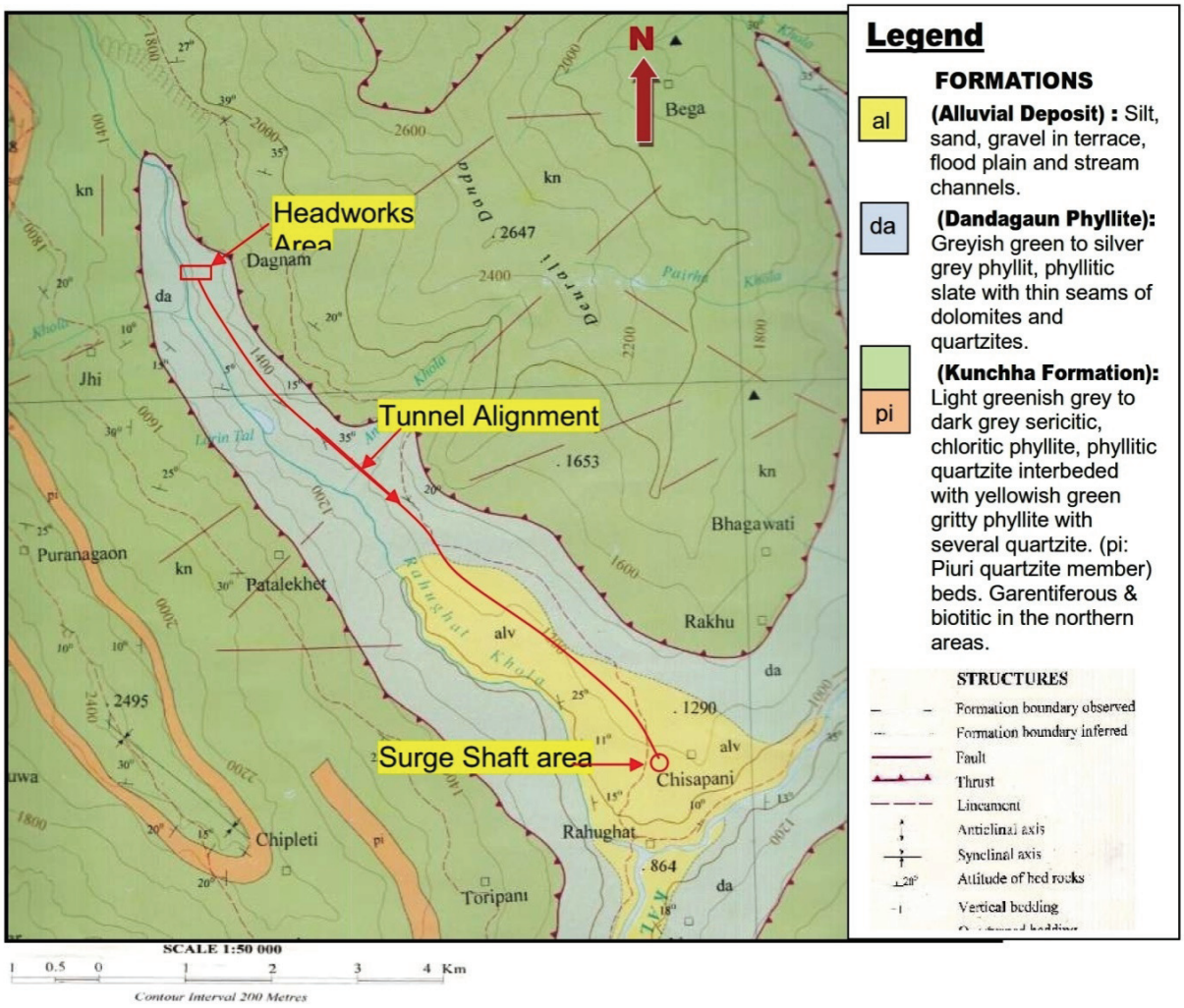

Fig. 1 Regional Geological Map of Rahughat Hydroelectric Project area (after DMG 2002).

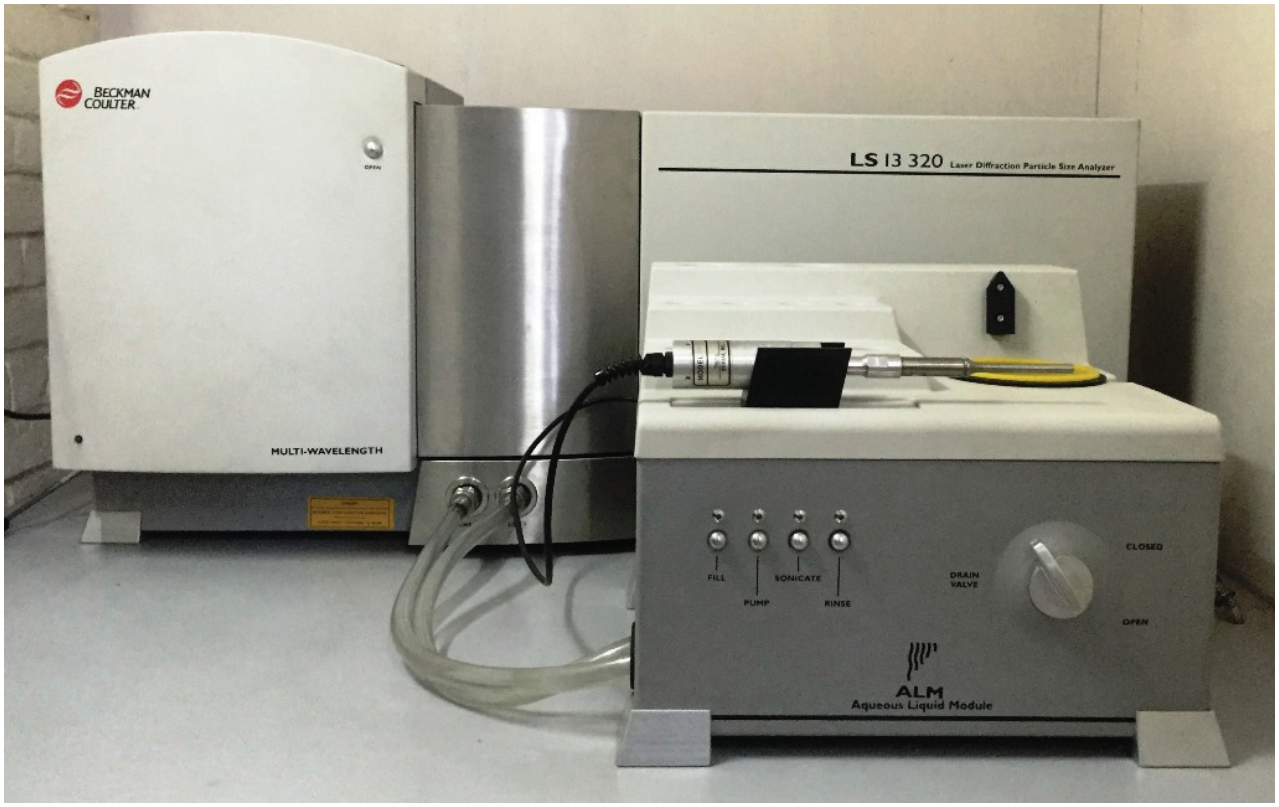

Fig. 2 Beckman Coulter Particle Size Analyzer.

4. Result and Discussion

The minimum and maximum sediment concentration measured during the sampling period is 54 PPM and 3,759 PPM respectively. During this period, it was observed that 18% of the samples contained sediment concentration below 100 PPM, 58% between 100-500 PPM, 12% between 500-1,000 PPM and 12% of samples having sediment concentration above 1,000 PPM.

The PSD analysis shows that 52% of the suspended sediment contained sand fraction (particles ranging from 0.062 mm to 2 mm) and 48% of the suspended sediment is fines (particles smaller than 0.062 mm).

A desander is essential to trap and exclude sediments from flowing water to minimize damage to turbine components. In Rahughat Hydroelectric Project, two settling basins of equal size (80.0 m × 8.0 m × 5.94 m) are proposed that are designed to settle all particles of size 0.2 mm and above. It is also noticed that 80% of the sediments are smaller than 0.2 mm size. The sediments lesser than 0.2 mm size (fine sand and silt size sediment) that reach the turbine may affect the loss of turbine material due to erosion.

The mineral content analysis shows presence of quartz, feldspar, mica, kyanite, garnet, carbonates, chlorite, clay and some fragments of shale, phyllite and slate with few unidentified sediments (Fig. 4) in the suspended sediments of Rahughat Hydroelectric Project. The suspended sediments contain 62% (quartz 47%, feldspar 11%, kyanite and garnet 4%) of hard minerals above 5 in Moh's hardness scale which is significant as these minerals are as hard as or harder than steel. The suspended sediment also contains 9% of carbonates, 18% of mica and 11% of other minerals as clay, chlorite, fragments of shale, phyllite and slate with few unidentified sediments.

Fig. 3 Zoom Microscope for mineral analysis.

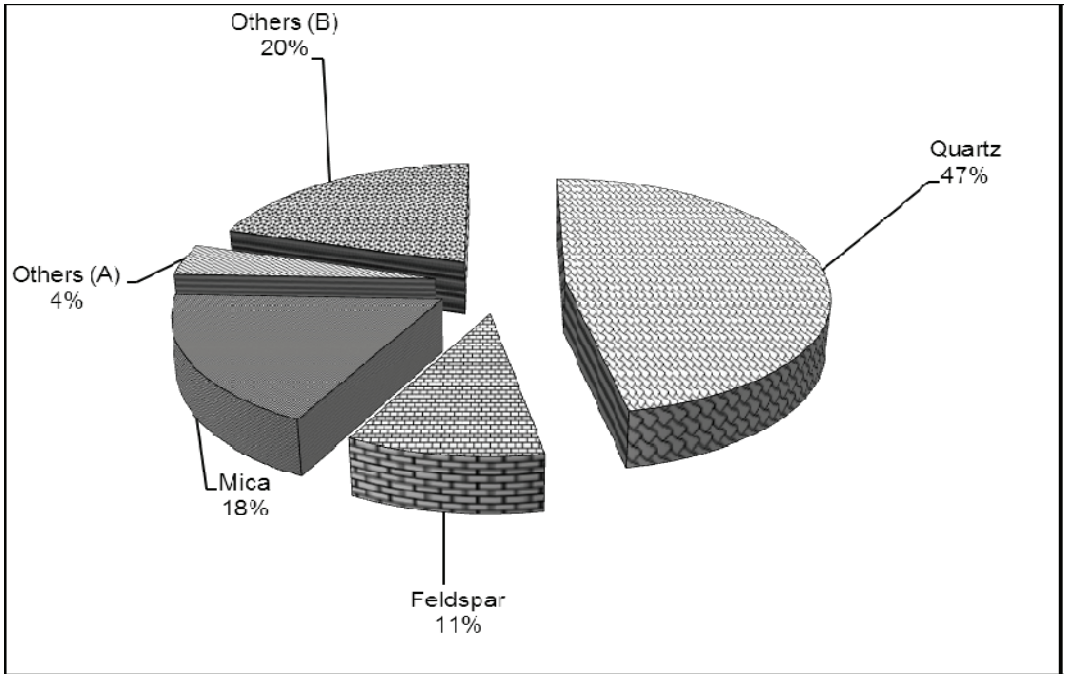

Fig. 4 Mineral content in the suspended sediment of Rahughat Hydroelectric Project.

Note: Other A: kyanite and garnet; Other B: carbonates, clay, chlorite, fragments of shale, phyllite and slate with few unidentified sediments.

5. Conclusion

Rahughat hydroelectric Project is an ROR (run of river) project with the installed capacity of 40 MW. The gross head of RGHEP is 292.83 m. The suspended sediment in Rahughat River contains 52% of sand fraction. The suspended sediments contain 62% (quartz 47%, feldspar 11%, kyanite and garnet 4%) of hard minerals above 5 in Moh's hardness scale. The proposed desander is designed to settle particles of size 0.2 mm and above. The sediments lesser than 0.2 mm size (fine sand and silt size sediment) are significant in number that reach the turbine may affect the loss of turbine material due to erosion. So it can be concluded that while selecting the hydraulic turbine material the mineral content of the suspended sediment in the Rahughat River should be considered.

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