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Detrimental effects of tiny silt particles on large hydro power stations and some remedies☆

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Summary Emergence of silt conscious designs of hydro power plants is an great challenge which calls for pooling the experiences of concerned. It also under lines the desirability of silt consciousness during investigations, design, operation, maintenance, refurbishment and upgrading.

Due to inherent weak geology, rock instability, population explosions and deforestation, all rivers emanating from Himalayas carry enormous quantity of silt during heavy runoff of monsoon from June to September.

Hydro Power stations located in Himalayan region face heavy silt problems during high inflow periods. Siul River carries heavy silt concentration of the order of 30,000 PPM (Part Per Million) (4) affecting generation, eroding turbines and cooling water system, requiring heavy cost towards maintenance of Baira Siul project.

Similarly Chenab River on which Salal Project is located also carries enormous quantity of silt affecting shut down, damage to glacis to the tune of 15 cm to 20 cm, and severe damages to turbines and cooling water system of the project.

Remedial measures have been taken like replacing the metallurgy of stainless steel for runner, guide vanes by 13 Cr Ni4 and hydro siphoning from the reservoir to maintain the generation. A series of other experiments were also tried on these projects by using modern technology. Some of them are successful to some extent.

Review of previous work

Water Analysis of Chenab on which Salal project is located and River Baira on which Baira Suil project is located, show that they do not contain any harmful chemicals which may

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Table 1 Silt analysis (NHPC, 1998).

Average dimensions of silt particles in mm	Percentage	Class
0.62—0.031	3—5	Coarse silt
0.031—0.016	25	Medium Silt
0.016—0.008	45	Fine Silt
0.008—0.004	25	Very Fine Silt
0.004 and below	0.5	Clay Fraction

have detrimental effects on the components of turbines working under water and cooling system. On the other hand it indicates that there is 75—98.5% of nano particles of quartz in total silt having hardness 7—8 on Mohar scale. About 90% of the particles are of 0.25 mm and less and thus making de-silting at Baira Suil hydro Project in-effective.

Suil carries a silt concentration of 30,000 PPM (Part Per Million) during heavy monsoon. Similar is the case of Chenab River on which Salal Project is located. Results of silt analysis is shown below in Table 1.

Detrimental effects of nano silt particles on major components

Silt wash load and total load

Total silt load is the sum of the bed load, suspended load and wash load. Bed load is that part of total load sediment mix of which the stream composed. The particle size finer than those represented in bed load is determined by characteristics of bank and available upslope rate. In American practice normally the fine sediment load is finer than 0.062 mm for sand and clay channel. The silty clay and sand could be considered as coarse gravel and stable bed channel.

Detrimental Effects of Silt Normally Observed on The Following Components of Hydro Power Projects.

A) Reservoirs
The accumulation of silt along with rock fragments and boulders reduced the capacity of the reservoirs over the life of them during the operation period. Often cleaning is not an easy task. Sedimentation is a serious growing problem in the country. Dams constructed on rivers carrying heavy silt charge get silted with consequent reduction in useful life of reservoirs. Data on 116 large dams was analyzed to determine the detrimental effects of silt in India and it was revealed that by the year 2020, over 20% of reservoirs would have lost about 50% of the capacity (Prasad and Darde, 1996).

B) Spill Way Glacis
Silt and rolling boulders erode the spill way glacis. At some places the erosion is quite abnormal and repair becomes a challenge.

C) Turbines
High silt loads with quartz having large hardness damages turbines and guide vanes. The abrasion of guide vanes, bushes, cup seals and rubber cords causes heavy leakages.

Figure 1 Layout of Baira Dam.

The shaft seals get damaged frequently. If the failure of shaft seal takes place with leakage from bearing, the situation becomes very alarming resulting in shut down of the machine.

D) Cooling Water System
The cooling water system meant for cooling of thrust bearing, stator and generator transformers get fully or partially choked due to silt present in the water derived from water conductor system. In case silt content is very high the strainer gets completely choked. Cooling tubes getting chocked causing rise in temperature of machines stator and generator transformer beyond permissible limit. The impact is such that it requires additional dewatering pumps and continuous repair of one or other machines throughout the year. Ultimately heavy cost of repair.

Preventive measures taken on Baira Suil and Salal Hydro projects

A) Baira Suil project

Baira Suil Hydro Power Located in Himachal State, utilizes combined flow of River Baira and River Bhaled totalling 88 cumecs to generate 750 MU (Million Units) of energy annually, has an installed capacity of 198 MW (Mega Watts) (Fig. 1). It was commissioned in 1982. The flow of Bhaled is diverted to reservoir created by constructing a Rock Fill Dam across the river Baira. The combined flow of Bhailed and Baira rivers is lead to Head Race Tunnel 7.7 km taking off from intake at Baira reservoir. The head race tunnel commences from Baira Dam passes under the river Suil enroute. The flow of river Suil is intercepted by a weir across river Suil and fed in head race tunnel to augment the flow of tunnel through a vertical drop shaft of 80 m length. The power house located on right bank of Suil, houses three Francis Turbines of 66 MW capacity each.

Damage to civil structures
In addition to de-silting basins provided at three locations designed to remove particle size greater than 0.5 mm