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Lake Tapping as a method of Electricity Generation and Recharging of Aquifers in India.

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ABSTRACT: Lake tapping is one of the most common approaches towards purification, limitation and efficient use of Lake Water as seen in countries like Norway, Chile and even Alaska, especially due to the uncertain pattern of rainfall. This technique has been used for the first time in India as well as in the Asian Region on Koyna Hydroelectric Project Stage-IV. This project has been an inspiration for several other approaches involving hydropower in order to generate sustainable resources of energy in India.With its productive use India can lead in economy by eradicating the effects of numerous disasters and subsequently adopt Eco-friendly measures to make a stabler environment.

Keywords: Lake tapping, Hydroelectric, Research, Risks, Advantages, Impact, Approach, Sustainability, Innovative, Modification, Tunnel, Freshwater, Recharge, Aquifers.

I. INTRODUCTION:

India is a the seventh largestcountry in the world with landmass of twenty eight states and eight Union Territories, spread over an area of 3.287 Million Km^2representing the Himalayan River System and the Peninsular river system with numerous rivers and their tributaries and several other lakes. India's total renewable water resources are estimated at 1,907.8 km^3 a year. Its annual supply of usable and replenish able groundwater amounts to 350 billion cubic metres. About 44 million tonnes of cargo is moved annually through the country's major rivers and waterways. Groundwater supplies 40% of water in India's irrigation canals. Thus, it is extremely crucial to maintain the resources and at the same time extend the availability to areas where its scarce especially due to the uneven pattern of rainfall in various parts of the country, that leads to drought, floods and manmade disasters such as overflow of reservoirs leading to death and destruction as a result of tremendous landslides and erosion.

Lake tapping is a Norwegian technique developed in order to tap the freshwater lakes located high up in the mountains below their normal levels in order to generate electricity and supply drinking water. It has been put into action in several lakes in Norway followed by Brazil, Chile and even Alaska as shown below.

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LAKE TAPS
DESIGNED BY NORCONSULT 1975 - 1999

COUNTRY	CLIENT	PROJECT	WATER DEPTH m	CROSS SECTION m^2	YEAR
Norway	Röldal - Suldal Power Board	Svandalsflona Power Plant	20	10	1975
			30	14	1975
			20	14	1975
	I/S Övre Otra Power Board	Brokke II Power Plant	20	65	1976
	Aust-Agder Energy	Rygene Power Plant	9	95	1976
	Salten Power Board	Lomi Power Plant	70	18	1978
	Municipal Sewerage System (IVAR)	Intake Haga lake	15	3	1979
	Troms Power Board	Skibotn Power Plant	24	6	1980
	Hedmark Energy Board	Osa Power Plant	20	30	1980
	I/S Övre Otra	Holen Power Plant	50	45	1981
	Vestfjord Sewerage System (VEAS)	Outlet tunnel	23	10	1982
Alaska, USA	International Engineering Co.	Tyee Lake Power Plant	50	9	1982
Norway	Hol Power Utility	Ustekveikja Power Plant	10	23	1983
	Statoil	Cooling water tunnels, Kaarstö Gas Terminal	30	5	1983
			10	3	1983
	Oppland Power Board	Lomen Power Plant	15	20	1983
			15	20	1983
	Lyse Power Utility	Tjodan Power Plant	25	16	1984
			20	16	1984
			36	16	1984
			8	7	1985
	I/S Övre Otra	Skarjes Power Plan	20	30	1986
			8	20	1986
			8	20	1986
	Norsk Hydro	Shore approach, Sture Oil Terminal	80	$700m^3$	1986
Chile	Endesa	Canutillar	35	25	1986-87
Alaska	Pacific Ventures Inc.	Crater Lake Tap	65	10	1987-88
Norway	Sogn og Fjordane Power Plant	Mel Power Plant	78	6	1988
			20	4	1988
			19	4	1988
			45	4	1989
	Municipal Sewerage System (IVAR)	Outlet tunnel	80	5	1989
Brazil	Electricidade De Sao Paulo	Pirapora Lake Tap	20	40	1987-93
Norway	A/S Norske Shell	Shore approach, Kollsnes Oil and Gas Terminal	160	2×39	1993-94
	Norsk Hydro	Fröystul Power Plant	25	45	1995
	Lyse Kraft	Flöyrli Hydropower Plant	5	20	1999
	Elkem ASA	Lakshola Hydropower Plant	5	80	1999
India	Patel Engineering Company Ltd.	Koyna Hydro Electric Plant	32	2×45	1995-99

Table1: List of countries where lake tap has been installed.

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Hydropower generation is the bestfrom many points of view. These include simplicity of design, easy maintenance, absence of pollution and zero fuelling cost, as the source is a perpetual one and it goes to waste if not exploited. It is a pollution free source since it does not contribute to air and water pollution or to Green House Effect.

If a dam is not having outlets of sufficient capacity or if some additional outlets are required for power generation etc., then the dam should be provided with new/additional outlet system. This outlet system will serve as intake system for the power generation system. This outlet system is known as Lake Taps.

This technique has been used for the first time in the Asian region in India on Koyna Hydroelectric Project Stage-IV.Lake tapping is gaining importance in India, particularly, in Maharashtra State in India. Two lake taps have been carried out one in Koyna Hydroelectric Project as mentioned and another at ModakSagar near Mumbai.

This paper focuses on the utility of lake tapping in various other parts of the country effectively in order to mitigate the most recent problems such as depletion of groundwater level and shortage of electricity in various parts of the country.

II. DIFFERENT METHODS AND APPROACHES:

Lake tapping is a technique for connecting the water conductor system to the lake which can either be natural or man-made.There are two known methods for piercing the lake – dry and wet (submerged) methods.

- In dry method, the lake is depleted forcedly and the rock plug is blasted from the top (open blasting)
- In submerged method, the rock plug is blasted from bottom without depleting the lake. This method has seen more utility than the former.

Submerged method however is executed by two different approaches – closed approach and open approach.

- In case of the closed approach, the control gate is on the upstream side of the shaft and thus, the tunnel is not in contact with the atmosphere. The tunnel is dry or partially filled with water. In this case, shooting of the plug can take place shortly after loading. The tunnel friction plays a very important role. This approach is better suited for long length tunnels and low reservoir heads.
- In case of open approach, the control gate is on the downstream side of the shaft, and there is a direct connection between the funnel face at the plug and atmosphere, through the gate shaft. The tunnel system is partly filled with water, keeping a sufficient pressurised air pocket underneath the plug.

After the blast, the water flows with extra pressure through the tunnel and the water is supposed to have sufficient pressure to run the turbines. After the tunnel has been dug the protecting resistant rock is blasted to permit water into the tunnel. This is surprisingly important in the fact that the water may be used to provide electricity and this increased flow of water is then driven to the hydroelectric power generation plant for increased current production

III. CONSIDERATIONS:

Important necessity for the successful construction of lake tapping is suitable ground conditions. The successful construction of the great number of lake taps is based on the fact that the piercing process has been controlled by a highlytrained professional having practical experience in these challenging works. There are various factors to be considered prior to the installation of Lake Taps regarding the site selection:

- Geology at Lake Tap Location. Compact, Joint less Rock with low permeability is preferable.
- Location of Gate Shaft. : Above normal Flood level
- Length of Intake Tunnel: Minimum length is preferable particularly in open Lake Tap.
- Air Pocket required providing Cushion for blast shock
- Muck Pit: Muck pit is provided at the bottom of the plug to collect the fragmented rock of the plug. As a thumb rule, the volume of the Muck Pit should be 3 times the loose volume of the rock plug.
- Plug Thickness: Thickness of the plug should be equal to the diameter of the intake tunnel or if the intake tunnel is rectangular, it shall be equal to the short side of the rectangle.

The final design of the rock plug depends mainly on two parameters –

- Quality and permeability of the rock mass in the final plug.
- Quality and permeability of the consolidated soil cover.

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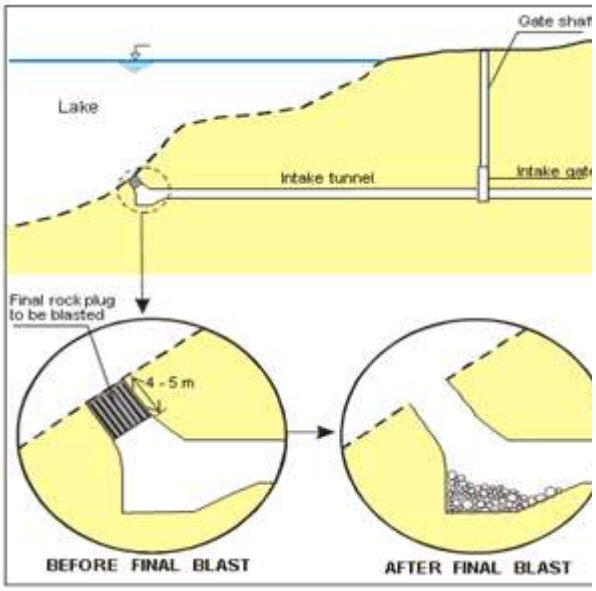

Figure1: Tunnel piercing the lake

IV. ADVANTAGES:

- One of the major benefits of lake tapping is that it is used for the establishment of waterways for hydro-power. Thus paving the way for uninterrupted generation of electricity.
- It can be used to replenish the depleting ground water level by directing the water towards defunct bore wells and pits thereby recharge the aquifers.
- It is used for making drinking water available and for irrigation purposes.
- .It is done to purify the lake water.
- It is done to limit the lake water.
- It is done to effectively drain out the lake water.
- It is also used for the landing of oil and gas pipes from offshore fields.
- It can be also be used to divert the reservoir water on the verge of overflowing..

V. RISKS:

There are several risks associated with the installation of the lake taps, which include:

- In closed method, hydrodynamic conditions are uncertain. Unacceptable pressure rise can be generated if the distance between the plug and the gate is short. The plug fragments and the sediments above it are likely to be carried uncontrolled into the tunnel and can cause damage to the gate.
- In open method, the task of water filling is complicated and there is a considerable time lag between explosive loading and shooting. Also, the velocity of water in the tunnel after blast is low and the debris are easily trapped in the muck pit.
- In open method, proper estimation of explosives and the sufficiency of the pocket volume are required to be ascertained at the layout stage only. Otherwise, the dynamic pressure on the gate after the plug blasting is excessive and the gate design becomes very complicated.
- Rock mass condition needs to be inspected before commencement of the drilling, in case of faults or cracks, and hence further requirement of rock supports.

Thus, the successful construction of the great number of lake taps is based on the fact that the piercing process has been controlled by a highly trained professional having practical experience in these challenging works. Due to the difficulty and risk of damage to existing structures, a thorough and detailed design based on detailed geological data and experience from similar work is a precondition for a successful design.

VI. CONCLUSION:

Apart from the risks, which can be dealt with by proper training and planning, the technique of lake tapping has proven to be extremely beneficial over the years to the masses. Its more advantageous in the manner that can solve the basic problem that our developing country is still a victim of, such as generation and availability of electricity in every household. Lake tapping can play a vital role in the replenishment of our depleting groundwater levels which has become a matter of severe concern in various regions in our country. Besides this, lake tapping can also help reduce the negative impacts of floods in areas such as erosion and further contribute to irrigation especially during droughts.In the present day, with higher technological advancements in designing and statistical analysis, prior to commencement of the work and its further supervision, risk involved in the process can be considerably reduced.

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