International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 4 Issue: 4
ISSN: 2321-8169
498 - 501

An Innovative Technique as Lake Tapping for Dam Structure: A Case Study

Prof. Aakash Suresh Pawar
Department of Civil Engineering
North Maharashtra University, Jalgaon
Maharashtra, India
aakashrcpit@gmail.com

Prof. Lomesh S. Mahajan
Department of Civil Engineering
North Maharashtra University, Jalgaon
Maharashtra, India
loms786@gmail.com

Prof. Mahesh N. Patil
Department of Civil Engineering
North Maharashtra University, Jalgaon
Maharashtra, India
m.patil123@gmail.com

Abstract – From the last three decades water resource management becomes very special issue due to uncertain pattern of rainfall all over globe and mainly its drastically affects in south Asian parts. Hydroelectricity uses the energy of running water, without minimizing its quantity, to generate electricity. Therefore, all hydroelectric developments, of small or huge size, whether run of the river accumulated storage, fit the concept of renewable energy. Hydroelectric power plants reservoirs offer incomparable operational flexibility, since they can fast respond to fluctuations in the demand for electricity. The free to adjustment, flexibility and storage capacity of hydroelectric power plants becomes efficient and considerably economical in supplement the use of irregular sources of renewable energy. The operation of electricity systems depends on rapid and flexible generation sources to meet peak demands, maintain the system voltage levels, and quickly re-establish supply after a blackout. Energy generated by hydroelectric installations can be injected into the electricity system faster than that of any other energy source. So providing ancillary services to the electricity system, thus maintaining the balance of water supply availability and fulfill that demand by using a new technique as an additional arrangement for continuous power generation via lake tapping.
A lake tap involves excavating a tunnel to the water and rock contact after that they blasting out the final protective rock under the lake to allow water to suddenly inflow into the head race tunnel, after that excavating one limb of the Head Race Tunnel towards the lake, and the other limb towards power house. First lake tapping was done on Koyna dam in year 1999. In this paper mainly focussing on utility of tapping across Koyna dam as a model all over the other resource management system.

Index Terms – *Hydroelectricity, Koyna dam, lake tapping.*

*****

I. INTRODUCTION

The Koyna Hydroelectric Project is the biggest finished hydroelectric force plant in India. It is an intricate undertaking with four dams including the biggest dam on the Koyna River known as the Koyna Dam thus the name Koyna Hydroelectric Project. The task site is in Satara region close Patan. The town Helwak close to the dam was later known as Koyna nagar. The aggregate limit of the undertaking is 1,960 MW. The venture comprises of four phases of force era. Every one of the generators is situated in underground powerhouses unearthed profound inside the mountains of the Western Ghats. A dam foot powerhouse additionally adds to the power era. Because of the task's power creating potential the Koyna River is considered as the life line of Maharashtra.
The undertaking exploits the stature of Western Ghats. In this way an extensive pressure driven head is accessible over a short separation yet a few restrictions ought to be overcome by filling of fake water stores in questionable condition like tremor. Dam-supply collaboration is broke down utilizing limited component approach.

Koyna Dam is a rubble solid dam 103.02 m high over the most profound establishment level, and 85.35 m high above River Bed. It has an aggregate length of 807.22 m. It is built crosswise over stream Koyna, which is a noteworthy a tributary of River Krishna. The dam is situated close town Deshmukhwadi in Patan Tahasil in Satara District of Maharashtra State of India. The Dam is established on basalt rock. Koyna is one of the major Hydro Electric Projects in the Country. The dam seizes 2980.34 MCum water to produce 1960 MW power. With particular maintainable improvement ecological comprise variables influencing to oversee perspectives like characteristic assets, contamination control, versatility and dam security.

Lake tapping technique includes running a passage towards and under a lake, leaving a short shake attachment to the lake floor underneath the tapping level as appeared in Figure 1.

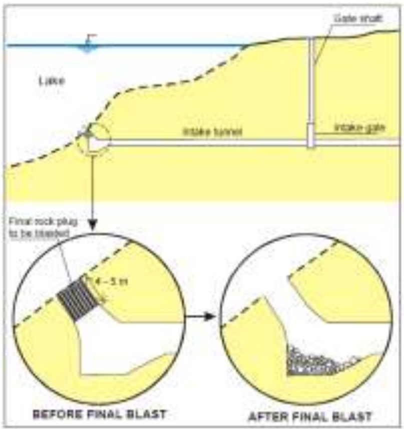

Figure 1 Lake tap method for a water tunnel

The environmental impacts by various kinds of dams have been recognized in the primary stage of modern dam construction phase so comprehensive action programmed may effective. The dam is built in 53 monoliths of which six end monoliths are constructed in masonry and the rest in rubble concrete. The spillway is centrally located and extends from monolith number 18 to 24 over a length of 88.70 m. six radial gates of size 41 ft X 25 ft are installed in the spillway. In year 2003, these gates are fixed with 5 ft high flaps which are independently operated hydraulically. The height of gates can thus now be considered as 30 ft. Catchment area of the Dam is 891.78 SqKm and submerged area is 115.35 Sq Km. 98 villages were affected by the submergence and 9069 families were displaced. These families are rehabilitated in 6 districts viz. Satara, Sangali, Sholapur, Kolhapur, Raigad and Ratnagiri.

II. LAKE TAPPING

When we plan a Hydro project, we construct the water outlet in the body of the dam or a separate Head Race Tunnel is excavated from the reservoir side. So long as there is no impoundment of the water in the reservoir, excavation of Head Race Tunnel can be done in conventional ways. After the reservoir is impounded and we are planning for a new powerhouse for whom Head Race Tunnel is to be excavated, we cannot excavate it from reservoir side, because there is water. In such situation, we choose a suitable location on the bank of the lake, above the high flood level and from there we start excavating either a shaft or an approach tunnel. After reaching the required level of Head Race Tunnel, we start excavating one limb of the Head Race Tunnel towards the lake, and the other limb towards powerhouse. The limb which is being excavated towards Lake is not connected finally to the Lake. A suitable rock plug with calculated thickness is left unexcavated at the mouth of this limb and the water is kept at bay. At the other end the construction of the powerhouse is carried out uninterrupted. Once the construction of powerhouse is completed and the powerhouse is on the verge of commissioning, the rock plug at the bottom of the lake and at the mouth of the Head Race Tunnel is blasted and water is allowed to flow towards the powerhouse. This process of finally blasting the rock plug at the bottom of the lake with underwater procedures is known as Lake tap. If a reservoir is not having outlets of sufficient discharge or if some extended outlets are provided for electricity generation etc. It should be provided with some extra outlet system. This out flow system will serve as intake system for the electricity generation system. This reservoir storage system can be an uneconomical intake system by puncturing the lake from bottom by blasting the rock plug using dynamites. This is called as Lake Tapping.

This procedure is extensively used in Norway to connect Lakes at different levels for either power production of for supply of water. Blasting view of Koyna lake tap as shown in Figure 2 below.

Figure 2 Lake tapping at koyna hydro project

Since the HRT of Stage IV was introduced after impoundment of Shivaji Sagar Lake, Koyna project had to resort to this technique and accordingly first Lake Tap to connect the HRT of Stage IV was done on 13 March 1999. Lake tap mouth was planned at KRL 618 m.

A. Geotechnical Aspects of the Design of Under Water Lake Tap in Koyna Hydro Electric Project

Under Water Lake tapping is a Norwegian technique developed in that country mainly to tap the inland lakes located high up in the mountains below their normal levels for electricity generation and drinking water supply. This technique is used in sub-sea tunnels for oil and gas activities. In this technique, a shaft is sunk on the fringe of the lake/reservoir up to the bottom of the water conductor tunnel from which an intake tunnel is excavated underneath the lake to reach the lake bottom leaving a break-through rock plug which is finally blasted to connect the lake with the pre conceived water conductor system. The blast is designed in such a way that vibration produced in the adjoining roll mass and the resultant hydro dynamic pressure built up in the system are kept at minimum acceptable levels, thus protecting the adjoining structures.

This technique has been used for the first time in India as well in Asian region on Koyna Hydroelectric Project Stage-IV. This paper is a case study describing the various aspects along with geotechnical aspects from investigations to actual execution of this technique on said project. This technique has opened a new avenue on several other projects involving improved utilization of water from the existing reservoirs.

B. Selection of site for under water lake tapping

Important Aspects involved.

- 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 (For Koyna it is 220m.)
- Air Pocket required providing Cushion for blast shock: Based on model studies air cushion kept was 13m.
- 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.

C. Components of Koyna Left Bank Power Station

The Intake structure is provided in three separate shafts for stop-log gate, trash rack and service gates are provided. Following types of gates are proposed.

- Emergency / Stop Log Gates Provision of one emergency gate of size 5000M X 7000OM - MT Capacity EOT Crane with lifting beams is made for lifting and lowering the emergency gate. Arrangement of ACC hoisting structure is to be provided.
- Trash Rack Gate: Trash Rack Panels with E.O.T cranes of 20 Metric Ton Capacity with lifting beam and RCC hoisting structure is proposed.
- Service Gate The service gate consists of gate of size 4X9 meter with hydraulic lifting and lowering system.
- Intake Tunnel: A circular Intake Tunnel of 7.2 m finished dia with 50 cm R.C.C lining is proposed, considering 4 m/s limiting velocity. Length of intake tunnel is proposed as 227 m with radius of curvature 70 m at the junction with intake structure. A bed slope of 1:100 is provided.
- Head Race Tunnel: A circular HRT of 7.2 m finished dia with 50 m R.C.C lining is proposed. Length of HRT is proposed as 30 m upto the junction of Y-piece. Discharge through the tunnel is considered as 160 cumecs.
- Pressure Shafts: It is proposed to install 2 units of 40MW reversible turbines. A steel line Y-piece is provided to branch the pressure shafts, after which two circular steel lined pressure shafts 2.9m dia, are provided upto spiral case inlet. Similar arrangement is provided on the d/s after draft tube control valves.
- Power House: Power House is so located that adequate rock cover above the cavern is available and at the same time it is sufficiently away from the dam proper. Considering these points a site which is 150m away from dam proper and where rock cover of 42m with approx. 17m overburden is available is selected. Size of power house is 21m X70m and height is 43 m. As rock cover is nearly equal to span, full R.C.C lining is therefore proposed for power house.
- Tail Race Tunnel & River Intake A circular tunnel of 7.2 m finished dia, with 50 cm thick lining is proposed. At the mouth of tail race, vertical well will be taken up to R.B.L. Trash rack panel provided to block debris entering the T.R.T. during pump operation of the unit. The size of river intake structure is 20 X 20 X 7m with its top at R.L 589 m. Provision for control structure to separate power house and downstream intake has been made.
- Ventilation and Bus Duct Tunnel: Two D Shaped Tunnels are provided, one as Ventilation Tunnel and another as Bus Duct Tunnel. Length of ventilation tunnel and bus duct tunnel proposed is 160m and 115m respectively. Size of ventilation tunnel is 4X4m & bus duct tunnel is 6X4m.
- Access Tunnel: A'D' shaped access tunnel of size 7mX7m is proposed with curves. Service Bay level is 578.8m and entry of Access Tunnel is kept at KRL 606m.which is above HFL of river at KRL 605.79m for discharge of 2 lakhs cusecs.

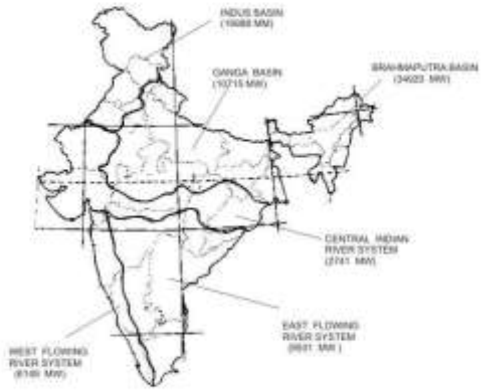

Figure 3 Basin-Wise Hydro power Potential of India

III. STAGES OF INSTALLATION OF UNITS

A. *Stage I and II*

The main phase of the undertaking was affirmed in late 1953 and development started in mid 1954. At first a two-stage development was considered. In any case, the aggregate era limit of the two stages was too substantial for burden conjectures of that time. So a period slack of over 10 years was proposed between the two stages. Inside two years from there on, it came to be seen that the 10 year's time tag between these two stages won't be moderate and to adapt up to the force prerequisites, the two stages ought to be blended and both the stages ought to be developed all the while. Henceforth, it was acknowledged that the two stages must be executed as one.

The first and second stages offer same powerhouse with aggregate eight Pelton turbine units. Each of the two stages has four turbines having limit of 65 MW each for first stage and 75 MW each for second stage. The water from Shivasagar repository is taken through an admission structure known as Navja tower close town of Navja into the head race burrow. At that point it voyages towards the surge tank. It is further isolated into four weight shafts which run vertically descending conveying water to the turbines. At that point the water is released into the tail race burrow.

A dam foot powerhouse was additionally developed which is utilized to create power by the water which is released from the Koyna Dam for watering system reason. It has two Francis turbine units of 20 MW each. This powerhouse is keep running as indicated by the watering system prerequisites of the downstream ranges. The consolidated introduced limit of the two stages and the dam foot powerhouse is 600 MW.

B. *Stage III*

Initially a weir was proposed to divert the water coming out of tail race tunnel of Stage I and II. But it was later observed that the water still had a hydraulic head of about 120 m which could be used. To use this head, the Kolkewadi Dam was constructed at this location. It forms a balancing reservoir and maintains the head. This dam impounds the tail race water from Stage I and II. This water is drawn through penstocks and electricity is generated by four Francis turbine units with a capacity of 80 MW each. The tail race water from these stages

 ISSN: 2321-8169
498 - 501

then flows through a channel and joins the Arabian Sea near Chiplun. The installed generating capacity of this stage is 320 MW.

C. Stage IV

Later in the 1980s, the power interest of the Maharashtra expanded massively bringing about deficient force supply. The Planning Commission agreed endorsement to Stage IV with establishment limit of 4 × 250 MW. Hence, one more stage called Stage IV was added to power arrangement of Stages I and II, along these lines changing over the Koyna Power Station into a cresting power station complex with burden element of around 18.7%. This plan likewise draws water from the current Shivasagar repository same as Stages I and II. A nonconventional admission framework was made by puncturing the lake from the base by impacting the stone fitting utilizing explosive. This twofold lake tapping procedure was the first of its kind in Asia.

The water in head race passage is specifically drawn from the store and conveyed to the head surge tank. At that point four weight shafts take the water descending vertically. The four gigantic Francis turbine units of 250 MW each create power and tail race water is taken into the Kolkewadi Dam store through tail race burrow. A progressive gas protected switchgear framework is utilized as a part of the underground powerhouse of this stage. The introduced limit of this stage alone is 1000 MW. This stage is generally used to provide food for the crest hour requests of the electric network. The general course of action of every one of the four phases of Koyna dam as appeared in Figure 3.

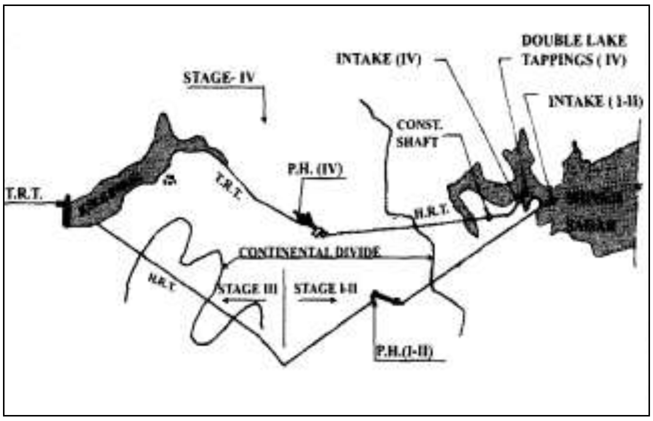

Figure 4 Schematic layout of Koyna dam

IV. Closing Remark and Conclusion

Lake tapping at Koyna dam is a Norwegian technique developed in that country mainly to tap the inland natural lakes located mountains which are bellows their normal levels for electricity generation as well as drinking water. In these 4 stages of power generation, the 4th stage of the generation is done by a unique, innovative and non-traditional intake system by puncturing the lake from bottom by blasting the rock plug using explosives.

A lake tapping is providing uninterrupted water supply, was carried out at the Koyna hydroelectric project in Satara district. The Koyna project generates power and the lake tapping will help provide supplementary water to the Krishna Valley projects. This massive force also enables larger quantities of water to be moved to greater distances for lift irrigation purposes and would greatly benefit the water-starved regions of Maharashtra.

Finally study concluded that lake tapping has initiative immerging idea towards sustainable water power if this type of lap tapping could possible in next upcoming decades then it's definitely positive impacts on water energy conservation.

References

[1] M. Pasbani-Khiavi, A.R.M. Gharabaghi and K.Abedi, "Dam-reservoir interaction analysis using finite element model," The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

[2] J. Manatunge, T. Priyadarshana and M. Nakayama, "Environmental and social impacts of reservoirs: Issues and Mitigation," Oceans and Aquatic ecosystems.

[3] Kyohei Baba and Toshio hirose, "Environmental impact assessment of dams and reservoirs, "water storage, transport and distribution.

[4] Mr. A. R. Chavan, Dr. S. S. Valunjkar, "Dam instrumentation in gravity dam: A case study on Koyna dam," International of engineering and technical research (IJETR) ISSN:2321-0869, volume-3, issue 5, may 2015.

[5] Jagtap R. N., Patil B. M, Bhosekar V. V. and Sohoni V. S., "Numerical Simulation of Lake Tap Flow," *International Research Journal of Engineering and Technology* (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 01 | Jan-2016 p-ISSN: 2395-0072.

[6] S. N. Huddar, "Geotechnical aspects of the design of under water lake tap in Koyna hydroelectric project stage-IV," W & E international(water resources section)

[7] Rajvardhan S. Patil, "Probabilistic approach for epistemic analysis of lake tapping of Koyna dam for future forecasting," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)* e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 4 Ver. II (Jul- Aug. 2014), PP 72-87

[8] Harsh K. Gupta, "A review of recent studies of triggered earthquakes by artificial water reservoirs with special emphasis on earthquakes in Koyna, India," Earth-Science Reviews 58 (2002) 279–310 National Geophysical Research Institute, Hyderabad 500007, India Received 15 March 2000; accepted 29 October 2000.