International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 08 | August - 2022 Impact Factor: 7.185 ISSN: 2582-3930

A STUDY OF LAKE TAPPING IN KOYNA DAM

AYUSH DUBEY[1]

Undergraduate[1]

Dept of Civil Engineering, Alard college of engineering and management,Pune

ABSTRACT:

The statistical technique like confidence interval (CI) is used to determine the confidence limits of water head over lake tapping site of Koyna Dam (India, Maharashtra) from water level data taken from government of Maharashtra 2000-2010, which helps in future forecasting. It is the statistical technique which gives the Probable Value of the water head in the relative month. By studying these probable values of water heads, monthly variation in the heads seasonal variation can be achieved. Contour maps and variograms are studied to check the variation of Water head from year-2000-2010. It also helps to determine the probable nature by knowing the confidence Interval of heads and it is more useful and helpful for the water management of rain water which is accumulated on ground by the means of large reservoirs. Predication of rainfall and head variation is achieved.

Keywords: Statistical Technique, Confidence Interval, surfer10, Contour maps, variograms, Koyna Dam, Water head, Lake Tapping etc.

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.

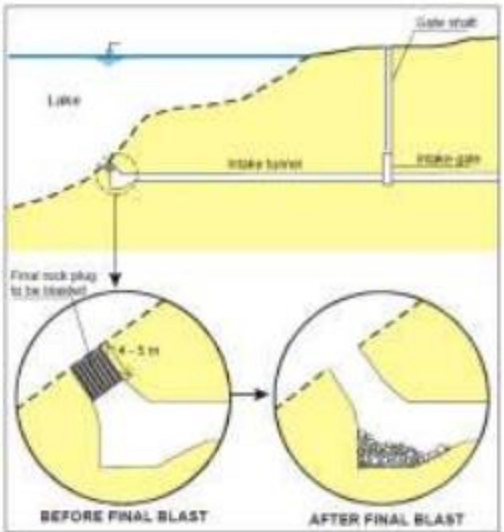

Figure 1 Lake tap method for a water tunnel

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. NUMERICAL MODELLING TECHNIQUE

In the present study, FLUENT software (2006) is used to simulate the lake tap flow. It is based on numerical solution of 3D equations of flow namely, mass conservation i.e. continuity equation, momentum conservation equation i.e. Reynolds Average Navier-Stokes (RANS) equations and the standard k−ϵ model for simulation of turbulent flows which is a model based on transport equations for the turbulence kinetic energy (k) and its dissipation rate (ϵ). The governing equations are: A Governing Equations The continuity equation for the mixture is:

$$\frac{\partial}{\partial t}(\alpha * \rho) + \nabla.(\alpha * \rho * \vartheta) = \sum_{p=1}^{n} m$$

Where α denotes the volume fraction of single material, is the density of a material, m is the mass flow rate. The Navier-Stokes equations are,

$$\rho \frac{Du_i}{Dt} = -\frac{\partial p}{\partial x_i} + \frac{\partial \tau_{ij}}{\partial x_j} + \rho F_i$$

$$\rho \frac{De}{Dt} = -p\frac{\partial u_k}{\partial x_k} + \varphi + \frac{\partial}{\partial x_k}\left(k\frac{\partial T}{\partial x_k}\right)$$

$$\tau_{ij} = \mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} - 2/3 \frac{\partial u_k}{\partial x_k}\delta_{ij}\right)$$

$$\varphi = \tau_{ij}\frac{D\rho}{Dt} + \rho\frac{\partial u_i}{\partial x_i} = 0\frac{\partial u_i}{\partial x_i}$$

where is the viscous stress tensor with the bulk density omitted and Φ is the dissipation function where u is the fluid velocity, ῤthe density of fluid, T the absolute temperature, k the thermal conductivity, e the internal energy, Fi is a body force term, µ is the dynamic viscosity and δij is the Kronecker delta. k-ϵ model is the most commonly used turbulence model when modeling turbulent flow.

A. Boundary Conditions

In the present study, pressure outlet boundary condition and the mass flow inlet boundary condition are imposed on the outlet and the inlet of the tunnel, respectively. In the water-boulder mixture flow the mass flow rate is set to180 m3/s. The gravitational acceleration is considered as 9.81 m/s2 in downward direction i.e. in negative ‘y’ direction and 101326 pa of Operating pressure is considered. The density of water is taken as 998.3 kg/m3. The size of boulder is given to be 0.3 m. GAMBIT software is used for mesh generation. To discretize the computation domain non-uniform grid system with tetrahedral elements and a multi-block unstructured is used. For discretization schemes of both diffusion and convection terms, central difference and the second order upwind are selected, respectively.

III. STUDY AREA

Koyna river originates from the Sahyadri hill ranges in Maharashtra and flows in a north south direction to Helwak. The Koyna dam is situated at Koynanagar in Patan taluka of Satara district of Maharashtra. The Koyna Hydroelectric Project (KHEP) is situated at Koynanagar in Maharashtra. The project was initiated in late fifties with the construction of 103 m high ruble concrete dam across Koyna river with a gross storage of 2797.40 MCM (98.78 TMC). The hydro power development on this project has taken place in four stages over the past 40 to 50 years. In the stage 4 the Lake tapping techniques are used for the development with two Lake Taps were already completed and third is being planned.

IV. 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.

V. LAKE TAPPING METHOD

METHOD OF LAKE TAPPING ARE AS FOLLOWS:

- **Dry method**:

In dry piercing the lake is depleted forcibly and the rock plug is blasted from top (open blasting). In open method the control gate is on down streamside of the shaft, and t here is a direct connection between the tunnel face at the rock plug and the atmosphere, through the gate shaft. Th e tunnel system is partly filled with water, keeping a suf ficient pressurized air pocket underneath the plug. In thi s system, hydrodynamics condition are clearly set out an d the pressure accuracy. However, the explosive loading and shooting. In this system the velocity of water in the tunnel after blast is low and the debris is easily trapped i n muck pit.

Figure 3: Dry method

- **Wet method**:

In closed method, the control gate is on the upstream sid e of the shaft and thus the tunnel is not connected to the atmosphere. The tunnel is dry or partially filled with wa ter. In closed system shooting of the plug can take place shortly after loading. However, the hydrodynamics cond itions are uncertain. Unacceptable pressure rise at the to p gate can be generated if the distance between the plug and the gate is short. The plug fragment and the sediment above it are likely to be carried uncontrolled into the tunnel and can cause damage to the gate. In closed method the tunnel friction plays very important role. This method is better suited for long tunnel lengths & low reservoir heads.

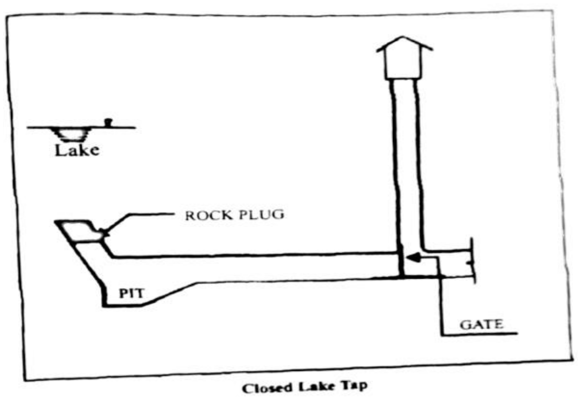

Figure 4: Closed Lake Tap

In open method of lake pricing volume of compressed air pocket has a key role which depends on quantity of explosives thus proper estimation of explosive and the sufficiency of air pocket volume are required to be ascertained at layout stage only. Otherwise the dynamic pressure on the gate after plug blasting are excessive and the gate design become very complicated.

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