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Bathymetric Survey To Study The Sediment Deposit In Reservoir Of Peechi Dam

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Abstract: *Bathymetric survey is a direct method for the assessment of sedimentation distribution and its bed profile in the reservoir of dams. This method is mainly used to estimate the capacity of reservoir and there by the amount of sedimentation. Peechi dam reservoir is selected for the study by conducting bathymetric survey with the help of "Sedimentation division of Govt. Irrigation department" in Peechi. The survey was conducted when the reservoir level reached FRL. The equipments used to conduct bathymetric survey are DGPS, NS-415 echo-sounder, sound velocity prob, survey PC. The software used for the calculations are navisoft survey software and surfer software*
Keywords - *Bathymetry, Sediment, Dam, Reservoir, DGPS, Eco sounder.*

I. Introduction

The measurement of water depth at various places in a body of water.

The term "bathymetry" originally referred to the ocean's depth relative to sea level, although it has come to mean "submarine topography," or the depths and shapes of underwater terrain.

Bathymetry is the foundation of the science of hydrography, which measures the physical features of a water body. Hydrography includes not only bathymetry, but also the shape and features of the shoreline; the characteristics of tides, currents, and waves; and the physical and chemical properties of the water itself.

On topographic maps, the lines connect points of equal elevation. On bathymetric maps, they connect points of equal depth. A circular shape with increasingly smaller circles inside of it can indicate an ocean trench. It can also indicate a seamount, or underwater mountain
Survey is conducted in grid pattern. The line spacing is decided based on the resolution required.

II. Integrated Bathymetric System

The construction of dam is a common practice across rivers in areas where different environment and uneven distribution of rainfall occurs. Dams have the function to store rainfall and runoff water from the catchment and serve as water storage for domestic use, irrigation, and stock watering. At the same time, they are potential sinks for upstream sediments. Soil particles accumulating in the reservoirs can lead to changes in their morphology, which will decrease water storage capacity and water use potential. Small reservoirs in particular are affected by these storage losses as the maximum water depth is often only a few meters and an accumulated sediment layer of a few decimeters at the bottom of the reservoir causes a comparatively large reduction in water volume. Therefore, it would be useful to monitor changes in reservoir morphology, to measure the thickness of the layer of accumulated soil particles and to calculate siltation rates by bathymetric survey or lake sediment retrieval.

Traditionally reservoir sedimentation has been studied by carrying out bottom topographic survey using boat, sextant, ranging rods, echo-sounder etc. Naturally this involved lot of time and the outcome was susceptible to human error of monotony of work.

The bathymetric approach is based on a simple comparison of reservoirs morphology at two different time periods, first at the time of the construction of the dam and second at the time of the survey, which should be at least 10 years later to detect significant changes. The initial topographical map of the reservoir (resolution at least 1:1000) and the corresponding geo-technical report are required to get information about area-volume curves, potential water storage capacity, water surface and catchment area, spillway, overflow and runoff data as well as construction details of the dam, such as the degree of surface soil disturbed or sediments removed.

The bathymetric survey provides a useful tool to get an overview of sediment storage in reservoirs. The fieldwork requires a comparatively small commitment of time and does not involve permanent monitoring and/or maintenance of sediment yield/runoff devices. However, the technical equipment is relatively costly (such as a depth-sonar and a Beaker sampler) and some expertise is needed for data processing and the construction of a digital elevation model.

Integrated Bathymetric system consists of modern sophisticated electronics equipments. Data collection, processing, and calculations are done by means of computer software. The results are more accurate than the conventional survey methods. The principle of this method is to send an acoustic signal and measure the travel time to derive a depth. This depth conversion process is done by first measuring the velocity of sound in the water at different depths. This calibration is done twice a day to ensure a good accuracy.

The water depth measurements can be expected to be accurate to within ±10 cm. The bathymetry equipment is a small equipment which is mounted on a boat and survey conducted along with other geo-physical methods.

III. Equipments Used

3.1Differential Global Positioning System (DGPS) –LEICA MX 9250

Differential Global Positioning System (DGPS) is a method of providing differential corrections to a Global Positioning System (GPS) receiver in order to improve the accuracy of the navigation solution. DGPS corrections originate from a reference station at a known location. The receivers in these reference stations can estimate errors in the GPS because, unlike the general population of GPS receivers, they have an accurate knowledge of their position. As a result of applying DGPS corrections, the horizontal accuracy of the system can be improved from 100m (95% of the time) to better than 10m (95% of the time).

GPS is a satellite based positioning system operated by the United Sates Department of Defense. GPS encompasses three segments, space control and user. The space segment includes the 24 operational NAVSTAR satellites that orbit the earth every 12 hours at an altitude of approximately 20,206 kilometers. Each satellite contains several high precision automatic clocks and constantly transmits radio signals using a unique identifying code.

One Master Control Station, five Monitor Stations and Ground Antennas comprise the control segment. The Monitor Station passively tracks each satellite continuously and provides this data to the Master Control station. The Master Control station calculates any changes in each satellite position and timing. The changes are forwarded to the Ground Antennas and transmitted to each satellite daily. This ensures that each satellite is transmitting accurate information about its orbital path.

Reference Station with UHF transmitter link along with choke- ring antenna forms stationary part of DGPS. It can track up to 12 satellites to achieve accurate position. The horizontal accuracy is 2 to 3 meters.

A GPS receiver must acquire signals from at least four satellites to reliably calculate a three-dimensional position. Ideally, these satellites should be distributed across the sky. The receiver performs mathematical calculations to establish the distance from a satellite, which in turn is used to determine its position. The GPS receiver knows where each satellite is the instant its distance is measured. This position is displayed on the data logger and saved along with any other descriptive information entered in the field software.

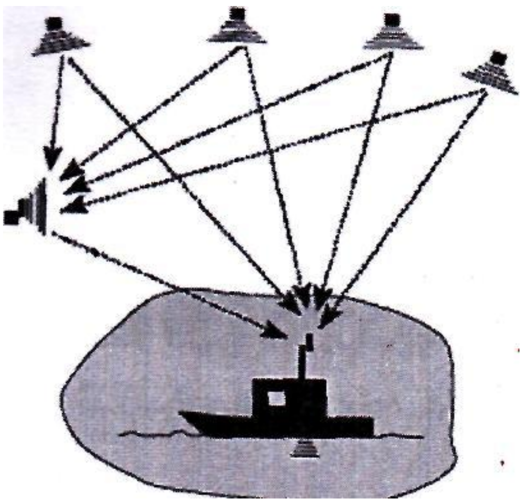

Fig.1: Schematic of GPS positioning survey system.

The underlying premise of differential GPS (DGPS) is that any two receivers that are relatively close together will experience similar atmospheric errors. DGPS requires that a GPS receiver be set up on a precisely known location. This GPS receiver is the base or reference station. The base station receiver calculates its position based on satellite signals and compares this location to the known location. The difference is applied to the GPS data recorded by the second GPS receiver, which is known as the roving receiver. The corrected information can be applied to data from the roving receiver in real time in the field using radio signals or through post processing after data capture using special processing software.

3.2 Gps Leica Mx 420(Mobile Station)

DGPS Navigator is one such highly reliable, accurate, state of art device to get position by observing satellite .It can also track up to 12 satellites to achieve maximum positional accuracy. The DGPS receiver receives error correction from reference station and combines them with the received satellite signals to compute much more accurate self position. The validity of error correction decreases with the distance from the reference stations, however they are valid up to 80 Km. The accuracy in position is lm.

3.3 NS-415 Echo-Sounder.

Navitronic Echo-sounder NS 415 is designed to measure under water depth up to 1200m. Accuracy of instrument is l cm. A dual frequency echo-sounder is specified to distinguish between fluff top depth and the consolidated bottom. The high frequency (200 KHz) is used to detect the top of the mud/sediment. Under favorable conditions the low frequency signal (33 KHz) can penetrate into the bottom and reveal information about the bottom structure.

3.4 Sound Velocity Probe

The velocity of sound under water depends on many parameters such as depth, temperature, salinity etc. A sound velocity calibrator (Refer Plate.3) is necessary to calculate the velocity of sound for taking the accurate depth readings by Navi Sound echo-sounder.

3.5 Survey Fc (Laptop)

The Navi soft survey software installed in the PC (laptop) controls the Bathy "netric data collection. All the data collected using DGPS and echo-sounder are recorded in computer and processed.. Ease of use, and cost efficiency make this device a perfect choice for bathymetric survey and marine geophysical applications. This unit is compact, interfaces directly to a standard laptop or PC, and comes complete with transceiver unit and Windows ® PC Software.

3.6fiber Plastic Boat

The mobile station setup is mounted on 'Fiber Reinforced Plastic' (FRP) boat. The boat has dimension of 7.5mX 2.66mX 1.20m and 8 person capacity with the equipments.

Fig.2: Mobile Station Mounted on FRP Boat

IV. Softwares

4.1 Navisoft Survey Software

This software assists the operator in planning of run lines, track grids using its *'Planning and Presentation'* menu. The collection, processing and storing of data can be done using 'survey' menu. All the data were stored in a file with extension [.RAW]. This data include depth intimation and position information. This *raw* data was converted into Product file [.PRD] and this was then used for further data processing. *'Data edif* menu is used for graphically editing the data. In addition to this the module also generates the profile, over view and cross sectional view of surveyed data. Track searching, GPS positioning, depth are also available to be displayed on the LCD monitor for guiding boat driver.

The Bathymetric software supports NMEA 0183 compatible devices. Local grid UTM (WGS-84) is the projection that is supported by the software. Using Navisoft and Surfer software, the sedimentation survey becomes easy, accurate and time saving. It also provides pictorial presentation of contour map and bottom morphology of the reservoir

4.2 Surfer Software

Surfer is a graphic program used for calculating the volume based on the logged data. For this purpose it is necessary to convert *(prd & raw)* files into *[.dat]* format which can be done using 'Data Exchange' option. This exchanged data convert in to 'Grid data' option, by triangulation with linear interpolation method. Using this grid data, contour maps are drawn and volume is calculated using 'grid volume' option. Surfer is a full-function 3D visualization, contouring and surface modeling package that runs under Microsoft Windows. Surfer is used extensively for terrain modeling, bathymetric modeling, landscape visualization, surface analysis, contour mapping, watershed and 3D surface mapping, gridding, volumetric, and much more.

Surfer's sophisticated interpolation engine transforms XYZ data into publication-quality maps. Surfer provides more gridding methods and more control over gridding parameters, including customized variograms, than any other software package on the market. You can also use grid files obtained from other sources, such as USGS DEM files or ESRI grid files. Display your grid as outstanding contour, ^D surface, 3D wireframe, watershed, vector, image, shaded relief, and post maps. Add base maps and combine map types to create the most informative display possible. Virtually all aspects of your maps can be customized to produce exactly the presentation you want. Generating publication quality maps has never been quicker or easier.

Surfer contour maps give you full control over all map parameters. You can accept the Surfer intelligent defaults to automatically create a contour map, or double-click a map to easily customize map features.

V. Work Procedure

5.1 Installation Of Reference Station

The first step in DGPS based survey is to select the location of reference station, for getting accurate position. The reference station is one which is fixed on the land from which the corrected positions are transmitted to mobile station for survey and it should cover maximum area. The reference station was fixed at Dam site. Reference station was configured in self survey mode for 24 hours.

5.2 Launching Of Boat

The survey boat was launched and retrieved in the reservoir with the help of boat trailer and tractor. The lists of equipments which are installed in FRP boat have already explained.

5.3 Hydrographic Survey

The first reference station was fixed at near dam site. All the settings were done in the reference station and allow it for getting accurate position. .

Using survey module planning and presentation was done by entering the position as UTM (Universal Transverse Mercator:~A special transverse Mercator grid which divides the world in to 6°zones of Longitude.) co-ordinate, and drawn reference line, with respect to this reference line, parallel lines are drawn at suitable interval to cover the entire lake. The survey was conducted along the predetermined segment lines after setting the data logging software to record the readings at 2m intervals. The boat was sailed along the track maintaining a speed of 3 to 4 knots. The depth of water and its corresponding position is recorded successively at each point. The software enables generation of depth profile and overviews using the data recorded. The data is then edited to eliminate spurious readings caused due to violent winds waves and the presents of water hyacinth. The edited data are then transferred to surfer using Data Exchange program. This exchanged data converts in to grid data by

triangulation with linear interpolation method. Using the grid data contour maps is drawn and volume was calculated at required intervals.

VI. Conclusion

Integrated bathymetric survey provides reservoir sedimentation details and much needed information such as reservoir depth, capacity and bottom topography with great accuracy to optimize reservoir operations. This survey can be conducted in Peechi dam when the reservoir level reaches Full Reservoir Level (FRL).When the survey was conducted the reservoir was at FRL and the survey was conducted along with the sedimentation sub division of the Kerala Engineering Research Institute (KERI) Peechi. The software used for the survey were very confidential and it was provided by KERI, Peechi.

The original capacity of the reservoir at full reservoir level (79.25m) is 110.436Mm^3 .As per IBS study the current capacity calculated is 94.946Mm^3 **.**Hence there is a loss of capacity of 15.490Mm^3 in 56 years. The reduction in capacity is 14.027% of the original. Rate of sedimentation is 0.27$Mm^{3.}$ (0.25%) per year. As per IBS study in 2004 the capacity was 96.414Mm^3 .Now the capacity calculated as 94.946Mm^3 and it is reduced to 1.468 $Mm^{3.}$ For 9 years.

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