Dam Safety and Instrumentation

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***Abstract*:** Instrumentation is a very effective monitoring system. Instrumentation involves different types of instruments and devices which are used for determining different features of dam. The features of dam monitoring by instruments includes measurement of different parameters like movement, pore pressure, uplift pressure, water level and flow, seepage flow, water quality, temperature cracks, joints size, seismic activity, weather and precipitation, stress and strain etc.

Monitoring method is a phenomena which helps to determine the failure of a dam with the help of instruments and procedure. Dam safety program must be properly designed and considered for all hydrologic and hydraulic factors which are necessary in operation. Each instrument which is used in operation is used specifically for accurate results which is necessary for maintaining the health of a dam. The instruments which should be used for monitoring purpose should be properly designed, should be properly installed, evaluated and should be monitored for obtaining accurate results to maintain the health of the dam and to provide dam safety.

Instrumentation system is necessary for defining and analyzing a problem related to dam safety. It is necessary to evaluate a problem according to its behavior and provide a remedial action for the same.

***Key Words* – Dam instrumentation, Dam health, Dam safety.**

I. INTRODUCTION

The safety of the dam plays an important role for the purpose of safeguarding the national investment. As dam belongs to the national property of the nation and constructed for good growth of the national economy.

There are different types of benefits which are achieved from the dam project. An unsafe dam becomes a threat to human life and national property. Instrumentation of dam is necessary for construction design and modifies the design. Data collected from the instruments can be valuable in determining the various causes of dam failure. By instrumentation constant watch over the performance of the structure can be recorded. As per IS 6512 - 1984 specification (Design of Gravity Dam) basic parameters like strain, stress, seepage, dynamic load, temperature, uplift pressure, displacement, pore pressure can be studied with the help of various instruments. There are 4291 large dams are in India. Out of this 1529 dams are in Maharashtra state of India, there are near about of 40 number of dams which are having proper instruments mounted.(Bamane,2014).

The approximate cost of this instrument work out to nearly 1% of total construction of dam. In some cases, it reaches to 2 to 3 %. (Bamane, 2014).

The instruments which are used in instrumentation system listed below:

1. Tilt meter.
2. Piezometer.
3. Seismometer.
4. Temperature sector.
5. V – notch weir.
6. Stress meter.
7. Uplift pressure cell

1.1 AIM

To study and analyze the safety measures of dam and feasibility of Instrumentation.

1.2 OBJECTIVES

1. To study safety measures.
2. To study about the health of the dam constructed
3. To study the safety and operational performance of existing dams.
4. To study the advanced instrumentation.
5. To identify the problems and provide the safety maintenance of dam

1.3 PROBLEM STATEMENT

Effects of dam failure on man and environment are well known, these require both preventive and mitigation measures. So it is necessary and required that instrumentation with proper monitoring for appropriate safety, working and functioning of the dam to avoid the failure of a dam.

II. METHODOLOGY

Data is collected about the dam safety and Instrumentation. Different dams are visited and data related to failure of dam is collected. Different case studies about different dams are prepared. It includes all the basic information about the instrument which are mounted on the dam. Near about all the dam in Pune region are covered and their instruments is studied. By studying about the various instruments present on the dam data is collected about the working conditions and Present scenario of the dam instrumentation.

2.1 STUDY ANALYSIS

The study about different types of dams, material used for construction are studied. Failure occurrence data and instruments mounted are also studied. The detailed information about the Warasgaon dam in the form of Case Study is mentioned below.

CASE STUDY - WARASGAON DAM

Sr. No.	Attribute	Value
1	Name of Dam	Warasgaon Dam
2	River	Mose
3	Location	Near Velhe, Dist. Pune, State Maharashtra
4	Purpose of Dam	Hydroelectric, Irrigation
5	Type of Dam	Earthen/ Gravity & Masonry
6	Catchment Area	
	1. Main Dam	130 sq. km.
	2. Pick up Weir	30 sq. km.
7	Length of Dam	780 m
8	Max Height above Foundation	66.6 m
9	Spillway	
	1. Type	Ogee
	2. Length	70 m
	3. Type of Spillway Gate	Radial
	4. No. of spillway	5

OBSERVED INSTRUMENTS

1. Rain gauge
2. Tiltmeter
3. Pumps
4. Evaporation pan

PROBLEMS OBSERVED DURING VISIT

1. Leakages in retaining wall of the dam
2. Gallery Condition is not good
3. Instruments in gallery are not accessible
4. All instruments are not in working condition

RECOMMENDATIONS

- Optical fiber joint meter can be mounted to observe crack movement.
- Tiltmeter currently installed on dam is very old. New type of tiltmeter is available in which work mass is suspended in magnetic field. This tiltmeter gives accurate reading in digital format.
- Automatic weather station needs to be mounted to monitor weather condition. Automatic weather station provides information about rainfall, weather forecast, wind velocity, temperature using GIS.
- The instruments which can give digital output are very useful because we can access these data from everywhere and analyze it very quickly.
- Artificial Intelligence can be used to monitor health of dam which can analyze problems very quickly.
- Ultrasonic sensor can be used to find crack location.
- Proper lighting should be provided in the gallery to observe different instrument reading.
- Instruments which are installed on dam needs to be replaced.
- Grouting with a proper time limit is needed to stop leakages of retaining wall of the dam.
- Maintainance of instruments is to be carried out every three months.

2.2 INSTRUMENTATION

1. TILTMETER

It is a device which is used to measure the vertical rotation of the surface. Tiltmeter (Fig. 1) is made up of base plate sensor and readout device. The base plate of tiltmeter is fixed with cement or bolts to horizontal and vertical surface. Tiltmeter is mounted at fixed location permanently for recording movements.

The advanced tiltmeter is available in market and it can be replaced eletrilytic tiltmeter in place of old tiltmeter.

2. PIEZOMETER:

Piezometer is a device which used to measure water pressure in dam bodies. Piezometer can also to use to measure water pressure of foundation and abutment at a specific point within mass of earth, rack or concrete with a filter, a piezometer tube and upper section with protective devices. The piezometer is divided into two types. 1) hydraulic piezometer, 2) electrical piezometer.

The hydraulic piezometer is used to measure the water level or the pressure into the tube. The electrical piezometer measures the pressure with electrical acoustics or with pneumatic sensors.

3. SEISMOMETER:

Tremors are caused due to earthquake added load and deformation at dam. The tremors can highly affect the dam due to which the collection and analysis data becomes at most important. The seismic instrument is made up of strong motion accelerometer, broadband seismometer and associated data acquisition.

Seismometer (Fig. 3) measuring the movement in horizontal as well as vertical direction. The seismometer gives the output in seismograph manner. The seismograph shows up – down motion of earth by visualizing a weight hanging on a spring.

4. TEMPERATURE SENSOR:

It measures the temperature of dam and water in the reservoir. It is used to correct the values of expansion and contraction of the structure of dam given by extensometer.

5. WEIRS:

Weir is device which is used to measure the seepage and leakages in the dam. Weir (Fig. 5) is very simple, old and reliable device to measuring flow rate of water or discharge. The three types of weirs are normally used rectangular, triangular and trapezoidal. weirs are consisting of flat plates of metal or plastic. The weirs are mounted in ditch, gutter and pipes. The triangular notch is used for flow rates less than about 0.05 m3/sec. Rectangular and Trapezoidal are used to longer area flows.

6. STAFF GAUGE:

Staff gauge (Fig. 6) is device which is used to measure the water level in stream or dam to record highest water elevation. The water gauge is made up of metal pipe and pole with scale marked on it. The scale provides the information related to the reduced level and increase level of water at dam. The water level gauge provides the valuable information about height reached by water in dam or stream. The water level used in needed manner. It is vertically as well as in inclined position on the upstream flow of the dam.

7. RAIN GAUGE:

Rain gauge is the device which measures the rainfall. It is very simple and effective method to measure rainfall. The rain gauge (Fig. 7) is divided into three types, Standard Gauge, Storage Gauge and Recording Gauge. Standard or non-recording gauge is in circular shape of 20.3 cm in diameter. The standard gauge is having a lower cost.

Storage gauge has same size opening as compared to standard gauge, but the storage gauge is having more capacity as compared to standard gauge. The storage gauge is having measurement capacity of 1525 to 2540 mm of rainfall.

8. EVAPORATION PAN:

Many areas are depending on reservoir to provide water for Human, Irrigation and Industrial uses. The determination of evaporation losses from stored water is very important factor. For measurement of water evaporation, the evaporation pan is used in India. Evaporation pan (Fig. 8) is made up of metal which has cylindrical shape. The diameter of pan is 122 cm and it is 250 cm in depth. If the evaporation from large bodies cannot be measured, then the coefficient is applied to the measured value. The coefficient value is lies between 0.5 to 0.8. The coefficient depends upon the changes in ambient air temp and reservoir water temperature.

All the above explained instruments are as shown below.

Fig.1 Tiltmeter

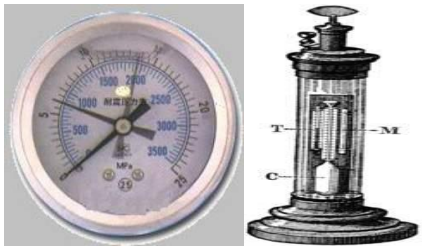

Fig. 2 Piezometer

Fig. 3 Seismometer

Fig. 4 Temp. sensor

Fig. 5 Weir Fig. 6 Staff gauge Fig. 7 Rain gauge Fig. 8 Evaporation pan

III. CONCLUSION

1. The instrumentation program which should be installed to identify problems related to structural, geotechnical must be clearly defined.
2. The measurements of all the quantities which is necessary in the problem to be studied should be planned properly and comprehensively with the help of proper instrumentation program.
3. Proper coordination between the dam in charge, instrumentation specialist and other site authorized person should be there to keep all the instruments in proper working condition.
4. The results obtain with the help of instruments should be made available and it should be properly analyzed.
5. After analyzing all the data obtained from the instruments. It should be used to make proper changes in the instrumentation of the dam.
6. With the help of proper instrumentation, the health of the dam can be maintained. Standard behavior of the dam can be monitored etc.
7. The downstream area of the dam can be kept safe with the proper implementation of the instrumentation.

IV. FUTURE SCOPE

By visiting some dams in Pune region, we have studied the each and every part of the dam and watch it carefully at a particular dam site and what precaution to be taken to avoid such conditions. We are going to suggest them about that problems.

Also, we are going to study about advance instruments which are recently introduced in the market regarding dams and how they are beneficial than older instruments.

We are going to submit all the data to Sinchan Bhavan.

V. REFERENCES

[1] Chen, J., and Huang, W. (2000). ―Failure probability of gravity dam on rock foundation. ‖ Int. Com. on Large Dams. The Ministry of Water Resources, People's Republic of China, Beijing, 425 – 436.

[2] Bowles, D. S. (2001). ―Evaluation and use of risk estimates in dam safety decision making. ‖ Proc., United Eng. Foundation Conf. on Risk-Based Decision-Making in Water Resources IX, ASCE, Reston, VA, 1 – 17.

[3] Richard E. Goodman and Chris Powell, ―Investigations of Blocks in Foundations and Abutments of Concrete Dams ‖, J. Geotech. Geoenviron. Eng. 2003.129:105-116.

[4] Bhadauria, S. S., and Gupta, M. C. (2006). ―In-service durability performance of water tanks. ‖ J. Perform. Constr. Facil, 20(2), 136 – 145.

[5] Hao-Feng Xing and Xiao-Nan Gong, ―Construction of Concrete-Faced Rock fill Dams with Weak Rocks ‖, Journal of Geotechnical and Geo environmental Engineering © Asce / June 2006.

[6] Bernstone, C., Westberg, M., and Jeppsson, J. (2009). ―Structural assessment of a concrete dam based on uplift pressure monitoring. ‖ J. Geotech. Geoenviron. Eng., 135(1), 133 – 142.

[7] Raúl Flores-Berrones and Martín Ramírez-Reynaga, ―Internal Erosion and Rehabilitation of an Earth-Rock Dam ‖, J. Geotech. Geoenviron. Eng. 2011.137:150-160.

[8] Salaheddin Shmel and Najy Shakshem, ―Seepage phenomenon for Wadi Megenin dam ‖, International Journal of Environmental Monitoring and Analysis 2013; 1(5): 248-257.

[9] H. Mirzabozorg and M.A. Hariri-Ardebili, ―Structural safety evaluation of Karun III Dam and calibration of its finite element model using instrumentation and site observation ‖, Case Studies in Structural Engineering 1 (2014) 6 – 12.