



# Technical Specifications of Hydro-meteorological, Geodetic, Geotechnical and Seismic Instruments

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Central Water Commission  
Ministry of Water Resources,  
River Development & Ganga Rejuvenation  
Government of India

**Front cover photograph:** Water level sensor at Ichari Dam, Uttarakhand (left), Readout Unit for the normal plumb line at Idukki Dam, Kerala and general view of different types of instruments (right).



Government of India  
Central Water Commission  
Central Dam Safety Organisation

**Technical Specifications of  
Hydro-meteorological, Geodetic,  
Geotechnical and Seismic Instruments  
for Dams**

**January 2018**

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Government of India  
Central Water Commission  
Central Dam Safety Organization

The *Technical Specification of Hydro-meteorological, Geodetic Geotechnical and Seismic Instruments* has been published for the first time in January, 2018 under the Dam Rehabilitation and Improvement Project (DRIP).

Disclaimer

The *Technical Specification of Hydro-meteorological, Geodetic Geotechnical and Seismic Instruments* in no way restricts the dam owner in digressing from it. The Central Dam Safety Organization or the Central Water Commission cannot be held responsible for any actions based on these specifications. Appropriate discretion may be exercised while preparing and implementing dam instrumentation programme.

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## FOREWORD

The health and safety of our existing and new dams are of paramount importance for sustainable utilization of these valuable assets, besides protecting people, property, and the environment. The Dam Rehabilitation and Improvement Project (DRIP) taken up by the Central Water Commission (CWC), with financial assistance from the World Bank, emphasizes the pivotal role played by instrumentation in assessing the health of a dam.

The main purpose of instrumentation in a dam is to monitor the safety of the structure and to warn of any changes that could endanger the safety of a dam as well as to provide a confirmatory check in design assumptions and methods of computation presently in vogue. Instrumentation is effective and worthwhile only if it provides sufficient and reliable data from which the safety and performance of the dam can be reasonably and reliably evaluated. Likewise, a mere collection of data is of no value unless a critical and timely interpretation and evaluation of recorded data is done and remedial measures adopted to ensure the continued safety and satisfactory performance of the structure. The quality of installed instruments plays a very prominent role in getting accurate data. Instruments for long-term monitoring should be rugged and easy to maintain and should be capable of being verified or calibrated. A well instrumented dam shall impart better health monitoring and rehabilitation which is very much required more so in the context of prospective legislation on dam safety.

There has been an urgent need for a uniform set of Technical Specifications which can be used for instrumentation by dam owners to bring longevity and sustainability with the uniform output of information for making all analyses simpler, accurate and meaningful. The specifications of instruments play a very critical role in procuring, installing and operation of high quality and reliable instrumentation to perform reliably and accurately in the adverse environment. Specifications have to be clear, concise, complete and correct so that there is less chance of misunderstanding, delay, and conflict. The procurement specifications of instruments are also to be combined with field services of installation, calibration, data collection, transmission, analysis, interpretation and presentation for a suitable time period.

This document entitled *Technical Specifications of Hydro-meteorological, Geodetic, Geotechnical and Seismic Instruments* has been finalized by CPMU in consultation with leading national and international agencies as well as experts working in the field of dam instrumentation. I am sure these specifications will be of immense help to the Water Resource Departments as well as other agencies for their use for preparation of a suitable dam instrumentation plan.

I sincerely hope that this compilation will be quite useful especially for the engineers of dam-owning agencies and water resources engineers handling dam safety and rehabilitation efforts for all dams.



(N.K. Mathur)

Member (Design & Research)  
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New Delhi  
January 2018

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## PREFACE

The Central Water Commission (CWC), with financial help from the World Bank, started the Dam Rehabilitation and Improvement Project (DRIP) to repair about 250 large dams in seven States. Instrumentation plays a very vital role in ensuring the safety of dams in this Project. It is proposed to install hydro-meteorological, geodetic, geotechnical and seismic instruments in dams under DRIP. It is also proposed to automate the whole process of data acquisition, processing, analysis and interpretation. This will help in taking timely appropriate remedial action.

For achieving this task, it is necessary that there is complete uniformity in the technical specifications of instruments that will be installed by various implementing agencies (IAs). IAs in the State Governments might not have the necessary ability in the field of Instrumentation. The DRIP Central Project Management Unit (CPMU) has undertaken this work of compilation of Technical Specifications of Hydro-meteorological, Geodetic, Geotechnical and Seismic Instrumentation on the advice of World Bank. A committee headed by Chief Engineer (Dam Safety Organisation), CWC and consisting of experts from CWC and renowned institutes viz. CWPRS, CSMRS, NGRI, IIT Roorkee, (National Centre for Seismology, IMD) as members was formed to complete these technical specifications.

The instrumentation has been so planned that analysed and processed data of instrumentation shall be available on real time basis to network connected State Governments, CWC and authorised Specialized Institutes for giving their inputs and feedback for proper action by dam owning authorities for ensuring the safety of dams.

The present compilation consists of technical specifications of hydro-meteorological, geodetic, geotechnical and seismic instruments and the associated data recording instruments and processing software. The publication of these specifications will be very useful specially to all DRIP Implementing Agencies as well as other dam owners for procurement of dam instruments, installation, commissioning, putting in service, operation and maintenance, etc.

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# 1. SPECIFICATIONS OF HYDRO-METEOROLOGICAL INSTRUMENTS

## 1.1 WATER LEVEL RECORDERS

### 1.1.1 SHAFT ENCODER TYPE

**Functional Requirement:** To measure the reservoir water level

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature range	From -20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Shaft encoder based incremental rotary position sensor with digital display
	Range	1 to 100 metres
	Resolution	3 mm or less
	Accuracy	0.025% FSO
	Output interface	SDI-12 / RS 485 / 4-20 mA / compatible with data logger
	Power supply	12 V DC or switch rated for 12 V DC
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel or aluminium)
	Enclosure	Lockable (key) box provided by the supplier to be mounted in a stilling well or gauge hut, with IP65 or NEMA 4 protection
	Tools	Complete tool kit for operation and routine maintenance

Feature		Value
	Graduated tape	The tape should be of high quality to withstand a harsh and humid environment, should not get twisted or wrinkled during operation.
	Accessories	Sensor mounting support, floats, graduated tapes (metric), wheel, counterweight, and cabling
	Protection	NEMA 4 or IP65
	Manuals	Full documentation and maintenance manual in English

### 1.1.2 RADAR TYPE

**Functional Requirement:** To measure the reservoir water level

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature range	-20 to + 60°C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Microwave non-contact sensor
	Range	15 m/20 m/35 m/40 m/70 m/75 m
	Resolution	3 mm or less
	Accuracy	0.02% FSO
	Beam angle:	≤ 16 °
	Output interface	SDI-12 / RS 485 / 4-20 mA / compatible with data logger
	Power supply	10-15 V DC
	Linearity	--
	Damping	--
	Skewness	--
Digitization rate	--	

Feature		Value
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel / aluminium or PVC)
	Enclosure	The sensor shall be easy to dismount and replace in the event of a malfunction.
	Tools	Complete tool kit for operation and routine maintenance
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	NEMA 4 or IP65
	Manuals	Full documentation and maintenance manual in English
	Horizontal mounting / installation arrangements	Above FRL, below a bridge girder wherever available otherwise horizontal cantilever arrangement from a mast / wall / pedestal
	Radar sensor should have display feature for diagnostic purpose	

### 1.1.3 ULTRASONIC SENSOR TYPE

**Functional Requirement:** To measure the water level

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature range	From -20 to + 60°C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Ultrasonic non-contact sensor
	Range	Up to 10 metres
	Resolution	3 mm or less
	Accuracy	0.02% FSO
	Output interface	SDI-12/RS 485 /4-20 mA/compatible with data logger
	Power supply	10-15 V DC
	Linearity	--

Feature		Value
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel / aluminium or PVC)
	Enclosure	The sensor shall be easy to dismount and replace in the event of a malfunction.
	Tools	Complete tool kit for operation and routine maintenance
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	NEMA 4 or IP65
	Manuals	Full documentation and maintenance manual in English

#### 1.1.4 BUBBLER TYPE

**Functional Requirement:** To measure the water level

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature	From -20 to + 60 °C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Continuous bubbling system and non-submersible transducer
	Range	15 to 30 psi (0.1 to 0.2 MPa)
	Resolution	0.0001 psi or less (0.7 Pa or less)
	Accuracy	0.1% FSO
	Output interface	SDI-12 / 4-20 mA / RS485, compatible with data logger
	Power supply	11 to 15 V DC
	Average current draw	<15 mA based on 1 bubble per second
Purge	Manual line purge	

Feature		Value
	Bubble Rate	Programmable 30 to 120 bubbles per minute
	Desiccators	The bubbling mechanism and the non-submersible transducer must be equipped with a desiccating system to keep the system from malfunctioning for a period not less than one year.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Tools	Complete tool kit for installation and routine maintenance
	Accessories	Sensor mounting support, cables and other accessories as required
	Enclosure	NEMA4 or IP65
	Manuals	Full documentation and maintenance instructions in English

### 1.1.5 PRESSURE TRANSDUCER TYPE

**Functional Requirement:** To measure the water level

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature	From -20 to + 60°C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Pressure Sensor
	Operating range	Up to 30 metres of water column
	Resolution	3 mm or less
	Accuracy	0.02% FSO
	Output interface	SDI-12 / RS 485 / 4-20 mA / compatible with data logger

Feature		Value
	Power supply	10-15 V DC
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel / aluminium or PVC)
	Enclosure	The sensor shall be easy to dismount and replace in case of a malfunction.
	Tools	Complete tool kit for operation and routine maintenance
	Accessories	Sensor Mounting support, cables and other accessories as required
	Protection	NEMA 4 or IP65
	Manuals	Full documentation and maintenance manual in English

## 1.2 AUTOMATIC WEATHER STATION

**Functional Requirement:** To measure the weather parameters

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature	From -20 to + 60 °C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Air Temperature Sensor	Sensor type	Platinum resistance or less or equivalent
	Range	-20 to +60 °C
	Resolution	± 0.1 °C
	Accuracy	Within ± 0.2 °C in the entire working range
	Response time	10 second or less
	Self-aspirated	To ensure a continuous supply of air. free from turbulence, water droplets and radiation
	Power supply	12 V DC or switch rated for 12 VDC
	Accessories	All accessories for mounting the instrument; e.g. special cross arm clamps or flag, if any, shall be provided.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
Relative Humidity Sensor	Sensor type	Capacitive/ solid state humidity sensor
	Range	0 to 100%
	Resolution	1%
	Accuracy	±3% or less
	Power supply	12 V DC or switch rated for 12 V DC
	Response time	10 seconds or less
	Linearity	--

Feature		Value
	Damping	--
	Skewness	--
	Digitization rate	--
	Lightning protection	Required
Wind Speed and Direction Sensor	Sensor type	Ultrasonic sensor (no moving parts)
	Range	0 to 60 m/s for speed and 0 to 360 degrees for direction or better
	Resolution	0.1 m/s for Speed; $\pm 1$ degree for direction
	Accuracy	$\pm 0.5$ m/s or less for wind speed, $\pm 5$ degree or less for wind direction
	Response time	Less than 1 second lag in operating range
	Mounting	All accessories for mounting the instrument e.g. special cross arm clamps or flag if any shall be provided.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
Air Pressure Sensor	Sensor type	Temperature compensated
	Range	600 to 1200 hPa
	Resolution	$\pm 0.1$ hPa
	Accuracy	$\pm 0.2$ hPa
	Power supply	12 V DC or switch rated for 12 V DC
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
Solar Radiation	Sensor type	ISO Class 1 Pyranometer (CMP 11 or better)
	Threshold	120 W/m <sup>2</sup> of direct solar irradiance

Feature		Value
	Methodology	Alternate shading of sensor to account for sky radiation
	Spectral range	400 nm to 1100 nm
	Range	0 to 2000 W/m <sup>2</sup>
	Resolution	1 W/m <sup>2</sup>
	Accuracy (including temperature compensation)	3% or less
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
Evaporation- Pan Specification	Operating temperature	-20 to 60 °C
	Diameter of the pan	1.2 m or more
	Accuracy	+/- 1%
	Accessories	As required for complete installation of the sensors and equipment
	Material	Clean cast seamless acrylic plastic tubing or brass sheet
	Platform	Rot resistant timber treated with creosote or another effective wood preservative.
	Graduation	In millimetres.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel, aluminium, or PVC)
	Tools	Complete tool kit for operation and routine maintenance
	Accessories	Sensor mounting support, cables and other accessories as required

Feature		Value
	Manuals	Full documentation and maintenance manual in English
	Output interface	SDI 12/RS 485/ 4-20 mA/ compatible with data logger

### 1.3 AUTOMATIC RAIN GAUGE

Feature		Value
Site Conditions	Operating ambient temperature range	From -20 to + 60 °C
	Operating humidity	0 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Tipping bucket with siphon
	Range	0 to 500 mm/h
	Material	UV resistant plastic or corrosion-resistant metal (aluminium, stainless steel), shock and vibration resistant
	Rim diameter	Receiver/collecting funnel diameter: 200 ± 0.3 mm diameter with machined aluminium 200 mm rim or equivalent
	Resolution	0.2 mm
	Accuracy	2% of intensity (up to 10 cm/h)
	Output interface	SDI-12 / RS 485 / 4-20 mA / compatible with data logger
	Power supply	12 V DC or switch rated for 12 V DC
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Material	Corrosion resistance metal (stainless steel or aluminium)
	Enclosure	Lockable (key) box provided by the supplier to be mounted in Stilling well or Gauge hut, with IP65 or NEMA 4 protection
	Tools	Complete tool kit for operation and routine maintenance

Feature		Value
	Graduated tape	The tape should be of high quality to withstand a harsh and humid environment, should not get twisted or wrinkled during operation.
	Accessories	Sensor Mounting support, cables (power and signal), and other accessories as required. Complete tool kit for installation and routine maintenance giving full details.
	Protection	NEMA 4 or IP65
	Manuals	Full documentation and maintenance manual in English

**2. SPECIFICATIONS OF GEODETIC INSTRUMENTS**

**2.1 TOTAL STATION**

<b>Automatic total station 0.5"</b>	Automatic / manual total station with 0.5" second accuracy, least count 0.1, reflectorless range of 500 m, range with reflector of 4000 m, RS-232 interface communication side cover (USB-Host, USB-device ports and Bluetooth), laser plummet, quick guide and container with protective cover, single side keyboard supplied with all accessories
<b>Manual total station 1"</b>	Manual total station with 1-second accuracy, least count 0.1, reflectorless range of 500 m, range with reflector of 7500 m, RS-232 interface communication side cover (USB-Host, USB-device ports and Bluetooth), laser plummet, quick guide and container with protective cover, single side keyboard supplied with all accessories

**2.2 SURVEY TARGETS OR REFLECTORS FOR OPTO-ELECTRONIC MEASUREMENTS**

<b>Bi reflex targets</b>	A convergence bolt made of 12 mm x 170 mm galvanized steel rebar with SS threaded stud shall be securely attached to the exposed rock or shotcrete surface. The bolt shall be provided with a plastic cap with a breaking point serving as an adapter for the mounting of a reflector with a marked centre point. This device shall be designed for high precision measurements with two axes of rotation and to be observable from both sides. The manufacturing accuracy must be better than $\pm 0.1$ mm to achieve an overall accuracy of $\pm 1$ mm within the measuring section. The targets must be replaceable without loss of precision.
<b>Prism targets</b>	<ul style="list-style-type: none"> <li>i. Used if the distance from the total station is less than 140 m.</li> <li>ii. The plastic reflector shall be replaced by a positive-centred prism with the same standard as the reflector above.</li> <li>iii. Used if the distance from the total station is up to 600 m.</li> </ul>

### 3. SPECIFICATIONS OF GEOTECHNICAL INSTRUMENTS

#### 3.1 PIEZOMETER

**Functional Requirement:** To measure the pore water pressure

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating ambient temperature	From -20 to + 60°C
	Compensated	From 0 to + 60 °C
	Temperature compensation	Inbuilt
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Sensor type	Vibrating wire piezometer in stainless steel housing with stainless steel filter stone, thermistor, unvented
	Operating range	3 kg/cm <sup>2</sup> , 5 kg/cm <sup>2</sup> , 7.5 kg/cm <sup>2</sup> , 10 kg/cm <sup>2</sup> (Project Specific)
	Over range	1.5 x rated pressure
	Over range effect	±0.1% F.S. up to 150%
	Resolution	0.025% F.S. (minimum)
	Accuracy	±0.1% F.S
	Output interface	SDI-12 / RS 485 / 4-20 mA /compatible with data logger
	Power supply	10-15 V DC
	Linearity	<0.5% F.S
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	IP 68 or NEMA-4
	Manuals	Full documentation and maintenance manual in English

### 3.2 TEMPERATURE SENSOR

**Functional Requirement:** To measure temperature

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Resistance type
	Coil resistance	140 to 160 Ohm @ 25°C
	Surge arrestor	Citel 90 V gas discharge tube
	Over range	0 to +80 °C
	Over range effect	±0.1% F.S. up to 150%
	Resolution	0.05°C
	Accuracy	1% F.S
	Dimensions	Approximately 20 mm diameter x 120 mm length
	Cable	1m, 2 core shielded
	Linearity	<0.5% F.S
	Damping	--
	Skewness	--
	Digitisation rate	--
Lightning protection	Required	
General Features	Enclosure	Stainless steel
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	IP 68 or NEMA-4
	Manuals	Full documentation and maintenance manual in English

### 3.3 JOINT METER / CRACK METER

**Functional Requirement:** To measure deformation across joints/cracks

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire
	Operating range	12.5 mm, 25 mm, 50 mm (Project Specific)
	Over Range	1.25 x range
	Resolution	0.025% F.S.
	Accuracy	±0.2% F.S ( ±0.1% F.S. optional)
	Linearity	<0.5% F.S
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel, IP 68
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	IP 68 or NEMA-4
	Manuals	Full documentation and maintenance manual in English

### 3.4 UPLIFT PRESSURE MEASUREMENT SYSTEM

**Functional Requirement:** To measure uplift pressure

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Mechanical, vibrating wire
	Operating range	10 kg/cm <sup>2</sup>
	Over Range	1.50 x Range
	Over range effect	± 0.1% F S
	Resolution	0.025% F.S.
	Accuracy	±0.1% F. S.
	Temperature compensation	Inbuilt
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel, IP 68
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	IP 68 or NEMA-4
	Manuals	Full documentation and maintenance manual in English

### 3.5 TILT METER

**Functional Requirement:** To measure rotation

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60°C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire / MEMS biaxial
	Operating range	±10 °C
	Temperature limit	Insulated enclosure
	Resolution	± 0.05 mm/m (8 arc seconds)
	Accuracy	±0.1% F. S.
	Size (l x b x h)	162 x 90 x 145 mm (App.)
	Tilt plate size	142 x 24 mm high (App.) aluminium alloy
	Cable	4 core shielded
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel
	Accessories	Sensor mounting support, cables and other accessories as required
	Protection	IP 68 or NEMA-4
	Manuals	Full documentation and maintenance manual in English

### 3.6 NORMAL PLUMB LINE

**Functional Requirement:** To measure displacement

**Design Requirements:** Plumb line device shall have long-term stability and all its components shall be robust and protected against corrosion. It shall be provided with two travelling telescopes (one each for the X and Y axes) for measurement of displacement. To facilitate observation from the same direction, one of the telescopes to have a right angle prism before the objective lens. This helps the observer in taking both X and Y readings from the same place, and also saves floor space. The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Measuring Method / Sensor	Measuring method	Travelling telescope
	Focus range	250 to 500 mm
	Measuring range	± 50 mm ±75 mm (Project Specific)
	Table size	Table size 625 x 625 mm (approximately)
	Resolution	0.01 mm
	Accuracy	0.1 mm
	Suspension wire	Stainless steel wire 1 mm diameter suspended from collet on a rectangular bar grouted at the top
	Suspension Weight	10 kg.
	Oil Tank	PVC 40 litre capacity
	Damping oil	SAE 40
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Accessories	Mounting support, cables and other accessories as required
	Manuals	Full documentation and maintenance manual in English

**3.7 INVERTED PLUMB LINE**

**Functional Requirement:** To measure Displacement

**Design Requirements:** Plumb line device shall have long-term stability and all its components shall be robust and protected against corrosion. It shall be provided with two travelling telescopes (one each for the X and Y axes) for measurement of displacement. To facilitate observation from the same direction, one of the telescopes to have a right-angle prism before the objective lens. This helps the observer in taking both X and Y readings sitting at the same place and also saves floor space. The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Measuring Method/Sensor	Measuring method	Travelling telescope
	Focus range	250 to 500 mm
	Measuring range	±50 mm
	Table size	Table size 625 x 625 mm (approximately)
	Resolution	0.01 mm
	Accuracy	0.1 mm
	Suspension wire	Stainless steel wire 1 mm diameter. Suspended from hollow float in tank filled with water
	Suspension weight	8 kg.
	Oil tank	Fibreglass, 800 mm diameter x 500 mm height
	Float material	PVC
	Damping oil	SAE 40
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
Lightning protection	Required	
General Features	Accessories	Mounting support, cables, and other accessories as required
	Manuals	Full documentation and maintenance manual in English

**3.8 AUTOMATIC PENDULUM READOUT**

**Functional Requirement:** To measure displacement

**Design Requirements:** Automatic pendulum readout, designed to make accurate measurements of the relative movements of normal and inverted pendulums, to be installed as an electronic upgrade for an existing system. Unless specified otherwise, the system shall be limited to the measurement of horizontal (radial/tangential) deflections. The unit is to be supplied with suitable mounts. The equipment offered should conform to the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Measuring Method	Measuring method	Automatic
	Resolution	0.01 mm minimum
	Accuracy	Accuracy 0.1 mm minimum
	Data communication	4-20ma EIA RS485
	Data storage 2000 data sets minimum	Data storage 2000 data sets minimum
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Accessories	Mounting support, cables and other accessories as required
	Manuals	Full documentation and maintenance manual in English

### 3.9 V-NOTCH WEIR FOR FLOW MEASUREMENT

**Functional Requirement:** To measure flow of water

**Design Requirements:** Weirs are typically installed in open channels such as streams to determine discharge (flow rate). The basic principle is that the discharge is directly related to the water depth above the crotch (bottom) of the V; this distance is called head (h). The V-notch design causes small changes in discharge to have a significant difference in depth allowing more accurate head measurement than with a rectangular weir. The equipment offered should conform to the following technical specifications:

Feature	Value
<b>Site Conditions</b>	
Operating Temperature Range	-20 to + 60 °C
Operating Humidity	5 to 100%
Altitude	0 to 2500 metres

**MEASURING METHOD:**

<b>(a) Electronic type</b>	<p>Vibrating wire seepage measurement system shall be designed to measure a flow rate of around 0-100 litre/second. The seepage water would be collected in a concrete reservoir and made to flow over a V-notch weir. The rate of seepage water flow is calculated from the level of water over the weir.</p> <p>The system to consist of a thin stainless steel plate 90° V-notch weir, a submersible cylinder and a vibrating wire load cell. The submersible cylinder to be permanently suspended from low capacity vibrating wire load cell mounted on a stilling well or a gage well such that the cylinder hangs inside the overflow water from the weir. Any change in the water level would affect the vertical thrust on the submersible cylinder. The output proportional to the water level (and flow) to be transmitted to the observation room through a four core jelly filled cable.</p>
Type	Vibrating wire
Flow range	100 litre/second
Over range capacity	150%
Sensitivity	0.01 litre with read-out unit
Accuracy	± 1% fs
Operating temperature	-20 to 60°C
<b>(b) Mechanical type</b>	<p>Seepage measurement system shall be designed to measure a flow rate of around 0 to 50 litre/second. The seepage water would be collected in a concrete reservoir (by the civil contractor) with suitable filters to make the flow as nearly streamline as possible and made to flow over a V-notch weir. The rate of seepage water flow is calculated from the level of water over the weir. The V-notch weir is graduated directly in flow in terms of litre/second.</p>
The instrument shall conform to IS 7436 (Part 1)	

**3.10 MULTIPLE POINT (3 P<sub>POINT</sub> & 5 P<sub>POINT</sub>) BORE HOLE EXTENSOMETER**

**Functional Requirement:** To measure deformation at various depths

**Design Requirements:** The equipment offered should comply with the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating Wire
	Operating range	100 mm
	Resolution	0.01 mm
	Accuracy	± 0.5 mm.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel
	Manuals	Full documentation and maintenance manual in English
	Accessories	Connecting rods, protective pipes, measuring head assembly, grouting jigs, hydraulically inflatable anchors
	Protection	IP 68 or NEMA-4

### 3.11 INCLINOMETER

**Functional Requirement:** To measure inclination

**Design Requirements:** The equipment offered should comply with the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire
	Probe	Biaxial (Length 500 mm)
	Operating range	± 15°
	Resolution	0.01 mm
	Accuracy	± 0.02% FS.
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel
	Manuals	Full documentation and maintenance manual in English
	Accessories	Special casing tubes and fixtures for connection
	Protection	IP 68 or NEMA-4

**3.12 STRESS METER**

**Functional Requirement:** To measure stress in concrete/masonry dams

**Design Requirements:** The equipment offered should comply with the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire with thermistor
	Thermistor	Temperature compensated
	Operating range	± 80 kg/cm <sup>2</sup>
	Over range limit	150% of range
	Overall dimensions	200 mm dia x 7 mm thick (App.)
	Resolution	10 kPa (0.1 kg/cm <sup>2</sup> ) with readout unit
	Accuracy	± 0.5% FS normal ± 0.1% FS optional
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
General Features	Enclosure	Stainless steel
	Manuals	Full documentation and maintenance manual in English
	Accessories	--
	Protection	IP 68 or NEMA-4

### 3.13 STRAIN METER

**Functional Requirement:** To measure strain in concrete/masonry dams

**Design Requirements:** The equipment offered should comply with the following technical specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire with thermistor
	Thermistor	Temperature compensated
	Operating range	± 1500 µε (Microstrain)
	Over range limit	150% of range
	Resolution	± 1 µε (Microstrain)
	Accuracy	± 0.5% FS normal ± 0.1% FS optional
	Linearity	< 0.5% FS
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
	Vibration resistance	Mechanical vibrations with 4 g and 5 to 100 Hz
	Frequency datum	800 Hz or more
	Surge protection	1.5 KVA
	Cable Type	4 conductor to twisted pair, 22 A WG
Thermal co-efficient of expansion	12.0 ppm / °C	
Temperature sensitivity	5 mm over operating temperature range	
General Features	Enclosure	Stainless steel
	Manuals	Full documentation and maintenance manual in English
	Accessories	--
	Protection	IP 68 or NEMA-4

**3.14 No STRESS/STRAIN METER**

**Functional Requirement:** To measure true stress/strain in concrete/masonry dams

**Design Requirements:** The equipment offered should conform to the following Technical Specifications:

Feature		Value
Site Conditions	Operating temperature range	-20 to + 60 °C
	Operating humidity	5 to 100%
	Altitude	0 to 2500 metres
Sensor	Type	Vibrating wire with thermistor
	Thermistor	Temperature compensated
	Operating range	± 1500 µε (microstrain)
	Over range limit	150% of range
	Resolution	± 1 µε (microstrain)
	Accuracy	± 0.5% FS normal ± 0.1% FS optional
	Linearity	--
	Damping	--
	Skewness	--
	Digitisation rate	--
	Lightning protection	Required
	Vibration resistance	Mechanical vibrations with 4 g and 5 to 100 Hz
	Frequency datum	800 Hz or more
	Surge protection	1.5 KVA
General Features	Enclosure	Stainless steel
	Manuals	Full documentation and maintenance manual in English
	Accessories	--
	Protection	IP 68 or NEMA-4

## 4. SPECIFICATIONS OF SEISMIC INSTRUMENTS

### 4.1 STRONG MOTION ACCELEROGRAPHS (BUILT-IN ACCELEROMETER)

**Functional Requirement:** To measure dynamic response of dam

**Design Requirements:** The equipment offered should conform to the following technical specifications

Feature	Value
Transducers	Triaxial, force balanced, orthogonal oriented transducers (two horizontal and one vertical) along with the data acquisition system in a single sealed unit.
Full scale Range	User selectable +0.5 g, +1 g, +2 g, +4 g
Frequency response	Flat (within +3dB) to ground acceleration in the range of DC to at least 200Hz
Dynamic range of accelerometer	>130 dB
Linearity	Better than 1% of full scale
Cross axis sensitivity	Less than 1% of full scale
Clip level	Greater than the full scale range
Leveling	Bubble level indicator for leveling the transducer.
Orientation	Suitable mark to indicate the direction of relative orientation of the transducer.
Frequency response curve and system information	Frequency response curve of the unit along with information regarding transfer function including poles, zeros and normalization factor should be provided (for each sensor as per the serial number)
Calibration	Calibration facility from the data acquisition system locally or remotely from central recording station through DAS
Anchoring	Provision for anchoring the accelerograph unit to the seismic pier.
Number of channels	Three
ADC	Independent 24-bit digitizers, one for each channel
Sampling rate	User selectable upto 1000 SPS per channel
Dynamic range of A/D converter	130dB or more @ 100sps
Input voltage range of A/D converter	to be matched with the accelerometer output

Feature	Value
Channel-to-channel skew	None
System response	$\pm 3$ dB flat from DC to nyquist frequency
Noise level	Noise level of the unit including the accelerometer and the data acquisition system should be less than 0.001% of the full scale level in the frequency range from DC to 50Hz
Timing System	<ul style="list-style-type: none"> <li>i) Internal GPS receiver based timing system</li> <li>ii) Timing accuracy of +10<math>\mu</math>sec or less when GPS is locked</li> <li>iii) Record of GPS status information</li> <li>iv) GPS antenna should be enclosed in weather proof sealed enclosure with lightning protection.</li> </ul>
Recording mode	<ul style="list-style-type: none"> <li>i) Both continuous and triggered recording mode</li> <li>ii) Triggering: The DAS should be capable of recording the acceleration data in the STA/LTA ratio trigger, threshold trigger and time window</li> <li>iii) Trigger selection: Independent selection for each channel</li> <li>iv) Pre-event Recording length: User selectable from 1 to 30 sec in steps of 1 sec</li> <li>v) Post event length: User selectable up to 90 sec or more</li> </ul>
Data storage	<ul style="list-style-type: none"> <li>i) User accessible compact flash card</li> <li>ii) The compact flash card should have the capacity of 32GB or more.</li> <li>iii) The compact flash card should be rugged and industrial grade suitable to withstand extreme temperature variations.</li> <li>iv) The bidder should attach the data sheet of the compact flash card to be supplied with the DAS.</li> </ul>
Recording format	<ul style="list-style-type: none"> <li>i) Standard seismic data in a format that is compatible with Windows and Linux platforms.</li> <li>ii) Conversion utilities to miniseed, SAC, SEISAN, ASCII formats to be provided.</li> </ul>
DAS firmware should support	<ul style="list-style-type: none"> <li>i) Web browsing support/ communication over TCP/ IP protocol.</li> <li>ii) Full Duplex communication between field station and Central Receiving Station (CRS)</li> <li>iii) Triggered or continuous data transmission</li> <li>iv) Support off-the- shelf communication equipment</li> <li>v) Extensive error correction</li> <li>vi) The DAS should be capable of recording the accelerometer data on the local compact flash card as well as support real-time data telemetry to a central site through VSAT telemetry network simultaneously.</li> </ul>

Feature	Value
	<ul style="list-style-type: none"> <li>vii) DAS should have facility to retrieve the old data in the compact flash card from Central Recording Station manually through VSAT network.</li> <li>viii) DAS should have the facility to check the state of health of the system including system voltage, temperature, GPS status etc.</li> <li>ix) DAS should be able to issue an alert and start the communication in case of earthquake detection or failure of state of health parameter.</li> <li>x) DAS should have the facility for Calibration of the Accelerometer</li> </ul>
Communication	<ul style="list-style-type: none"> <li>i) Ethernet Interface for real time telemetry</li> <li>ii) RS-232 interface for real time telemetry / parameter setup</li> <li>iii) In built modem</li> <li>iv) Ethernet port, RS-232 port, USB port should be provided</li> </ul>
Power	<ul style="list-style-type: none"> <li>i) Total Power consumption &lt; 3.0 watts at 12V DC (including accelerometer and DAS)</li> <li>ii) Status display indicators for power to be provided</li> <li>iii) Provision to connect external 12V battery source</li> <li>iv) Supply power isolated from signal ground</li> <li>v) Reverse voltage protection</li> <li>vi) Over voltage protection</li> <li>vii) DAS should resume data acquisition automatically when the power is restored after disruption.</li> </ul>
Operating temperature	-20° to 60° C
Humidity	Up to 100% RH
Enclosure	Accelerometer and DAS should be enclosed in weather and shock proof sealed single enclosure with lightning protection.
Cables	<ul style="list-style-type: none"> <li>i) Power cable to external Battery of 2m length to be provided with each unit</li> <li>ii) The Ethernet cable to connect DAS to VSAT IDU with end connectors (2m length) to be provided</li> <li>iii) DAS-GPS antenna cable length of at least 20 meters length with end connectors</li> </ul>
Notes	<ul style="list-style-type: none"> <li>i) All the hardware, software and cables required for parameter setting, data retrieval from the DAS at field seismic station and data storage should be provided and described.</li> <li>ii) Detailed user manual, data sheet and calibration data sheet of the accelerograph should be provided.</li> </ul>

## 4.2 BROADBAND SEISMOMETERS

**Functional Requirement:** To measure seismic ground motion

**Design Requirements:** The equipment offered should conform to the following technical specifications:

Feature	Value
Transducers	Tri-axial, force-balanced, broadband velocity transducer with electronic feedback in a single sealed module.
Frequency response	Flat response (within +/- 3dB) to ground velocity in the range of 120 secs to 50Hz.
Dynamic range	≥ 135 dB @ 5Hz.
Output voltage	± 20V
Damping	0.7 of critical
Generator constant	Atleast 750 V/m/sec.
Linearity	Better than 1% of full scale
Cross axis sensitivity	Less than 1 % of full scale
Mass centering	Mass centering automatic on external command locally and remotely from the central recording station through DAS. Control unit for mass position monitoring and mass centering (if any) to be provided.
Calibration facility	Calibration facility from Data Acquisition System
Frequency response curve	Frequency response curve of the unit along with information regarding transfer function including poles and zeros should be provided (for each sensor as per the serial number)
Noise response	Noise response must be below the USGS Low Noise Model in the frequency range of 35 secs to 5 Hz. Test reports of the sensor noise over the full pass band should be provided.
Leveling	Bubble level indicator for leveling the transducer.
Orientation	Suitable mark to indicate the direction of relative orientation of the transducer
Mass locking	Mass locking Should have a robust locking and safety mechanism during transportation
Enclosure	The sensor should be housed in a shockproof and waterproof enclosure.
Cabling	Low-loss shielded Seismometer-DAS cable of at least 20 meters with end connectors.
Connectors	The connectors also should be waterproof and rust proof

Feature	Value
Operating temperature range	-20° to 60°C
Humidity	up to 100% RH
Power consumption	< 2.0 watts at 12V DC
Protections	<ol style="list-style-type: none"><li>1. Reverse voltage protection</li><li>2. Over voltage protection</li></ol>
Thermal insulation cover	An airtight thermal insulation cover should be provided
carry case	Rugged field carry case for seismometer should be provided..
Supporting documents	Detailed user manual / data sheets / calibration data sheet to be provided

### 4.3 DATA ACQUISITION SYSTEMS (DAS) AND ITS ACCESSORIES

Feature	Value
Number of channels	Three
ADC resolution	Three independent 24-bits digitizers, one for each channel
Dynamic range	Greater than or equal to 135dB @ 100sps.
Input Full scale	Range should match the sensor output with full scale at $\pm 20V$ (40Vpp)
Common mode rejection ratio	Greater than 70dB.
Electromagnetic interference	Immunity to Electromagnetic interference
System noise	The overall system noise should not be more than 2-3 counts of 24-bits system on a RMS basis in the frequency range of 0.00833 to 50Hz.
Sampling rate	<ol style="list-style-type: none"> <li>1) User-selectable up to 500 sps per channel in the different data streams (at least two or more).</li> <li>2) Simultaneous recording at different sampling rates in different streams (two or more), both in continuous and trigger modes.</li> </ol>
Trigger parameters	Trigger parameters should be user selectable.
Gain	User selectable multiple gain settings
Sensor control	<ol style="list-style-type: none"> <li>1) Calibration facility for Broadband seismometer</li> <li>2) Mass position monitoring for Broadband seismometer</li> <li>3) Mass centering on command for Broadband seismometer</li> </ol>
RAM	At least 4 MB
Recording capacity	<ol style="list-style-type: none"> <li>1) Mass storage media 16GB or more and hot swappable.</li> <li>2) One spare mass storage media of same capacity for each digitizer to be supplied.</li> <li>3) The mass storage media should be rugged and industrial grade suitable to withstand extreme temperature variations. The bidder should attach the data sheet of the mass storage media to be supplied with the DAS.</li> </ol>
Recording mode	The DAS should be capable of recording on the local mass storage media as well as support real-time data telemetry to a central site through VSAT telemetry network simultaneously.
Recording format	Standard seismic data in a format that is compatible with Windows and Linux platforms with proven compression

Feature	Value
	technique. Conversion utilities to SAC, SEISAN, ASCII formats to be supplied.
Communication ports	<ol style="list-style-type: none"> <li>1) USB and / or serial port connectivity to a local terminal for parameter setting and data downloading</li> <li>2) Ethernet port (10/ 100 Base- T) supporting TCP/IP.</li> <li>3) The Ethernet cable to connect DAS to VSAT IDU with end connectors (length 2m) to be provided</li> </ol>
DAS firmware	<p>DAS firmware should support the following features:</p> <ol style="list-style-type: none"> <li>1) Web browsing support/ communication over TCP/ IP protocol.</li> <li>2) Full Duplex communication between field station and Central Receiving Station (CRS) Triggered or continuous data transmission.</li> <li>3) Support off-the- shelf communication equipment</li> <li>4) Extensive error correction</li> <li>5) Status display indicators for power, data acquisition, SOH, GPS status etc. should be provided on the front/top panel.</li> <li>6) DAS should have facility to retrieve the old data in the storage media from Central Recording Station manually through VSAT network.</li> <li>7) Provision for checking state of health information like battery voltage, temperature, memory used and available, GPS status, sensor mass position etc. locally and remotely from the central recording station.</li> </ol>
GPS Timing system	<ol style="list-style-type: none"> <li>1) UTC timed with digitally controlled precision VCXO clock phase locked to GPS</li> <li>2) Timing accuracy less than 0.1mSec when GPS is locked</li> <li>3) Free running TCXO accuracy of 1 ppm over wide temperature range.</li> <li>4) GPS receiver electronic circuit should be inside the DAS with Antenna exposed outside.</li> <li>5) Antenna cable length should be 20 mts or more with end connectors.</li> <li>6) Antenna should be enclosed in water tight and can work effectively in extreme climatic condition.</li> <li>7) Rust proof GPS mounting rod and accessories to be provided.</li> <li>8) Antenna cable should be laid through thick plastic conduit pipe from roof-terrace to the digitizer.</li> </ol>
Power requirements	<ol style="list-style-type: none"> <li>1) Supply voltage 10-24V DC.</li> <li>2) Power consumption: Less than 2W at 12V DC recording 3 channels at 100sps, continuous mode data acquisition</li> <li>3) Supply power should be isolated from the signal</li> </ol>

Feature	Value
	ground 4) Reverse voltage protection 5) Low battery voltage protection 6) DAS power cable at least 2m length to be supplied 7) DAS should resume data acquisition automatically when the power is restored after disruption.
Operating temperature	-20° to 60°C
Humidity	Up to 100% RH
Housing	DAS and GPS units should be enclosed in weather and shock proof sealed enclosures with lightning protection.
Supporting documents	Detailed user manual and data sheet to be provided.
Additional hardware and software	The hardware and software required for parameter setting, data retrieval from the DAS at field seismic station and data storage should be provided and described.
Other essential requirements	<ol style="list-style-type: none"> <li>1) A point-by-point statement of compliance of the technical specifications of the tender equipment should accompany the bid along with the explanations as to how the compliance is achieved. It should also be supported by illustrative literature / catalogues.</li> <li>2) The supplier should provide all operation, service and maintenance manuals (in English) along with necessary circuit diagrams.</li> <li>3) The bidder should provide the power consumption details of the broadband seismometers, data acquisition Systems and endurance of the internal batteries supplied with the unit.</li> <li>4) The bidder should be able to supply spares for the quoted model of the broadband seismometers and the data acquisition Systems for five-year period. The spares required for five-year period may be quoted as optional items.</li> <li>5) The bidder should propose any other hardware and software required at the field stations for installation and for the efficient operation and maintenance of the seismic stations.</li> <li>6) The supplier must provide the necessary training on installation, operation, maintenance and calibration of the system including usage and the system application software at for the period of five days. The cost of such training program may be quoted separately.</li> </ol>

## 5. SPECIFICATIONS OF DATA RECORDERS, MULTIPLEXERS, AND SOFTWARE

### 5.1 DATA RECORDER

Data from water level sensors, automatic weather stations, optical total-stations, and geotechnical sensors shall be acquired using a data logger and associated multiplexer where necessary. The data logger shall be supplied with required software. Data loggers and multiplexers should be protected in a cabinet with an IP 67 rating or better. The instruments shall meet the following minimum specifications:

S/N	Technical Specification
1	Minimum Scan Rate 100 Hz
2	Analog Inputs Configured: Minimum 8 single-ended or 4 differential individually
3	Pulse Counters: 2
4	Switched Excitation Channels compatible with sensors
5	Digital Ports 8 I/Os or 4 RS-232 COM
6	Communications/Data Storage Port 1 CS I/O, 1 RS-232, 1 parallel peripheral
7	Analog Voltage Accuracy $\pm 0.12\%$ F.S. of reading, plus offset (analogue) $\pm 0.013\%$ of reading (vibrating wire)
8	Analog Resolution: 0.33 $\mu\text{V}$
9	Range $\pm 2.5$ millivolts to $\pm 5$ volts (analogue), DC to 200 kHz (frequency)
10	Protocols Supported Pak Bus, Modbus, DNP3, FTP, HTTP, XML, POP3, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM
11	Battery-Backed SRAM: Minimum 4 MB

### 5.2 MULTIPLEXER

S/N	Technical Specification
1	Channels Minimum 24 channels
2	Switching Current 1 A (maximum)
3	Contact Resistance 0.1 $\Omega$ (maximum)
4	Insulation Resistance $> 1 \text{ G}\Omega$
5	Switch Life $> 200,000$ cycles
6	Operating Temperature $-20$ to $+50 \text{ }^\circ\text{C}$

### 5.3 SOFTWARE

The supplied software system must satisfy the following requirements:

S/N	Technical Specification
1.	A server-based software solution shall be provided.
2.	The software solution shall be capable of acquiring data from geodetic, geotechnical weather and seismic sensors), screening and filtering the data for data inconsistencies and outliers, processing that data and storing the data in an SQL database. The solution shall be capable of controlling and managing the data acquisition schedules and shall be capable of processing the geodetic data both in individual and combined, integrated network adjustments.
3.	Data shall be stored in an SQL database, in a structured manner, open to 3 <sup>rd</sup> party software.
4.	The data acquired by the monitoring solution shall be accessed, visualized, analysed, alarmed and reported via a secure web interface. Access to the internet interface shall be strictly controlled by customizable levels of access for users and groups of users of the system, with the system administrator having control and management of this access facility.
5.	Data visualization shall be displayed on a geo-referenced map background and capable of being displayed on a user-supplied image, with the alarm status of each sensor being clearly represented by the colour of the sensor icon. The status of each sensor shall be updated in rapid near real time.
6.	Displacements must be capable of being displayed in an upstream/downstream reference frame relative to the dam wall.
7.	The solution shall include interactive charts and analysis capabilities to allow advanced users the ability to analyse and compare data from different sensors and sources. The solution shall compute and alarm on data changes over time, velocity, inverse velocity. The system shall include a composite display of user definable panels of information, to allow the user to create a customized data display.
8.	The system shall include comprehensive alarming capabilities capable of triggering SMS, email and batch file alerts. There shall be 3 levels of alarm. The system shall track alarm responses and shall be capable of automatically and manually logging all issues related to alarms.
9.	The system shall be fully scalable, allowing for sensors to be added or removed, users to be added or removed, and additional dams to be added or removed. Where the system is used for many dams, there shall be a centralized control facility providing an overview of all the dam installations in the group.
10.	There is a requirement for DAS software package to be installed by the Bidder at the central location.
11.	DAS software will come free of annual licensing charges, such that it can run indefinitely without incurring further expense. No cost for software upgrades through the Warranty and Maintenance period.

12.	Ability to set alarm thresholds and issue SMS text. There must also be an ability to send an email to any number of stakeholders, based on either a single condition or multiple conditions.
13.	Ability to export the data in .xlsx or .xls format as well as in text format. The text format shall be in conformance with manufacturer’s standards. The export facility must be one that can be run automatically to feed another system (hot drive). Colour map display of installations and alarm related data that is automatically updated as data are received. Colours of installation data on the map will be user programmable based on the requirements of the user. A simple interface to program the display must be available.
14.	Ability to move data from the central location computer server to the cloud server.

**5.3.1 DATA CAPTURE AND PROCESSING**

S/N	Technical Specification
1	Software platform Windows based operating system SQL server database
2	Total station outlier detection on total station observations
3	Schedule total station observations Real-time processing of total station observations Post processing of Total station observations
4	Level data support of level data
5	Geotechnical sensors help data importation from geotechnical sensors. Process geotechnical sensor data
6	Weather station support data importation from weather station

**5.3.2 DATA STORAGE**

S/N	Technical Specification
1	Database deformation data shall be stored in SQL server database. Seismic data to be stored in suitable format

**5.3.3 DATA DISPLAY**

S/N	Technical Specification
1	Data interaction Shall be via a secure web interface
2	Web Interface functionality secure user access. Administrator control over levels of user access. Georeferenced map views with data overlay. Thematic display of displacement. User supplied images with data overlay. Displacements are relative to dam radial and tangential axes. Fast charting tools. Colour-coded scatter plots. Detailed analysis tools. High-frequency data analysis. Modal characteristic analysis. Bar chart analysis Inclinometer/tilt sensor array display. Single screen summarizing the status of the system. Automated generation and distributions of reports. Automated and manual event logging mobile browser support.
3	Alarming Functionality Boolean capabilities in alarm definition. Minimum of three levels of alarm level SMS, email and batch file alarm support User-definable alarm recipients. Alarm response monitoring and escalation capabilities.

**Note:** Supply of computer rack, Uninterruptable Power Supply (UPS) pack, table, chairs, electronic display boards, and other related equipment are included.

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# Central Dam Safety Organisation Central Water Commission

## Vision

To remain as a premier organisation with best technical and managerial expertise for providing advisory services on matters relating to dam safety.

## Mission

To provide expert services to State Dam Safety Organisations, dam owners, dam operating agencies and others concerned for ensuring safe functioning of dams with a view to protect human life, property and the environment.

## Values

**Integrity:** Act with integrity and honesty in all our actions and practices.

**Commitment:** Ensure good working conditions for employees and encourage professional excellence.

**Transparency:** Ensure clear, accurate and complete information in communications with stakeholders and take all decisions openly based on reliable information.

**Quality of service:** Provide state-of-the-art technical and managerial services within agreed time frame.

**Striving towards excellence:** Promote continual improvement as an integral part of our working and strive towards excellence in all our endeavours.

## Quality Policy

We provide technical and managerial assistance to dam owners and State Dam Safety Organisations for proper surveillance, inspection, operation and maintenance of all dams and appurtenant works in India to ensure safe functioning of dams and protecting human life, property and the environment.

We develop and nurture competent manpower and equip ourselves with state of the art technical infrastructure to provide expert services to all stakeholders.

We continually improve our systems, processes and services to ensure satisfaction of our customers.

