



Geotechnical & Structural Monitoring Instrumentation



2012 EDITION

where measurement matters

AIS

Instrumentation

Instrumentation plays a major role in every stage of project. It is used to accurately assess geological conditions and quality of certain parameters over time as well as monitoring their rate of change.

- At design stage the use of testing equipment (laboratory or in-situ) can determine geotechnical characteristics of soil and rock mass.
- Monitoring is used to accurately evaluate the geotechnical conditions as the excavation progresses. Design hypotheses can be confirmed, the needs of the support structures, control of constructions, quality of material being used, compaction etc. could be determined.
- Once the project is in service, long term monitoring ensures the safety. Auxiliary structures require a thorough assessment as well as continuous monitoring and control during construction and operation of the project well-planned and implemented monitoring is an essential component of successful construction and operation of project.

Selection Criteria for Instrumentation

Four major criteria guide for instruments selection

- Reliability of the measurements obtained (accuracy, resolution precision & drift).
- Longevity of the instruments supported by numerous references.
- Ease of readout automation, essential for efficient data collection and interpretation.
- Features of some instruments like their immunity to electromagnetic interferences and their intrinsically safe technology.

Monitoring involves numerous steps including direct or remote visual inspection as well as topographical measuring and instrumentation. The scope of the monitoring methods employed depends on the potential risk associated with site characteristics.

Automated Data Collection and Processing

The collection and analysis of large quantities of data, especially over long distance, requires centralized and automated measuring techniques. Results are more accurate and data can be processed more rapidly thus enabling efficient alarm system to be implemented when predetermined thresholds are exceeded. It is practically impossible to consider the instrumentation of a big project without automated data acquisition systems. This supports in identifying connected devices, measurement intervals, data conversion, statistical processing, strategies for alarm control and logging.

Water Pressure & Level

Casagrande Porous Tube Piezometer (IS:7365 Part-I)

AIS 101

Casagrande porous tube piezometers are used to monitor piezometric water levels. Observation wells are used to monitor ground water levels. Water level readings are typically obtained with a water level indicator. Typical applications include:

- ✓ Monitoring pore-water pressure to determine the stability of slopes, embankments, and landfill dykes.
- ✓ Monitoring of ground improvement techniques such as vertical drains, sand drains, and dynamic compaction.
- ✓ Monitoring dewatering schemes for excavations and underground openings.
- ✓ Monitoring seepage and ground water movement in embankments, landfill dykes, and dams.
- ✓ Monitoring water drawdown during pumping tests.

Specification

Porous Tube Piezometer is made of carborundum tube of length 200mm, 38mm OD, 6mm wall thickness, total length 600mm with tie rods and brass mesh.

Stand Pipe : 25mm Od, 17mm Id, 3m long
Protective Pipe : 100mm dia, 1m long with protective lock.



Stand Pipe Piezometer

AIS 201

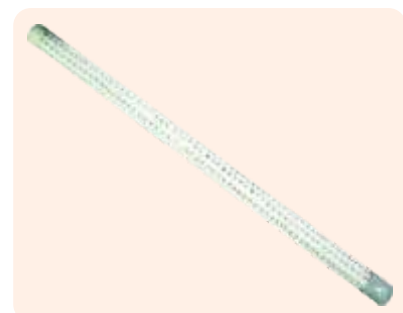
Standpipe piezometers are used to monitor piezometric water levels. Observation wells are used to monitor ground water levels. Water level readings are typically obtained with a water level indicator. Typical applications include:

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- ✓ Monitoring of ground improvement techniques such as vertical drains, sand drains, and dynamic compaction.
- ✓ Monitoring dewatering schemes for excavations and underground openings.
- ✓ Monitoring seepage and ground water movement in embankments, landfill dykes, and dams.
- ✓ Monitoring water drawdown during pumping tests.

Specification:

Stand pipe Piezometer is made of 50mm dia, 1 meter long perforated section PVC Pipe covered with brash mesh.

The 50mm dia 3 meter long raiser pipe is used to achieve the desired depth of piezometer. Suitable coupling is used to join the raiser pipe to each other.



Water Level Indicator

AIS 300

Electronic Water level indicator is used to measure the water levels in wells, casagrande porous tube piezometer and stand pipe piezometer.

Specifications:

Probe material	: Stainless Steel
Probe Diameter	: 12mm
Tape Type	: Contoured copper conductor
Tape material	: Polypropylene coated
Graduation	: cm/m
Indicator	: Audio & Visual



Water Level Recorder

AIS 550

Vibrating wire sensor is designed to measure the water level of reservoir/bore well remotely. It has special arrangement of vent tube to nullify the atmospheric pressure and measure exact water level. The data can be recorded using data recorder or data acquisition system.

Specifications:

Range	: 0-100mwc
Accuracy	: $\pm 0.25\%$ FS
Linearity	: 0.02%FS
Material	: stainless steel
Operating temperature	: -20 to +70°C



Water Seepage Measuring System

AIS 560

The water seepage can be monitored using weir which is made of stainless steel in 90° 'V' shape.

This can be designed for different size of channel and different flow capacity.

The 'V' Notch have marking for measuring flow rate. It is available for 20l/s, 25l/s, 30l/s, 50l/s and 60l/s.



Uplift Pressure Meter

AIS 400

Uplift pressure meters are installed in foundation gallery of dam to monitor the uplift water pressure acting on foundation. It consists of reducers, T-assembly, cock valves, nipples and Burdon Pressure Gauge. The vibrating wire sensor can also be used at the place of Burdon Pressure gauge, if the data is to be recorded in automatic mode.

Range	: 0-5 or 10 bar
Accuracy	: $\pm 0.5\%$ FS
Accessories:	
Raiser Pipe	: GI or PVC, diameter 50mm length 1m, 2m, 3m.
Perforated Section	: GI or PVC, diameter 50mm length 1m



Vibrating Wire Piezometer

AIS 300

Vibrating wire piezometer is standard piezometer, which can be used in all applications. It is very simple in installation and can be installed at multilevel too. This allows direct grouting using cement, bentonite grout. The application includes:

Monitoring pore water pressures to determine safe rates of fill or excavation.

Monitoring pore water pressures to determine slope stability.

Monitoring the effects of dewatering systems used for excavations.

Monitoring the effects of ground improvement systems such as vertical drains and sand drains.

Monitoring pore pressures to check the performance of earth fill dams and embankments.

Monitoring pore pressures to check containment systems at land fills and tailings dams.

Specifications:

Standard Range	: (kPa) 300-15,000
Accuracy	: $\pm 0.25\%$ full scale
Linearity	: $\pm 0.5\%$ full scale
Resolution	: 0.025% full scale
Over range	: 200% full scale
Material	: Stainless Steel
Diameter	: 20mm
Temperature Range	: -20 to +80°C



Differential Settlement

Surface Settlement Points

AIS 700

Surface settlement point is made of steel rod having 25mm dia, 250mm length and cross mark on top.

The surface settlement points are used to monitor the surface settlement of structures. It is generally installed at the surface of structures using concrete block so that it is in contact with surface which tends to move.

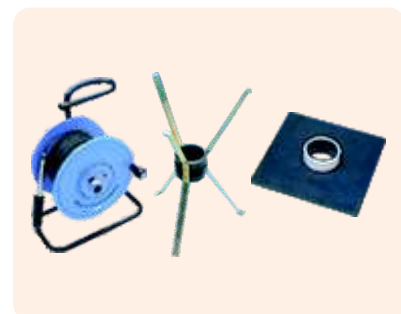
The monitoring is done using precise Total Station.



Magnetic Settlement System

AIS 800

The magnet extensometer is used to monitor settlement and heave in excavations, foundations, dams, and embankments. It can also be installed behind retaining structures, such as sheet piles and slurry walls, and above underground openings, such as tunnels and shafts. Data from the extensometer indicate the depths at which settlement has occurred as well as the total amount of settlement.



Local Strain

Vibrating Wire Embedment Type Strain Gauge

AIS 900

Embedment strain gauges measure strain in concrete. It can be used in multi directions using rosette to know the direction of strain in mass concrete. Typical applications include:

- ✓ Measuring strains in reinforced concrete and mass concrete.
- ✓ Measuring curing strains.
- ✓ Monitoring for changes in load.
- ✓ Measuring strain in tunnel linings and supports.

Specifications:

Range	: ± 1500 micro strain
Resolution	: 1 micro strain
Material	: Stainless steel
Operating temperature	: -10 to 80°C
Thermistor	: YSI 44055 or equivalent, 3K at 25°C



No Stress- Strain Meter

AIS 906

No-Stress -Strain Meter is installed in conjunction with group of strain meters in mass concrete in a special container where no external force is acting on strain gauge embedded in concrete. The data of No Stress-Strain meter is required to evaluate the strain gauge data to find out true strain.

Range	: ± 1500 micro strain
Resolution	: 1 micro strain
Material	: Stainless steel
Operating temperature	: -10 to 80°C
Thermistor	: YSI 44055 or equivalent, 3K at 25°C



Vibrating Wire Surface Mountable Strain Gauge

AIS 904

Vibrating wire surface mountable strain gauges are used to measure strain in steel or strain in concrete and masonry structures. Typical applications include:

- ✓ Monitoring structural members of buildings and bridges during and after construction.
- ✓ Monitoring load in struts used to brace deep excavations.
- ✓ Measuring strain in tunnel linings and supports.
- ✓ Monitoring areas of concentrated stress in pipes.
- ✓ Monitoring distribution of load in pile tests.
- ✓ Monitoring cracks in concrete (may require long-base strain gauge).

Specifications:

Range	: ± 1500 micro strain
Resolution	: 1 micro strain
Material	: Stainless steel
Operating temperature	: -10 to 80°C
Thermistor	: YSI 44055 or equivalent, 3K at 25°C



Load / Pressure

Vibrating Wire Total Pressure Cell

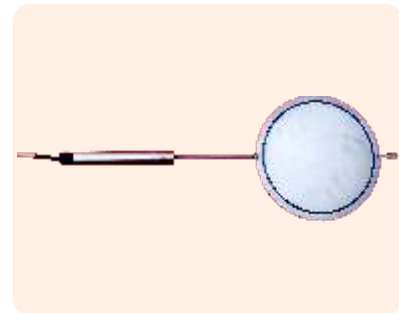
AIS 900

Total Pressure cells are designed to measure stress action on plane surface. It measures the combined pressure of effective stress and pore-water pressure. The pressure cells are constructed from two circular stainless steel plates, welded together around their periphery. The annular space between these plates is filled with oil. The cell is connected via a stainless tube to a transducer forming a closed hydraulic system. The stress then converted to a signal and may be remotely read in a portable read out unit or data logger. Typical applications include:

Monitoring total pressure exerted on a structure to verify design assumptions. Determining the magnitude, distribution, and orientation of stresses.

Specifications:

Capacity	: (Mpa) 1,2,3, 5,10,15
Accuracy	: $\pm 0.5\%FS$
Resolution	: $\pm 0.05\%FS$
Over Range	: 150%
Material	: Stainless Steel
Thermistor	: YSI 44055 or equivalent, 3K at 25°C
Operating Temperature	: -20 to +80°C



Vibrating Wire Concrete Pressure Cell

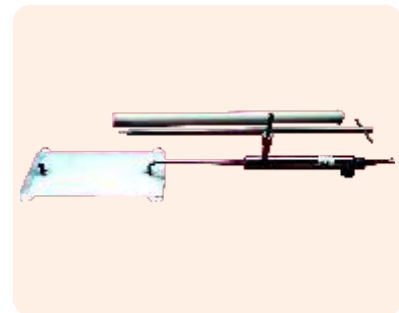
AIS 900

Vibrating wire concrete Pressure cells are used for the measurement of tangential and radial stresses in concrete and shotcrete tunnel linings. The typical application includes:

- ✓ Pressure on and within linings of underground excavations
- ✓ Monitoring of stress distribution within rock

Specifications:

Capacity	: (Mpa) 1,2,3, 5,10,15
Accuracy	: $\pm 0.5\%FS$
Resolution	: $\pm 0.05\%FS$
Over Range	: 150%
Material	: Stainless Steel
Thermistor	: YSI 44055 or equivalent, 3K at 25°C
Operating Temperature	: -20 to +80°C



Vibrating Wire Centre-Hole Load Cell

AIS 1200

Centre-hole load cells are designed to measure compressive and tensile loads in tiebacks, rock bolts, and cables. Typical applications include:

- ✓ Proof testing and performance monitoring of tiebacks, rock bolts, and other anchor systems.
- ✓ Monitoring loading of vertical supports in underground openings.

Specifications:

Capacity	: (kN) 50 to 3000
Accuracy	: $\pm 0.5\%FS$
Resolution	: $\pm 0.05\%FS$
Over Range	: 150%
Material	: Stainless Steel
Operating Temperature	: -20 to +80°C



Temperature Sensor

AIS 1100

Temperature sensors are used to monitor the heat of hydration in mass concrete structures.

Sensor Type.

- v Vibrating wire temperature sensors offer high accuracy and are convenient when other types of VW sensors are used.
- v Resistance temperature sensors (RTDs or Thermistors) are an economical alternative to the vibrating wire sensor.

Specifications:

Range	: -20 to +80°C
Accuracy	: $\pm 0.5\%$ FS
Resolution	: 0.03°C
Material	: Stainless Steel



Normal & Inverted Plumb Line

AIS 1330

The normal & inverted plumb lines are used for accurate measurement of horizontal movements associated with the rotation or tilting of a structure. The typical applications are determination of deflection of dam, horizontal movement of dam foundations, abutments, bridges, piers and tall buildings. Inverted and normal plumb lines are installed in same structure.

Specifications:

Telescope Focus Range	: 250 to 500mm
Range	: ± 75 mm
Accuracy	: 0.1mm
Resolution	: 0.01mm
Table Size	: 625mm x 625mm
Wire	: 1mm dia Stainless Steel
Weight	: 10kg



Uniaxial Tilt Sensor

AIS 1330

Tilt Sensors are used to monitor changes in the tilt of a structure. Such changes may be caused by excavation, tunneling, dewatering, or loading of the structure. Typical applications for tilt sensors include:

- v Monitoring stabilization measures, such as pressure grouting and underpinning.
- v Monitoring structures for the effects of tunneling and excavating.
- v Monitoring the deflection and deformation of retaining walls.
- v Monitoring convergence and other movements in tunnels.
- v Providing early warning of threatening deformations, allowing time for corrective action to be taken.

Specifications:

Applied Sensor	: Vibrating Wire
Range	: $\pm 5^\circ$ $\pm 10^\circ$
Resolution	: 5arc second /10arc second
Accuracy	: $\pm 0.1\%$ FS
Non Linearity	: $\pm 0.5\%$ FS



Inclinations & Rotations

Inclinometer Casing

AIS 1350

Inclinometer casing is permanently installed in a borehole that passes through suspected zones of movement. Inclinometer casing can also be embedded in fill, buried in a trench, cast into concrete, or attached to a structure. Important features of casing include the diameter of the casing, the coupling mechanism, groove dimensions, straightness, and the strength of the casing.

Specifications:

Material	: ABS
Collapse rating	: 1960kPa
Bend rating	: 3.07kN
Maximum Temperature	: 80°
Tensile strength	: 705Kgf
Outside Diameter	: 70mm
Inside Diameter	: 62mm
Casing Length	: 3m



Portable Vertical Inclinometer

AIS 1365

Vertical inclinometer provides accurate profile of lateral deflection in two perpendicular planes.

- Monitoring slopes and landslides to detect zones of movement and establish whether movement is constant, accelerating, or responding to remedial measures.
- Monitoring diaphragm walls and sheet piles to check that deflections are within design limits, that struts and anchors are performing as expected, and that adjacent buildings are not affected by ground movements.
- Monitoring dams, dam abutments, and upstream slopes for movement during and after impoundment.
- Monitoring the effects of tunneling operations to ensure that adjacent structures are not damaged by ground movements.

Specifications:

Probe	: Biaxial
Range	: $\pm 30^\circ$
Resolution	: 0.01mm
Sensor accuracy	: $\pm 0.02\%$ FS
Probe Length	: 500mm
Operating Temperature	: -20 to $+60^\circ$
System Accuracy	: ± 2 mm (over 25m)



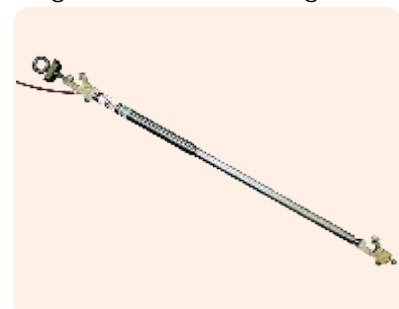
In-Place Inclinometer

AIS 1375

In-place inclinometer sensors are placed at specific depths to span a zone of suspected movement. They are left in-place (unlike the traversing probe) and usually monitored continuously to ensure safety. A data logger is used with in-place sensors. It monitors continuously and can trigger an alarm when it detects a change or rate of change that exceeds a preset value.

Specifications:

Range	: $\pm 5^\circ$, $\pm 10^\circ$
Resolution	: 0.005%FS
Accuracy	: $\pm 0.05\%$ FS
Operating Temperature	: -20 to $+70^\circ\text{C}$
Signal Output	: ± 2.5 VDC
Ingress Protection	: IP68
Material	: Stainless Steel



Deformations

Borehole Rod Extensometer

AI S 1500

The rod extensometer monitors changes in the distance between one or more downhole anchors and a reference head at the borehole collar. Typical applications include:

- ✓ Monitoring settlement in foundations.
- ✓ Monitoring subsidence above tunnels and mines.
- ✓ Monitoring heave in excavations.
- ✓ Monitoring the stability of tunnels and other underground openings.
- ✓ Monitoring deformation in abutments and walls.

Single Point Monitoring:

The single point rod extensometer can monitor the movement between anchor and reference head. It consists of single point reference head, rod, anchor and sleeve.

Multipoint Monitoring:

The rod extensometer can monitor up to six points along the borehole. The number of monitored points is limited by the size of the borehole, the type of anchor used, the diameter of the rods, and the amount of tubing required for grouting and activating anchors.

Specifications:

Manual Reading :

Range : 50mm with depth gauge
Resolution : 0.01mm
Accuracy : $\pm 0.05\text{mm}$

Remote Reading using VW displacement sensor :

Range : 50mm and 100mm
Resolution : 0.05% of range
Accuracy : $\pm 0.5\%FS$
Operating Temperature : -10 to $+70^{\circ}\text{C}$



Tape Extensometer

AI S 1600

The tape extensometer is used to detect and monitor changes in the distance between two reference points. Typical applications include:

- ✓ Monitoring convergence of tunnel walls.
- ✓ Monitoring deformations in underground openings.
- ✓ Monitoring displacement of retaining structures, bridge supports, and other structures.

Specifications:

Range : 30m
Accuracy : $\pm 0.01\text{mm}$
Resolution : 0.01mm
Calibration Frame : 1m
Reference Hook : 130mm long, 250mm long other length on request



Relative Displacement

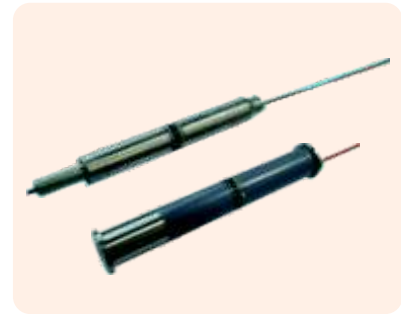
VW Linear Joint Meter

AIS 1400

The VW embedment jointmeter is used to monitor movement at joints in mass-concrete structures such as abutments, foundations, and dams.

Specifications:

Range	: 50mm and 100mm
Accuracy	: $\pm 0.5\%FS$
Temperature Range	: -10 to +70°C
Material of sensor	: Stainless steel



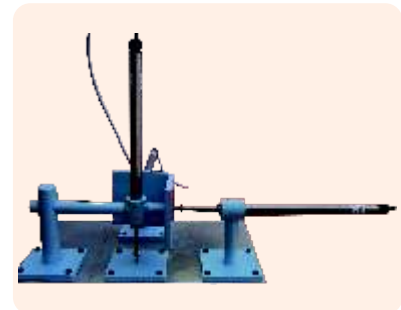
VW Triaxial Joint Meter

AIS 1420

Vibrating wire triaxial jointmeters are designed to monitor the relative displacement of two adjacent surfaces in three orthogonal directions. The typical application of triaxial jointmeter is monitoring of movement at constructions joints in concrete dam, tunnels and tanks or masonry structures.

Specifications :

Standard Range	: 50mm / 100mm
Accuracy	: $\pm 0.5\%$
Temperature Range	: -10 to +70°C
Sensor material	: stainless steel



Mechanical Triaxial Joint Meter

AIS 1420

Mechanical triaxial jointmeter is used to monitor the relative displacement of two adjacent surfaces in three orthogonal directions. The data is being recorded using digital depth gauge manually.

Specifications:

Range	: $\pm 10mm$, $\pm 25mm$, $\pm 50mm$
Accuracy	: $\pm 0.2\%FS$,
Operating Temperature	: -10 to +70°C
Reading Tool	: Digital Depth Gauge



Vibrating Wire Crack Meter

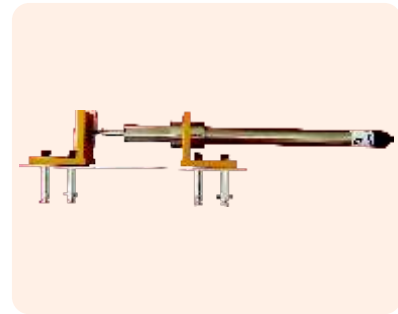
AIS 1500

The VW crackmeter is used to monitor movement at joints and cracks in concrete structures or rock. Typical applications include:

- v Monitoring joints for unexpected movement to provide early warning of performance problems
- v Monitoring joints and cracks in structures that may be affected by nearby excavation and construction activities.
- v Monitoring cracks in structures that have experienced seismic activity.

Specifications:

Range	: 50mm
Accuracy	: $\pm 0.5\%$ FS
Linearity	: 0.1% FS
Operating Temperature	: -10 to $+70^{\circ}\text{C}$
Sensor material	: Stainless Steel
Mounting Brackets	: Two



3-D Monitoring

Optical Target

AIS 1700

Optical target (Bi-reflex) is used to monitor the deformations in 3 dimensional at a point. Its application includes convergence monitoring of tunnel, caverns and surface movements in dam.

Optical range	: 250m with precise Total Station
Accuracy : Measurement in angle	: $\pm 0.5\text{mgon}$
Measurement in distance	: $\pm 1\text{mm}$
Weight	: 0.2Kg
Frame	: Polyamide and G.F 50% / ABS
Plate	: Polyamide and G.F 30% / ABS



Prism Target

AIS 1701

Prism targets are used to monitor the deformation and convergence in underground activities. It has great advantage over bi-reflex target as more precise monitoring, long distance coverage etc.

Features :

- Precision ground glass up to 2 arc second
- Fully compatible with leading manufacturer's Total Stations like Sokkia, Trimble, Topcon, Pentax, Nikon, Stonex etc.
- Hermitically sealed 62.5mm precise prism



Vibrating Wire Data Recorder

AIS 1800

The vibrating wire data recorder is microprocessor based recorder designed to measure most types of commercially available vibrating wire instruments requiring a sweep excitation signal.

The recorder is portable, robust, and suitable in harsh environments.

It is capable of storing and displaying time and date stamped engineering unit data.

The recorder will also simultaneously measure the thermistor which is commonly incorporated in to vibrating wire instruments and display the reading in °C.

Excitation range	: 500Hz to 5KHz
Excitation type	: 5 volt square wave (Peak to Peak)
Accuracy	: ±0.2% of reading
Battery	: 6V, 4Ah rechargeable suitable for 12hours in continuous use.
Resolution	: 0.1 micro second
Data Recording Unit	: Period, frequency, frequency square, engineering unit.
Communication Port	: RS 232
Display	: 16 characters one line
Operating Temperature	: -10 to +60°C
Temperature Measuring	: Thermistor
Measurement Cycle	: 128 Cycles
Memory	: EPROM Program Memory & (NVRAM) Data Memory
Real Time Clock	: RTC is provided for time & date Steaming of Stored Data, Accuracy ± 2 minutes / month



Cables

4-Core Cable:

AIS 1810

7/0.34mm annealed copper, 4-core cable in red/black and white /green petroleum jelly filled, 0.9mm² galvanized steel wire armoured, polythene sheathed, 13mm o.d., unit weight (approx) 0.3kg/m

6-Core Cable

AIS 1825

7/0.34 mm annealed copper, 2-core cable in red, black, white, green blue & gray petroleum jelly filled, 0.9mm² galvanized steel wire armoured, polythene sheathed, 15mm o.d., unit weight (approx) 0.35kg/m approx

10-Core Cable

AIS 1811

0.35mm² annealed bare copper, 10-core cable petroleum jelly filled, 0.9mm² galvanized steel wire armoured, polythene sheathed, 16mm o.d., unit weight (approx) 0.45kg/m approx

20-Core Cable

AIS 1812

0.35mm² annealed bare copper, 20-core cable petroleum jelly filled, 0.9mm² galvanized steel wire armoured, polythene sheathed, 18mm o.d., unit weight (approx) 0.55kg/m approx

40-Core Cable

AIS 1813

0.30mm² annealed bare copper, 40-core cable petroleum jelly filled, 0.9mm² galvanized steel wire armoured, polythene sheathed, 20 mm o.d., unit weight (approx) 0.60kg/m approx

Accessories

Switch Cum Junction Box - 10 Position

AIS 1819

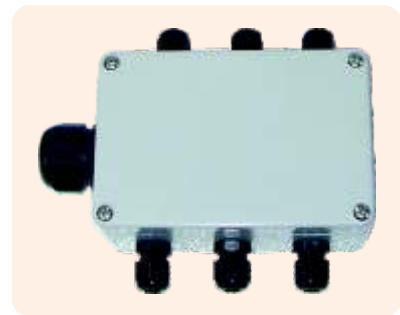
10-position switch cum junction box is suitable for connecting and switching input from up to 10 sensors through ten 4 core input cables to readout unit and to one output cable.



Junction Box 6:1

AIS 1820

This junction box is used to join cables from five strain gauges and one from No-Stress Strain meter to one 20 core cable.



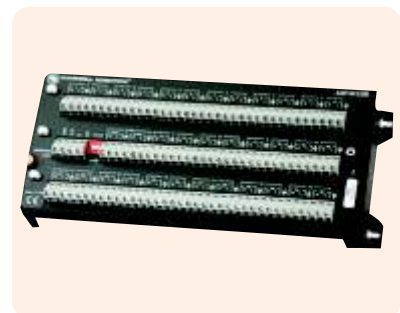
Automatic Data Acquisition System

AIS 2000

Generally large numbers of sensors are installed in geotechnical and structural monitoring. The data acquisition system is installed to acquire data from these instruments. The data acquisitions system is built around the Campbell Scientific CR 800 and CR 1000 modules can be used with other supporting parts like vibrating wire interface, multiplexers to increase the Number of channels.

Features:

- v Rugged with low power consumption
- v Powered by mains, battery or solar panel
- v Internal memory up to 4MB and can be increased through compact flash module (CR 1000 only)
- v Stores up to 20,00,000 data points
- v Data can be retrieved by GSM, GPRS, E-mail, TCP/IP, 2.4GHz Radio modem.
- v Reads most sensors common to geotechnical and structural instrumentation
- v Alarm trigger facility
- v Output data in simple ASCII format enables easy importing



Digital Vibration Meter

Vibration measuring instruments are used in construction work, mining, blasting, demolition or other works where vibration cannot be avoided.

Depending on the requirement of monitoring the transducers are chosen. They are available in following frequency ranges:



Recorder		Transducer	
Number of Channel	4/7	2-250 Hz Version	
Sampling Rate	2048SPS	Measurement Range	±200 mm/s
Analog to digital Convertor	16bits	Resolution	0.01mm/s
Record Time	1,2,4,8,16,32 S	Minimum measurement	0.05mm/s
Trigger Mode	Automatic/ Manual/External	Type of Transducer	Geophone fn = 8Hz
Ports for Data transfer	Ethernet (LAN), USB, GSM,GPRS	1-315 Hz Version	
Record & Data Transfer modes	Internal disk Printer, SMS Message, WEB server, FTP server, E-mail	Measurement Range	±120mm/s
Data Storage Memory	200MB	Resolution	0.01mm/s
External Power supply	12V DC	Minimum measurement	0.05mm/s
Autonomy	20 Hours continuous	Transducer Type	Geophone fn = 4.5Hz
Keyboard	8 keys	Sound Signal	
Operating temperature	-10? to 50?C	Measurement Range	±502 Pa (148dB)
Visualization	Graphic LCD screen 128x64 pixels	Resolution	0.1Pa
Dimensions	180x220x70mm	Minimum measurement	2 Pa
Weight	1.9Kg	Transducer Type	Pressure transducer



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