Slope Deformation Monitoring Solution

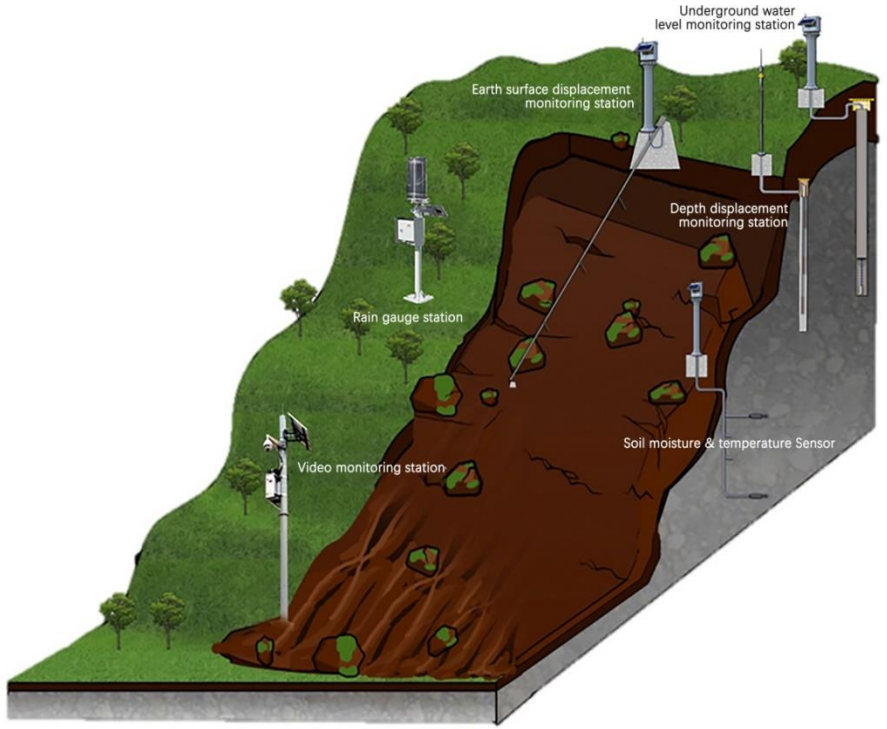
SOUTH Deformation monitoring team was founded in 2007, with more than 10 years development, monitoring team now have 200+ people, more than 600 project experiences.

Slope deformation Monitoring Solution

◆Application scenario

Highway as linear structure building, frequently cross all different kinds of geological envirenment, and it will encounter various slopes. When the highway is built in mountains or hilly area, usually through the dig and fill way to build the roadbed on natural slopes, that's easy to happen slope slip or collapse, and the rainfall also can cause the slope slip. Slope slide and collapse are often occourred suddenly due to its hidden.

Because of this disaster with hidden, wide range distribution, great damage, serious conseqences, it's necessary to establish the automatic monitoring solution to reach high frequency monitoring, high sensitivity perception and timely alert, which can make sure the safety of people's life and property.



Schematic plot of slope monitoring

◆Monitoring Items

In slope monitoring projects, adopt general applicability monitoring equipment as the monitoring sensors, built-in advanced communication modules which support 4G, NB-Iot, LoRa etc. because supportting multiple power supply, it's very convenient for the monitoring station construction; it can well cope with the all kinds of complex disaster environment.
The general items of road slope monitoring as below.

Monitoring Items	Automatic Monitoring Instruments	Monitoring Items	Automatic Monitoring Instruments
Ground Displacement	GNSS	Crack of Slope	Pull Cord Crack Gauge
Slope Emergency Monitoring	Robotic Total Station	Underground Water	Water Level Sensor
Rain Volume Monitoring	Rain Gauge	Displacement of depth soil mass	Stationary inclinometer or ADM
Settle Monitoring	Hydrostatic Level	Landslide	Vibration Accelerometer
Soil Pressure	Soil Pressure Meter(vibrating wire type)	Video Monitoring	Automatic Camera
Soil Water Ratio	Soil moisture temperature Sensor		

◆The frame of monitoring system

SOUTH

Data processing

Data transmission

Data Collection

Server

SMOS

2G 3G G4 IOT

Sound-light alarm

Email&SMS alarm

Analyses of Change

Report Generation
Control Suggestion

Alert Application

4G NB-Iot LoRa

3G 4G

DTU
RTU

RS485

RS485

Multi-channel Vibration wire signal collector

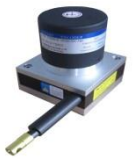
GNSS Base

GNSS monitoring stations

video

Soil Moisture Sensor

Integrated weather station



Pull Cord Crack Gauge

Radar water gauge

Stationary Inclinometer

vibrating wire piezometer

Workflow

Monitoring Data

Manual Survey

Automatic monitoring

Semi-Automatic monitoring

Transmission

Server

Application

SMS E-mail APP

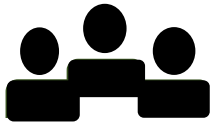
Sound and light alarm

Web

Disaster control

Application Field

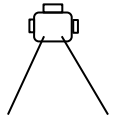
- Geological Disaster
- Bridge health
- Foundation Pit
- Dam safety
- Tailing Pond
- Highway Slope
- Tunnel



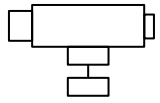
- Monitoring Units
- Construction Organization
- Natural resource Dept.
- Regulators
- Electrical power

Monitoring items Access

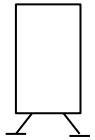
GNSS



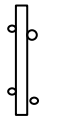
Robotic Total station



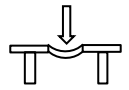
Electric level



Rain of environment

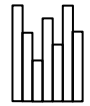


Inclinometer



Stress and strain

Crack



Vibration

◆General Applicability Equipment

GNSS monitoring station

GNSS is widely applied to monitor the displacement of earth surface.

Usually, base station is built on a stable bedrock which near by monitoring stations, monitoring stations are built on the risk slopes.

GNSS monitoring station

◆General Applicability Equipment

SOUTH

Tilt sensor

Wireless smart tilt & vibration sensor which is a three-axis tilt and vibration monitoring sensor integrated the data collection, wireless communication, power supply, self-protection all in one. Mainly apply in tilt angle measurement and vibration perception.

Wireless smart tilt & vibration sensor

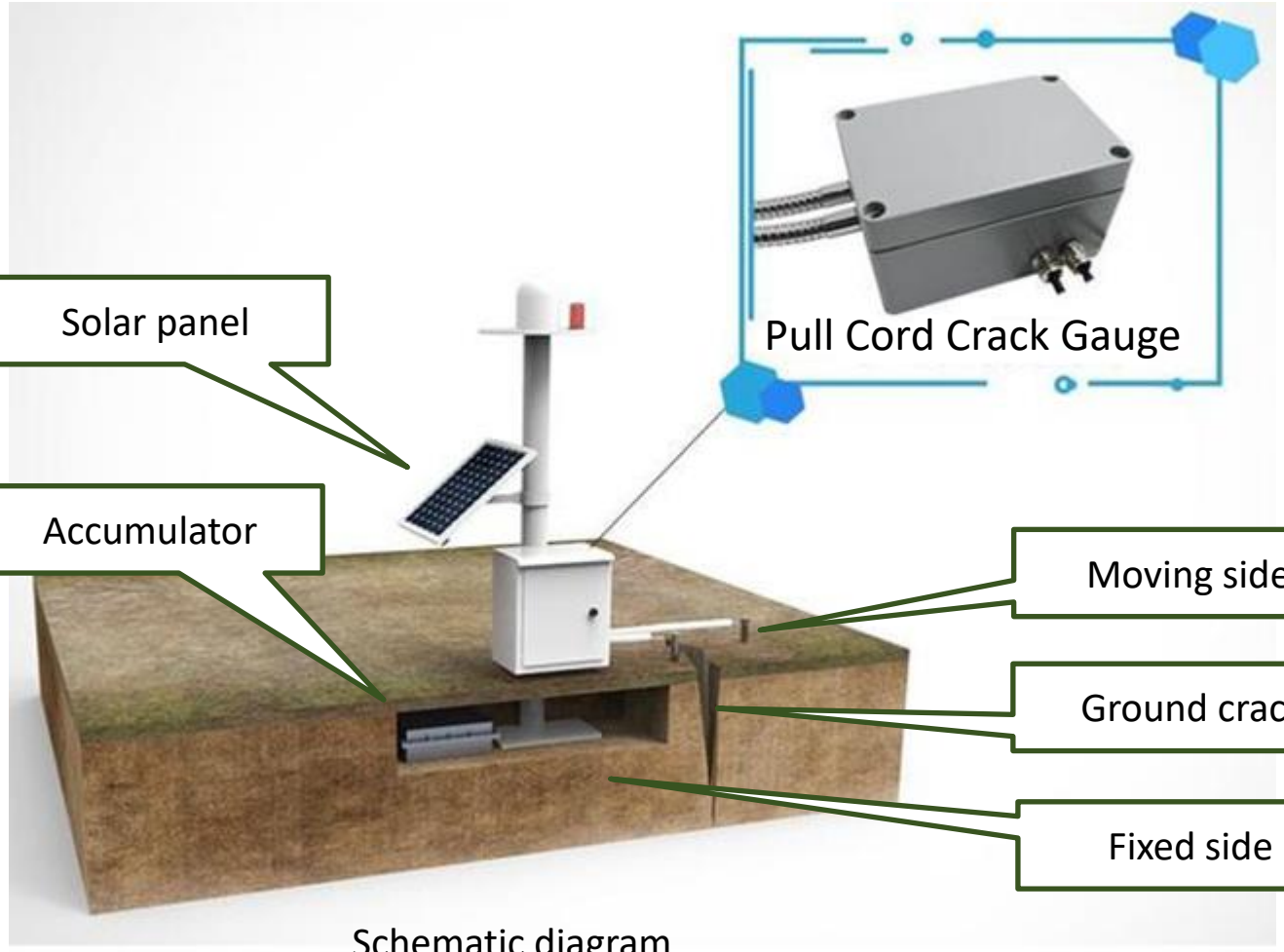
Install on disaster site

◆General Applicability Equipment

SOUTH

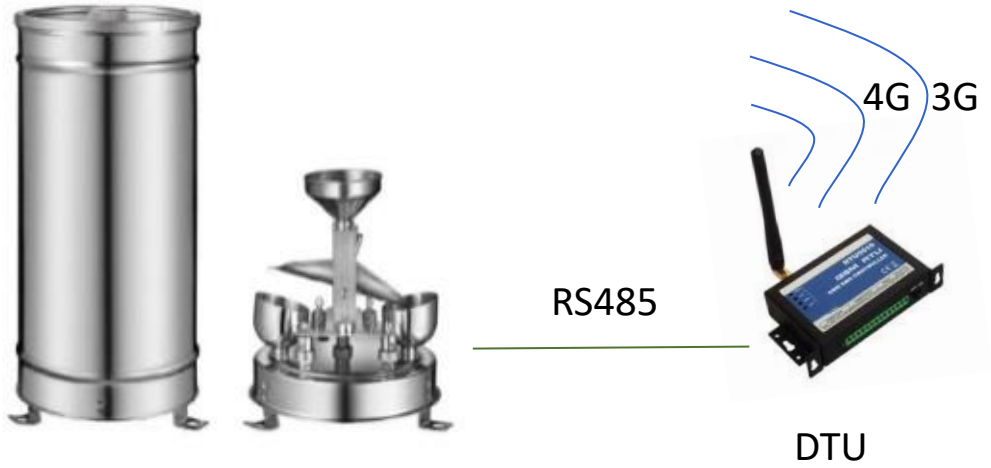
Pull Cord Crack Gauge

It’s a special purpose equipment for crack monitoring, wide measurement range, high sensitivity, quick response, low cost, and easy to install. It’s able to supplement with GNSS in slope monitoring.



Schematic diagram

◆General Applicability Equipment



Rain gauge

Occurrence of Slope disaster often with long time rainfall. There is an obvious directly proportional relationship between rainfall and slope slip or collapse, so the rain gauge is necessary in slope monitoring.

◆General Applicability Equipment

Integrated Soil Moisture Sensor

Pin type Soil Moisture Sensor

Soil Moisture Sensor

With the increase of rainfall, the increase of surface water content is easy to cause earth surface sliding. Conversely, too dry earth surface is also easy to cause soil sliding and collapse. Therefore, it's necessary to monitor the change of surface water on the slope.

◆General Applicability Equipment

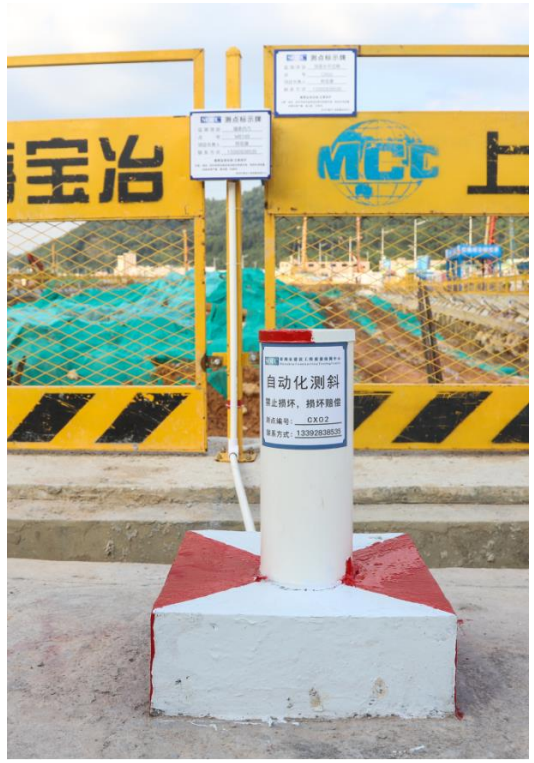
Radar water gauge
Launch ultrasonic wave and get reflection of the time difference to calculate water surface elevation.

◆General Applicability Equipment

Stationary Inclinometer

The occurrence of slope disasters is mostly caused by the internal soil-mass slipping. Earth surface quickly crack when the slip of internal soil-mass is accelerating. Displacement of deep soil-mass is also a very important monitoring item. Generally, the stationary-inclinometer or Array Displacement Meter(ADM) is used for monitoring.

Stationary Inclinometer



◆General Applicability Equipment

Total station

Video monitoring

Sound-Light Alarm

Automatic deformation monitoring solution

South deformation monitoring system is a fully automatic monitoring system based on advanced IOT technology, which is compatible with conventional monitoring solutions. It can achieve real-time and effective dynamic analysis and safety early alert of the monitoring target by various means, improve the accuracy and credibility of the monitoring data while reducing the workload of personal.

Solved pain points that man-made more factors in conventional monitoring and automatic monitoring.

Using sensors to monitor the targets (include geologic disasters, highway & railway slope, foundation pit, dam safety, trailing pond, bridges health, tunnel…etc.) for all-weather automatic real-time monitoring. Transmit all status and data of monitoring targets to the data processing center in real time by various wired or wireless network technology. To complete analysis, judgment, alert. Terminal devices can passively receive the alert information，also can actively log in the platform to acquire various status and data of monitoring targets, which is the basis for decision-making.

Road Slope Monitoring

Geological Disaster monitoring

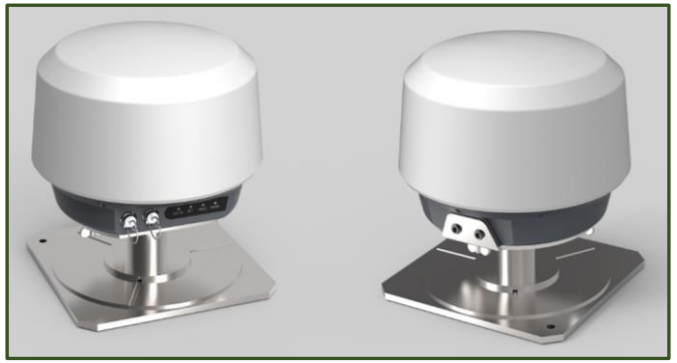
Dam Monitoring

Tailings pond Monitoring

Foundation Pit Monitoring

Bridge health Monitoring

◆GNSS Monitoring station



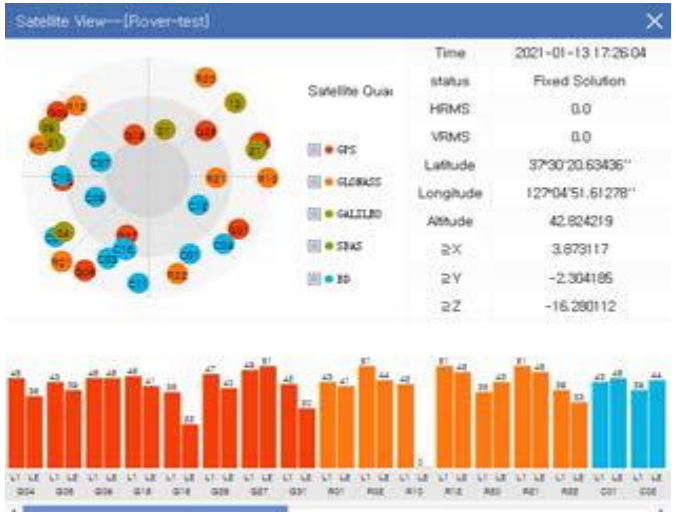
SOUTH Model: MR1

Integrated Design | High Accuracy | Low-power Consumption | Remote Control

Anti-Steal Design | Multiple Communication | Cloud Service | IP68

- ■ General applicability monitoring GNSS
- ■ Optimization Algorithm
- ■ Monitoring Accuracy 1mm/ 24 hours in short baseline

● Stable and high accuracy GNSS monitoring engine and dual independent GNSS process algorithms



● Real-time and history data and graphic view, report data export

◆GNSS Monitoring station

GNSS monitoring station MR1

MR1 is a special purpose model for deformation monitoring.

As the general applicability equipment, it's widely applied to monitor earth surface displacement. Usually, the base station is built on a stable bedrock which near by monitoring stations, monitoring stations are built on the risk slopes.

With stable and high accuracy GNSS monitoring engine and dual independent GNSS process algorithms, it can automatically and continuously monitor the slopes status for every second, the precision coordinate values can be calculated according to your interval settings.

Install on disaster site

◆GNSS Monitoring station

SOUTH

MR1

- Multi-frequency and Multi constellations GNSS board
- Integrated Design easy to install
- Low-power Consumption
- 3G/4G network unit
- Internal battery
- Bluetooth, WIFI
- WebUI
- Remote control
- magnesium aluminum alloy housing
- IP68

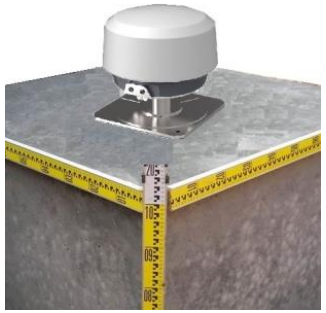
NET S10 mini

- Multi-frequency and Multi constellations GNSS board
- Support high speed network
- Bluetooth WIFI
- Support 5 independent data streams transmission
- Low-power Consumption
- Internal radio (option)
- Remote control
- magnesium aluminum alloy housing
- IP68

NET S10

- Multi-frequency and Multi constellations GNSS board
- 3G/4G network unit
- Bluetooth/ WIFI
- Support multiple data format
- Internal battery
- LCD screen
- Support connection weather station and tilt sensor
- Built in 13000mAH battery
- IP68

◆Installation



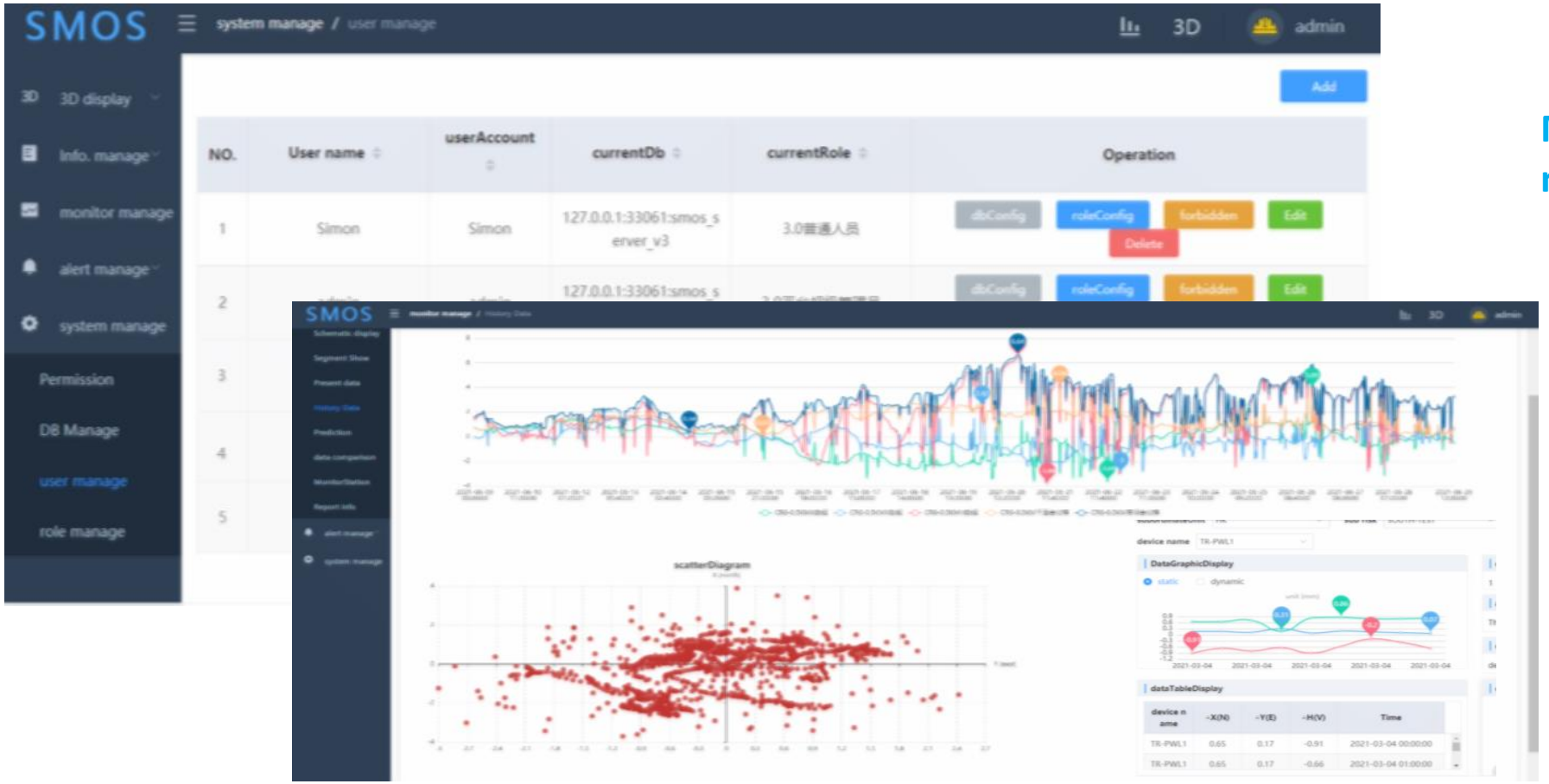
Install on observation pillar

Install on stand column

Software South monitoring system (SMOS)

SMOS software includes different functional modules to meet the user's demand, geological disaster, highway & railway slope, foundation pit, dam safety, trailing pond, bridge health, tunnel project…etc.

◆ Software interface

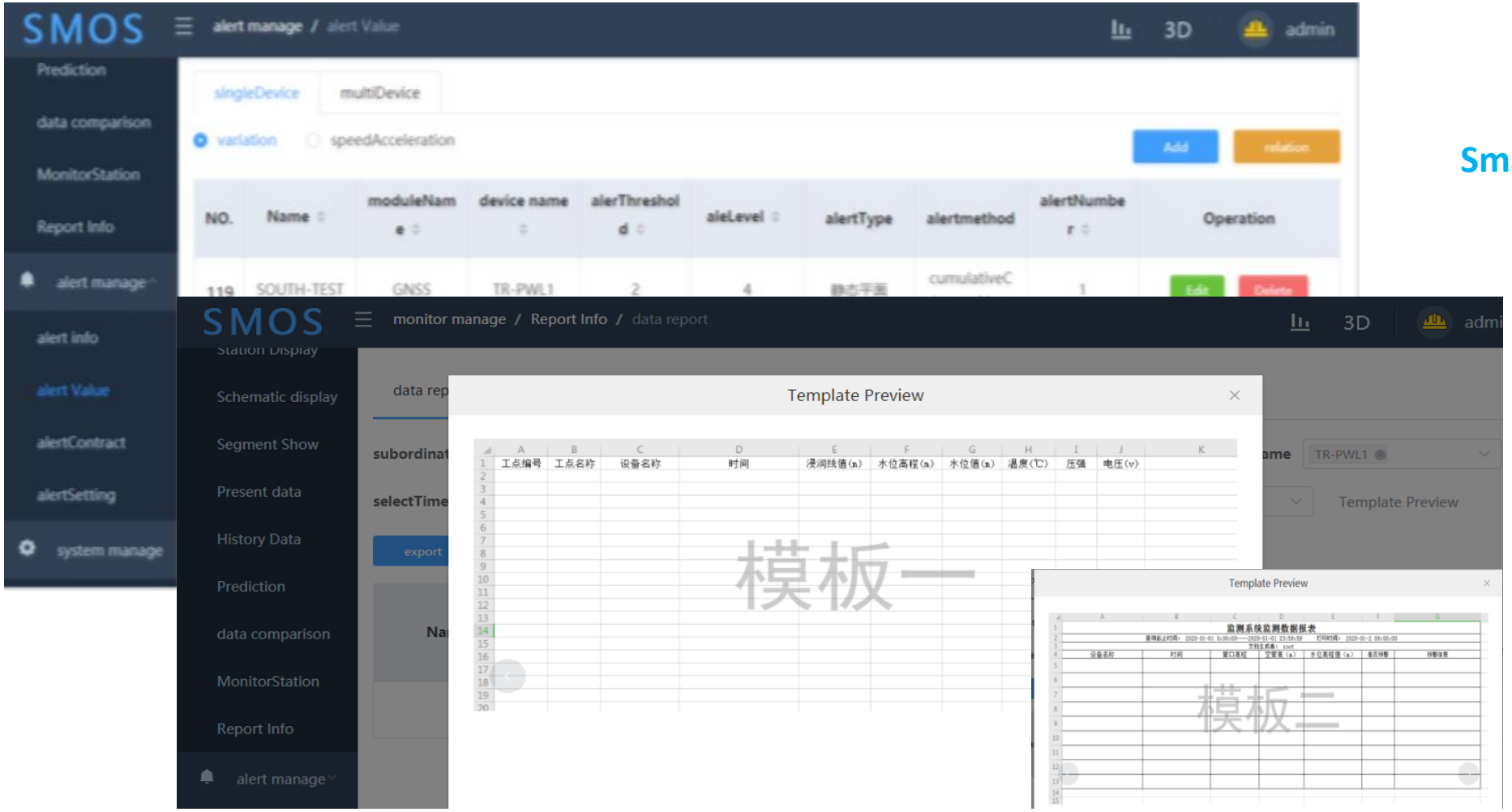


Multi-user management

Powerful Data analysis and chart show

Software South monitoring system (SMOS)

◆ Software interface



Smart alert model

Report export by user define

Project Case

SOUTH

Automatic monitoring project of Shazhuang Zengcheng to Beixing Huadu phase II highway project in Guangzhou

Project Case

SOUTH

1.project time

Automatic monitoring project for the second stage of highway construction from Shazhuang Zengcheng District to Beixing Huadu District, the term is April 2017 –June 2017.

2.Project profile

Shazhuang zengcheng district to Beixing Huadu district Guangzhou Highway the second stage (Licheng to Beixing Section Huadu) project is located in the northeast of Guangzhou. The route starts from Licheng Zengcheng connected the completed and opened first stage project from Shazhuang Zengcheng Guangzhou to Beixing Huadu highway. The first stage highway project passed through Zhongxin, Taiping, ends at Yanghe. Connected highway has been opened to traffic from Jiekou to Beixing, which connected to the Beijing-Hong Kong-Macao national Expressway. The total length of the project is about 45km, including about 30km in Zengcheng district, about 8km in Conghua district, about 3.5km in Baiyun District and about 3.5km in Huadu District.

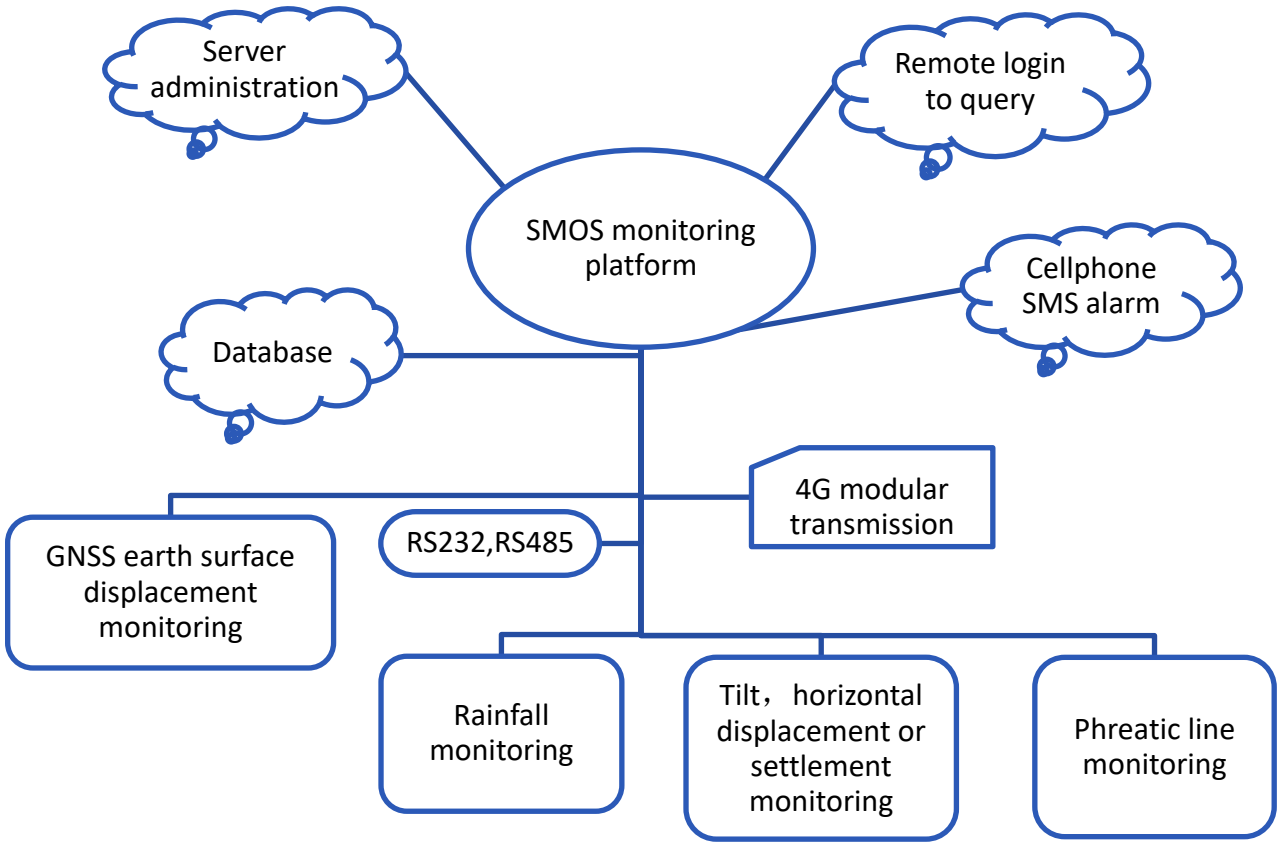
3.Design principle of the monitoring project

Years of research and development practice in the industry, the layout of automatic monitoring system is into three basic forms, namely the centralized monitoring system, the distributed monitoring system and the hybrid monitoring system. Finally the Hybrid monitoring system is adopted in this project, mainly because the project is not suitable for centralized and distributed monitoring system due to the dispersed monitoring objects, many monitoring contents and limited number of measurement points.

4.System framework of project

The online safety monitoring system consists of four parts: data collection layer, data transmission layer, data analysis and management layer (monitoring center) and alert application layer. The data collection layer consists of various monitoring equipment installing in the monitoring site; The collected raw data is transmitted through the data transmission layer, which is built by serial port server and 4G module. The raw data stream is finally transmitted to the monitoring center for automatic calculation and analysis by software. Alert application layer shows changes of data curves, and automatically creates report and timely sends the alert commands to different alert terminals, such as Email, SMS, sound and light alarm. The sampling period of system can be set according to the actual situation.
The system framework of the project is shown in the figure below:

- Figure 1 Frame of monitoring system



5. The monitoring contents

This carrying out of automatic monitoring project is on the slopes of 5 sections of high and steep highways along the second phase of Shazhuang Zengcheng district to Beixing Huandu district highway (Licheng to Beixing Duadu section) in Guangzhou city. The monitoring project includes earth surface displacement monitoring, phreatic line monitoring, deep displacement monitoring and rainfall monitoring.

5.1.Earth surface displacement

GNSS earth surface displacement monitoring station of the project is S8+C receiver of Guangzhou South satellite navigation instrument Co., Ltd. Totally 5 earth surface displacement monitoring stations are separately built on the top of slope of 5 sections highway. See Table 1 for the specific layout of measuring points. One GNSS base station is shared for the five GNSS displacement monitoring stations. The base station is located in the middle of the section of phase II project of shazhuang Zengcheng district to beixing Huadu district, Guangzhou (K43 + 754 ~ K43 + 850 ~ K49 + 500 ~ K49 + 740 section). One area with stable bedrock is selected to build as the surface displacement monitoring basic point.

- Table 1 Deploy table of earth surface displacement monitoring station

NO	Mileage stake number	Measurement point position	Earth surface Displacement （point）
1	K43+754~K43+850	Top of cutting	1
2	K44+000~K44+100	Top of cutting	1
3	K48+350~K48+550	Top of cutting	1
4	K49+300~K49+460	Top of cutting	1
5	K49+500~K49+740	Top of cutting	1
Total			5

Project Case

- **The photos of project carry out**

Foundation pit of displacement observation pillar

Pouring of displacement observation pillar

Displacement observation pillar pouring completion

Internal picture of equipment cabinet

Lightning protection construction

Ground lead operation

Displacement monitoring station and rainfall station

5.2. Seepage line monitoring

Adopt the vibrating wire piezometer the model VWP to measure the seepage line, it can measure the water level and water temperature. the slope with high and little buried depth groundwater level which should be monitored seepage line, because the groundwater level changing will change the stress status and physical properties of the slope, which is closely related to the formation or stability of slope slide and collapse. According to the hydrogeological conditions of the slope, the seepage line of the highway slope in K43 + 754 ~ K43 + 850 section is monitored, and a measuring point is arranged on the second step of the highway slope in K43 + 754 ~ K43 + 850 section.

5.3. Deep displacement monitoring

Adopt the stationary inclinometer GN-1B to monitor the deep displacement, which can measure the inclined deformation of the weak surface at different depths of the slope, can calculate horizontal displacement, position, thickness and deformation rate of the slope collapse surface and the slope weak zone.

See Table 2 for the location of monitoring points.

- Figure 1 Deploy table of deep displacement monitoring station

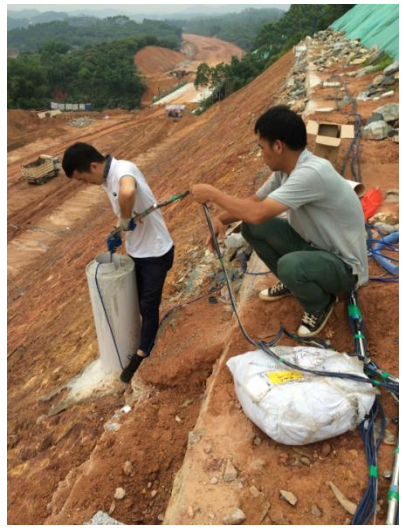
NO.	Mileage stake number	Measurement point position	Deep displacement monitoring points	Remark
1	K43+754~K43+850	class 2	1	8 measurement points
		Top of cutting	1	8 measurement points
2	K49+500~K49+740	Top of cutting	1	8 measurement points
Total			3	24 measurement points

Project Case

- **The photos of project carry out**

Inclinometer wiring

Inclinometer wiring



Inclinometer installation

Completion of Inclinometer installation

Site Topography

Site Slope

SOUTH

5.4. Rainfall monitoring

Adopt the rain gauge dj-02 model to monitor the rainfall, it has the intelligent collection, long-term solid-state storage and long-distance transmission. Rainfall is the main environmental factors for landslide and collapse. Generally, meteorological monitoring based on rainfall should be carried out. In order to comprehensively collect the rainfall data within the scope of the project, two rainfall monitoring stations are arranged on the both side of highway in the project. See Table 3.

- Table3 Deploy table of rain monitoring station

NO.	Mileage stake number	Measurement point position	Rainfall monitoring points
1	K43+754~K43+850	class 2	1
2	K49+500~K49+740	Top of cutting	1
Total			2

Thanks !