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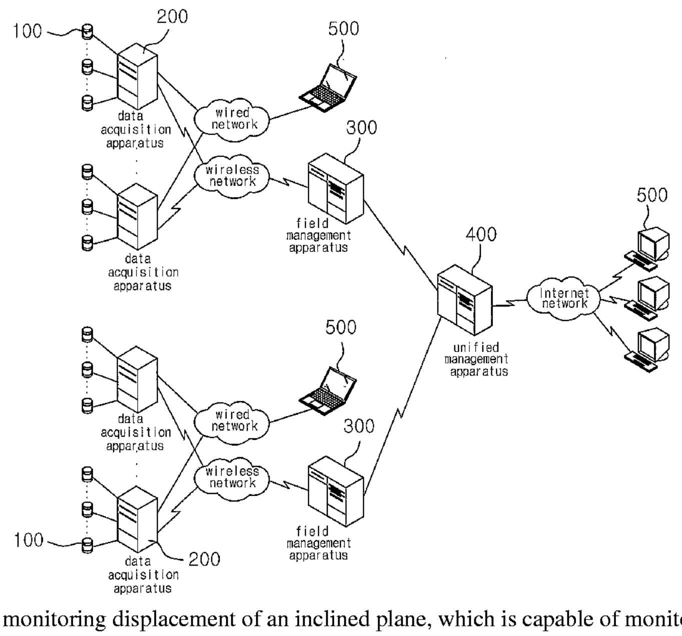

(57) Abstract: A system for monitoring displacement of an inclined plane, which is capable of monitoring behavior of the inclined plane in real time at a remote location through a plurality of measurement devices arranged in the longitudinal direction at the inclined plane. The system comprises a plurality of measurement devices for measuring ground data required to predict collapse possibility of an inclined plane, a plurality of data acquisition apparatuses in communication with the measurement devices for calculating behavior data at positions at which the measurement device are installed, using the ground data received from the measurement device, and a field management apparatus for analyzing and storing the behavior data received from the plurality of data acquisition apparatuses at remote locations, and managing the behavior state of the inclined plane based on a result of the analysis.

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SYSTEM FOR MONITORING DISPLACEMENT OF INCLINED PLANE

Technical Field

The present invention relates to a measurement system, and more particularly to a system for monitoring displacement of an inclined plane, which is capable of monitoring behavior of the inclined plane in real time at a remote location through various sensors arranged at the inclined plane.

Background Art

In general, since inclined planes have different ground physical properties depending on the degree of aeration, the degree of alteration, the presence and kind of geological structures, and the depth of crushing zones, it is a difficult task to exactly detect a degree of stability of the inclined planes. Particularly, since domestic inclined planes have complicated ground and geological features and ununiform geotechnological characteristics, it is difficult to determine the features and the characteristics precisely at a pre-survey stage for construction of buildings on the inclined planes.

Accordingly, there are many cases where building collapses take place during construction of the buildings on the inclined planes or after roads around the inclined planes are opened, or sufficient safety of the buildings is not ensured due to ground features different from those specified in design conditions. That is, there are many cases where anticipated behaviors of the inclined planes are not coincident to their actual behavior. In order to overcome such a problem, there is a need for a system for detecting behavior of an inclined plane during or after construction of buildings and adopting proper measures to handle abnormality if they are discovered.

Accordingly, recently, measurement systems for detecting the behavior of the inclined plane quantitatively so as to estimate the stability of the inclined planes are being increasingly used. However, many persons are necessary for operation of the measurement systems in current use, such as measurement using measurement equipment, and arrangement and analysis of data. Particularly, for inclined planes requiring large-scale measurement, there is a problem in that a great deal of effort and much time is required for the measurement and the process of measurement data.

In addition, if the residents in the field perform manual measurement, measurement frequency and measurement points may lack in rationality due to difficulty in measurement, and it is substantially impossible for them to take an active measure against an emergency situation.

Moreover, there may occur measurement errors due to differences in measurements between individuals. Therefore, since it is difficult to construct databases due to lack of measurement data and low reliability of the measurement data and to utilize data of measured inclined planes when similar inclined planes are measured, there arises a problem in that all inclined planes to be monitored must be measured one by one.

Particularly, measurers have to go to locations at which measurement devices are installed for measurement data acquisition in the field. However, after instability of the inclined planes are observed, this measurement work may put the measurers in danger and there arise difficulties in taking a safe measure. Therefore, it is almost impossible to persistently measure and manage behavior state of the inclined planes.

Disclosure of the Invention

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a system for monitoring displacement of inclined planes, which is capable of monitoring behavior of the inclined planes, such as instability and collapse of the inclined planes, in real time, in the field or at a remote location.

It is another object of the present invention to provide a system for monitoring displacement of inclined planes, which is capable of providing information on behavior of the inclined planes quickly and precisely by measuring variation of behavior of the inclined planes due to minute fluctuations of the inclined planes.

It is yet another object of the present invention to provide a system for monitoring displacement of inclined planes, which is capable of predicting collapse of inclined planes in advance.

It is yet another object of the present invention to provide a system for monitoring displacement of inclined planes, which is capable of promptly coping with behavior state of inclined planes by informing a manager of the behavior state of inclined planes in case of emergency.

It is yet another object of the present invention to provide a system for monitoring displacement of inclined planes, which is capable of monitoring information on behavior state of inclined planes anytime anywhere over the Internet.

In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a system for monitoring displacement of an inclined plane, comprising a plurality of measurement devices for measuring ground data required to predict collapse possibility of an inclined plane, a plurality of data acquisition apparatuses in communication with the measurement devices for calculating behavior data at positions at which the measurement device are installed, using the ground data received from the measurement devices, and a field management apparatus for analyzing and storing the behavior data received from the plurality of data acquisition apparatuses at remote locations, and managing the behavior state of the inclined plane based on a result of the analysis.

The plurality of measurement devices are mounted on a plurality of measurement piles arranged in a longitudinal direction with respect to one or more reference piles installed on the inclined plane for measuring ground data at positions at which the measurement piles are installed, in response to a measurement driving signal transmitted from the external.

The plurality of data acquisition apparatuses processes the ground data transmitted from the plurality of measurement devices to calculate behavior data of the inclined plane at positions at which the measurement devices are installed, and transmits the inclined plane behavior data of the measurement devices in response to requests for the inclined plane behavior data from the external.

The field management apparatus outputs the inclined plane behavior data transmitted from the plurality of data acquisition apparatuses installed at remote locations to a display, analyzes behavior state of the inclined plane with reference to a management reference value based on a predetermined collapse characteristic of the inclined plane, and outputs an alert signal based on a result of the analysis. With this configuration, the system for monitoring displacement of inclined planes in accordance with the present invention can predict and alert collapse of the inclined planes in advance by accurately analyzing behavior state of a plurality of inclined planes by means of a plurality of measurement devices installed at remote locations.

Preferably, each of the plurality of measurement devices includes a base member mounted on a respective one of the plurality of measurement piles fixed on the inclined plane in the longitudinal direction, and a body rotably connected to the top portion of the base member through a lower connection member and containing a measurement unit for measuring the ground data at a position at which the measurement pile is installed, an analog to digital conversion unit for converting analog data measured by the measurement unit to digital data, and a communication unit for transmitting the ground data inputted from the analog to digital conversion unit to the external and receiving control signals for the measurement unit from the external.

Preferably, each of the plurality of measurement devices includes a gradient measurement unit rotably arranged at an upper portion of the body through an upper connection member for measuring gradient of the measurement pile, a displacement measurement unit for measuring displacement of a wire connected to the measurement pile, and a temperature measurement unit for measuring ambient temperature.

With this configuration, by measuring an inclined plane at positions at which measurement devices are installed, by means of the gradient measurement unit, the displacement measurement unit, and the temperature measurement unit, and analyzing the behavior state of the inclined plane, collapse direction of inclined plane can be effectively determined when abnormality is detected.

Particularly, if there occurs large scale inclined plane collapse in regions other than a region at which measurement devices are installed, or minute movement such as translation activity, by measuring variation in distance between measurement piles using gradient variation of the inclined plane, collapse symptoms of the inclined plane can be more precisely analyzed and predicted and a manager can promptly cope with the collapse symptoms of the inclined planes.

Preferably, the system of the present invention further includes a unified management apparatus for storing information on behavior state of the inclined plane, which is transmitted from a plurality of field management apparatuses at remote locations, for each field management apparatus, and transmitting the information on the behavior state of the inclined plane to the manager computer in response to requests for the behavior state of the inclined plane, the requests being received through a communication network.

With this configuration, by transmitting the behavior state information of the inclined plane, such as instability and collapse characteristics of the inclined plane, to a plurality of manager computers accessed over Internet in real time, behavior state of inclined planes distributed at remote locations can be easily monitored and managed remotely.

Brief Description of the Drawings

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram illustrating the entire configuration of a network system to which a system according to a preferred embodiment of the present invention is applied;

Fig. 2 is a sectional view of an inclined plane measurement apparatus according to a preferred embodiment of the present invention;

Fig. 3 is an enlarged view of portion A shown in Fig. 2;

Fig. 4 is an enlarged view of portion B shown in Fig. 2;

Fig. 5 is a schematic diagram illustrating the configuration of a data acquisition apparatus according to a preferred embodiment of the present invention;

Fig. 6 is a schematic diagram illustrating the configuration of a field management apparatus according to a preferred embodiment of the present invention;

Fig. 7 is a view showing an exemplary data input screen of the field management apparatus;

Fig. 8 is a view showing an exemplary behavior data analysis screen of the field management apparatus; and

Fig. 9 is a schematic diagram illustrating the configuration of a unified management apparatus according to a preferred embodiment of the present invention.

Best Mode for Carrying Out the Invention

Hereinafter, preferred embodiments of the present invention will be described in detail so that those skilled in the art can easily understand and practice the present invention.

Fig. 1 is a schematic diagram illustrating the entire configuration of a network system to which a system according to a preferred embodiment of the present invention is applied. Referring to the figure, a system for monitoring displacement of an inclined plane in accordance with the present invention includes a plurality of measurement devices 100 for measuring ground data related to variation of behavior of the inclined plane, a plurality of data acquisition apparatuses 200 for exchanging data with the plurality of measurement devices 100, a plurality of field management apparatuses 300 for receiving behavior data transmitted from the plurality of data acquisition apparatuses 200 over communication networks and analyzing and managing behavior state of the inclined plane. In addition, the system of the present invention further includes a unified management apparatus 400 for providing information on the behavior state of the inclined plane transmitted from the plurality of field management apparatuses 300 to a plurality of manager computers 500 connected to the unified management apparatus 400 via

Internet networks.

More specifically, the plurality of measurement devices 100 in this embodiment are mounted on a plurality of measurement piles arranged in a longitudinal direction with respect to one or more reference piles installed on the inclined plane. The plurality of measurement devices 100 measure data including data on displacement between measurement devices, data on gradient of measurement devices, and data on ambient temperature (hereinafter, referred to as "ground data") through measurement units provided therein.

The plurality of data acquisition apparatuses 200 are installed at a remote location apart from the plurality of measurement devices 100 in the field at which the inclined plane is present. The plurality of data acquisition apparatus 200 calculate behavior data, which is utilized to predict possibility of collapse of the inclined plane at positions at which the measurement devices are installed, using the ground data acquired from various sensors contained in the measurement devices 100, and transmit the calculated behavior data to the plurality of field management apparatuses 300 via wireless networks. In this embodiment, the data acquisition apparatuses 200 may transmit the behavior data to manager computers 500 such as notebook computers, or mobile terminals such as personal digital assistants (PDA), via wired networks.

On the other hand, the field management apparatuses 300 analyze and store behavior states at positions at which the measurement devices are installed, using the behavior data transmitted from the data acquisition apparatuses 200 via the wired networks, and provide information on state of the inclined plane to a manager based on a result of the analysis. Also, the analysis result and the acquired behavior data are transmitted to the unified management apparatus 400 via the wireless networks.

The unified management apparatus 400 transmits the information on the behavior state of the inclined plane transmitted from the field management apparatus to the plurality of manager computers 500 in response to requests for the information on the behavior state from the plurality of manager computers 500 connected to the unified management apparatus 400 via the Internet network.

Accordingly, with the system for monitoring displacement of the inclined plane in accordance with the present invention, the managers can easily monitor the behavior of the inclined plane having any possibility of collapse in real time over the Internet at their offices or other locations. Particularly, since the managers can discover instability of the inclined plane early, and hence, can predict possible collapse of the inclined plane in advance and cope with such a situation properly and promptly, damage which may occur due to the possible collapse of the inclined plane can be minimized.

Hereinafter, components of the system for monitoring displacement of the inclined plane in accordance with the present invention will be described in detail with reference to Figs. 2 to 8.

In the preferred embodiment of the present invention, the measurement devices 100 are connected to respective ones of a plurality of measurement piles in the form of one column through wires drawn from the interior of the measurement devices 100 for measuring ground data at corresponding positions on the inclined plane.

More specifically, as shown in Fig, 2, a measurement device 100 in accordance with the present invention comprises a base member 110 mounted on a respective one of the measurement piles fixed on the inclined plane in the longitudinal direction, and a body 160 rotably connected to the top portion of the base member 110 through a lower connection member 120. The body 160 contains a measurement unit 130 for measuring the ground data at a position at which the measurement pile is installed, an analog to digital conversion unit 140 for converting analog data measured by the measurement unit 130 to digital data, and a communication unit 150 for communicating measurement data inputted from the analog to digital conversion unit 140 to the outside and receiving control signals for the measurement unit 130 from the outside.

In this embodiment, the base member 110 has an insertion groove 111 whose lower portion is opened such that the base member 110 can be inserted in the measurement pile. Also, one side of the base member 110 has a joint hole to which a fixation means, such as a bolt 112, for fixing the base member 110 to the measurement pile is engaged. Thus, by inserting the base member 110 in the measurement pile and fastening the base member 110 by means of the fixation means, the base member 110 can be strongly fixed to the measurement pile.

In addition, the body 160 located above the base member 110 is connected to the base member 110 through the lower connection member 120. In this embodiment, the lower connection member 120 includes a rotation axis 121 for connecting the base member 110 to the body 160, a bracket 122 formed above the base member 110 for enclosing the rotation axis 121, and a managing member 123 composed of a spring 123a and a ball 123b and horizontally mounted on the bracket 122 for managing a rotating angle of the rotation axis 121.

With the configuration as described above, when the measurement device 100 is mounted on a corresponding measurement pile fixed at the inclined plane, it can be easily connected to another measurement pile, which is provided above the corresponding measurement pile, using a wire drawn from the measurement device 100, as the rotation of the lower connection member 120 is managed.

More specifically, even when the direction of the wire drawn from the measurement device mounted on the measurement pile through the lower connection member 120 is different from the direction of a connection member of another measurement pile, the two measurement piles are placed on the same straight line since the body 160 is rotated. In this case, since the rotating angle of the body 160 is managed by the managing member 123 of the lower connection member 120, rotation of the body 160 itself can be prevented even when the wire shakes due to wind and so on.

On the other hand, the body 160 measures the ground data at the position at which the measurement pile, which is generated according to the behavior of the inclined plane, and transmits the measured ground data to the data acquisition apparatus 200. The body 160 includes the measurement unit 130, the analog to digital conversion unit 140 and the communication unit 150, as mentioned above.

The analog to digital conversion unit 140 and the communication unit 150 are mounted on a printed circuit board 180 provided inside the body 160, together with a displacement measurement unit 132 and a temperature measurement unit 133, which are provided inside the measurement unit 130 and will be described later. In addition, a communication port 190 connected to the data acquisition apparatus 200 via a communication cable is provided at one side of the body 160. In this embodiment, the communication port 190 is a serial communication port such as RS-232 used in local area networks (LAN). The measurement device 100 transmits the ground data to the data acquisition apparatus 200 through the communication port 190.

The measurement unit 130 measures the ground data of the measurement pile. In this embodiment, the measurement unit 130 contains a gradient measurement unit 131 for measuring gradient of the measurement pile, the displacement measurement unit 132 for measuring displacement between measurement piles, and the temperature measurement unit 133 for measuring ambient temperature.

The gradient measurement unit 131 is a sensor rotably arranged at an upper portion of the body 160 for measuring the gradient of the measurement pile. In this embodiment, the gradient measurement unit 131 is composed of an X-axis sensor 131a and a Y-axis sensor 131b for sensing a degree of gradient in an NS direction and a degree of gradient in an EW direction for the measurement pile, respectively. Based on the sensed degree of gradient, the gradient measurement unit 131 measures an angle of gradient of altered ground. In this embodiment, an inclinometer is used as the gradient measurement unit 131 for measuring the gradient of the measurement device 100 installed at the inclined plane. The inclinometer has been well known in the art, prior to the filing of the present application, and therefore, the detailed explanation thereof will be omitted.

With the above configuration, the gradient measurement unit 131 measures an altered angle occurring when a rock block moves in the direction of gravity, and outputs an electrical analog signal according to the measured altered angle. The electrical analog signal outputted from the gradient measurement unit 131 is inputted to the analog to digital conversion unit 140 through a cable passing through a vertical through hole 171a formed at a rotation axis 171 of an upper connection member 170, which will be described later. In the analog to digital conversion unit 140, the analog signal is converted to a digital signal to be transmitted to the data acquisition apparatus 200 through the communication unit 150.

As described above, the gradient measurement unit 131 for measuring the altered gradient of the ground is connected to the body 160 through the upper connection member 170.

As shown in Fig. 4, the upper connection member 170 for connecting the body 160 to the gradient measurement unit 131 includes the rotation axis 171 having the vertical through hole 171a formed therein for connecting the body 160 to the gradient measurement unit 131, a bracket 172 formed at the upper portion of the body 160 for enclosing the rotation axis 171, and a managing member 173, composed of a spring 173a and a ball 173b, horizontally mounted on the bracket 172 for managing a rotating angle of the rotation axis 171.

With the above configuration, when the measurement devices 100 are installed on the inclined plane, gradients of the measurement devices 100 can be coincident to each other in a certain direction with respect to the X and Y axes.

In other words, as the gradient measurement unit 131 is rotated by means of the upper connection member 170, reference directions for the gradients of measurement devices 100 can easily become coincident to each other when the measurement devices are initially installed on the inclined plane. In this way, as the gradient measurement unit 131 rotated by means of the upper connection member 170 is managed by the managing member 173, the gradients of the plurality of measurement devices 100 installed on the inclined plane are set in the same direction to measure gradient variation generated in the inclined plane.

The displacement measurement unit 132 is a displacement sensor for sensing a ground displacement due to a local and shallow breakage occurring in a slop in the case of an earth and sand inclined plane, and sensing a displacement occurring when a joint is released and fracture in tension is enlarged in the case of a rock inclined plane. In this embodiment, the displacement measurement unit 132 has a wire (W) wound on a strong spring, which alternates between unwinding and winding depending on movement of active rockwork or ped. The displacement measurement unit 132 measures the amount of displacement according to the unwinding and winding of the wire (W) and outputs an electrical signal generated according to the measured amount of displacement.

In this embodiment, the displacement measurement unit 132 measures displacement between measurement piles using a potentiometer. The potentiometer for measuring the displacement has been well known in the art, prior to the filing of the present application, and therefore, the detailed explanation thereof will be omitted.

The temperature measurement unit 133 measures ambient temperature and outputs an electrical signal generated according to the measured ambient temperature, in a manner similar to the displacement measurement unit 132. Data of the measured ambient temperature is used to correct measurement error of the wire due to temperature variation.

Analog signals outputted from the above-described measurement units 131, 132 and 133 composing the measurement unit 130 are converted to digital signals by means of the A/D conversion unit 32 mounted on the printed circuit board 180. The digital signals are transmitted to the data acquisition apparatus 200 through the communication unit 150 electrically connected to the communication port 190.

For the measurement device installed on the inclined plane in accordance with the present invention, the measurement units for measuring various data are of analog type, however the present invention is not limited to this, and may be of digital type. In the case where the measurement units are composed of digital sensors, the A/D conversion unit is not required.

In this embodiment, in addition to the displacement, temperature and gradient sensors, as described above, the measurement device 100 may further include other measurement units, for example, a pluviometer and a piezometer, for measuring data, such as rainfall or hydraulic pressure, required for analysis of behavior of the inclined plane.

On the other hand, the data acquisition apparatus 200 processes ground data transmitted from the plurality of measurement devices 100, calculates behavior data of the inclined plane at positions at which the measurement devices are installed, and transmits the inclined plane behavior data of the measurement devices in response to requests for the inclined plane behavior data from the outside.

In this embodiment, as shown in Fig. 5, the data acquisition apparatus 200 includes a communication unit 210, a measurement device interface 220, a memory 230 and a controller 240. Additionally, the data acquisition apparatus 200 may include an input unit 250 and a display 260.

In this embodiment, the data acquisition apparatus 200 is able to perform periodic measurement wherein measurement is performed with a certain period according to control signals transmitted from the field management apparatus, and non-periodic measurement wherein measurement is performed according to a request from a manager.

The communication unit 210 exchanges data with external devices. In this embodiment, the communication unit 210 includes a wireless communication unit 211 for exchanging data with the field management apparatus at a remote location through a wireless LAN using a CDMA communication system, and a wired communication unit 212 for exchanging data with the manager computer connected to the communication unit 210 via the communication port. In the case of the exchange of data through the wired communication unit 212, the data acquisition apparatus 200 exchanges various data with the manager computer using a serial communication system such as RS-242 used in the LAN.

With the above configuration, the data acquisition apparatus 200 exchanges various data, for example, the ground data measured by the measurement units of the measurement device, or driving control signals for the measurement units, with the field management apparatus through the wireless communication unit 211. Particularly, the data acquisition apparatus of the present invention is able to transmit the ground data for the inclined plane to the field management apparatus through the wired network if the wireless network encounters any obstacle.

On the other hand, the measurement device interface 220 selects one of the plurality of measurement devices 100 according to a control signal from the controller 240, which will be described later, and outputs the ground data inputted from the selected measurement device to the controller 240. In this embodiment, the measurement device interface 220 includes a multiplexing function to selectively output the ground data of the measurement devices.

The memory 230, which is composed of nonvolatile semiconductor memories such as EEPROM or flash ROM, preserves the ground data even when the power is abruptly disconnected. Although the memory 230 may be composed of two memories, i.e., a read only memory and a read/write memory, it is preferable that it is composed of a single read/write memory in this embodiment.

In this embodiment, the memory 230 stores a data table 231 for extracting measurement values corresponding to the ground data received through the measurement device interface 220 (hereinafter, referred to as "measurement data"), and unique information for each measurement device. In addition, the memory 230 of the data acquisition apparatus contains identification information of the data acquisition apparatuses, and behavior data of the measurement devices calculated by a data calculating unit 242 of the controller 240.

On the other hand, the controller 240 controls driving of the measurement devices based on signals inputted from the field management apparatus or the manager computer, and controls the communication unit 210 to transmit the ground data measured by various measurement units of the measurement devices to the field management apparatus 300.

In this embodiment, the controller 240 of the data acquisition apparatus includes a communication controlling unit 241, the data calculating unit 242 and a data processing unit 243.

The communication controlling unit 241 analyzes an input signal from the communication unit 210 and outputs a select input signal for the measurement devices to the measurement device interface 220. More specifically, the communication controlling unit 241 selects one of the measurement devices by referring to the identification information of the data acquisition apparatus and the unique information, which is contained in measurement driving signals inputted through the communication unit 210, of the measurement devices connected to the data acquisition apparatus, both of which are stored in the memory 230. Then, the selected measurement device is connected to the data acquisition apparatus through the measurement device interface 220.

The data calculating unit 242 extracts the measurement data corresponding to the ground data of the measurement devices using the data table 231 stored in the memory 230 and calculates data of the measurement devices, for example, vertical/horizontal/vibration displacement, gradient, collapse direction, etc., (hereinafter, referred to as "behavior data") at positions at which the measurement devices are installed, using the extracted ground data including the displacement, temperature and gradient data.

At this time, the data calculating unit 242 can enhance measurement accuracy by compensating for any fluctuation of the wire due to the variation of temperature and calculating behavior displacement data for the ground displacement data. Here, an equation, which may be used for temperature correction, is expressed as follows.

$$L = (t_1 - t_0) A + L_0$$

Where, L is real measurement length, L_0 is correction length at correction temperature, t_1 is real measurement temperature, t_0 is correction temperature, and A is a constant of length variation according to temperature variation of 1℃.

In addition, the amount of displacement between measurement devices is calculated using the extracted measurement displacement data, that is, data related to a distance between two measurement devices and measurement gradient data of a corresponding measurement device. For example, if a measurement device with a height of 1 and a gradient angle of 0°, which is connected to a reference measurement pile installed in a stable region, is altered by 10° due to behavior of the inclined plane, the displacement amount and movement direction of the measurement device are calculated using a sinusoidal function of the gradient angle. In this case, the gradient of the measurement device is measured by a gradient sensor composed of an X-axis sensor and a Y-axis sensor contained in the measurement device.

With the above configuration, if there occurs minute fluctuation such as translation activity in the inclined plane or large-scale inclined plane collapse in a range beyond a range within which the measurement piles are installed, the data acquisition apparatus can accurately measure the displacement between two measurement devices due to the behavior variation of the inclined plane using the gradient of the measurement device measured by means of the gradient sensor.

In addition, the data processing unit 243 stores the behavior data calculated by the data calculating unit 242, for example, the real displacement, temperature, and gradient data, in the memory 230, and outputs the behavior data stored in the memory 230, together with the unique information of each measurement device, to the communication unit 210, according to requests for the behavior data received from the outside through the communication unit 210.

With the above configuration, the data acquisition apparatus of the present invention calculates the behavior data at the positions at which the measurement devices are installed, using the ground data received from the plurality of measurement devices installed at unstable regions of the inclined plane. In addition, the data acquisition apparatus transmits the calculated behavior data, which is required to predict the collapse possibility of the inclined plane, to the field or the field management apparatus at a remote location through the wired or wireless communication unit.

In this embodiment, additionally, the data acquisition apparatus 200 includes the input unit 250 through which a manager can input manipulation signals, and the display 260 on which the measurement data calculated by the data calculating unit 242 is displayed.

In this embodiment, the input unit 250 is a known manager input means through which manipulation signals are inputted by the manager using various key buttons, and therefore, the detailed explanation thereof will be omitted.

The display 260 displays the measurement data of the measurement devices stored in the memory 230 based on the manipulation signals inputted by the manager through the input unit 250. In this embodiment, the display 260 may be a display composed of LEDs, or an LCD, by which the unique information of the various sensors and the measurement data measured by the measurement devices can be confirmed with the naked eye in the field.

On the other hand, the field management apparatus 300 outputs, through its screen, the inclined plane behavior data transmitted from the plurality of data acquisition apparatuses 200 installed at a remote location. Also, the field management apparatus 300 analyzes the behavior state of the inclined plane with reference to a management reference value based on a predetermined collapse characteristic of the inclined plane and outputs an alert signal according to a result of the analysis.

In this embodiment, as shown in Fig. 6, the field management apparatus 300 further includes an input unit 310, a communication unit 320 for exchanging data with the data acquisition apparatus 200, a field information database 330, a measurement database 340, a controller 350, an alert output unit 360, and a data output unit 370. Additionally, the field management apparatus 300 includes an image database 380 and a network communication unit 390.

The input unit 310 receives manipulation signals from the manager. The input unit 310 may be a known input means such as a keyboard or a mouse, and therefore, the detailed explanation thereof will be omitted.

The communication unit 320 exchanges various data with the data acquisition apparatus 200 through a wireless LAN using a CDMA communication system in this embodiment.

The field information database 330 stores unique information for the plurality of data acquisition apparatuses 200 installed at a remote location and the plurality of measurement devices connected to the data acquisition apparatuses 200. In addition, the field information database 330 stores a management reference value for the behavior data at the positions at which the measurement devices are installed. In this embodiment, additionally, the field information database 330 stores image information on the inclined plane, such as photographs of zones in which the measurement devices are installed.

With the above configuration, the field management apparatus 300 transmits control signals containing the unique information for the data acquisition apparatuses and the measurement devices, which are stored in the field information database 330, to the data acquisition apparatuses 200 distributed at the remote location, and receives the measurement data of the measurement devices from the data acquisition apparatuses 200.

The measurement database 340 stores the inclined plane behavior data received from the plurality of data acquisition apparatuses 200 through the communication unit 320. At this time, it is more preferable from a management point of view that the inclined plane behavior data stored in the measurement database 340 is stored for each data acquisition apparatus. In addition, the measurement database 340 stores behavior state information on the measurement devices, which is analyzed by the controller 350, which will be described later.

The controller 350 stores the behavior data of the measurement devices received through the communication unit 320, together with measurement time, in the measurement database 340 for each data acquisition apparatus. In addition, the controller 350 analyzes the behavior state of the measurement devices with reference to the management reference value stored in the field information database 330 and outputs an alert driving signal based on a result of the analysis.

In this embodiment, the controller 350 includes a data processing unit 351, a data analyzing unit 352, an alert controlling unit 353, and an output driving controlling unit 354. Additionally, the controller 350 may further include an image data calculating unit 355, a state analyzing unit 356, and a data converting unit 357.

The data processing unit 351 stores the behavior data of the measurement devices received through the communication unit 320, together with measurement time, in the measurement database 340 for each data acquisition apparatus 200.

The data analyzing unit 352 analyzes the behavior state at the positions on the inclined plane at which the measurement device are installed by comparing the behavior data of the measurement devices stored in the measurement database 340 with the management reference values of the sensors stored in the field information database 330. In this embodiment, the management reference values include the uppermost limit set value and the lowermost limit set value for measurement units contained in the measurement devices.

Accordingly, the data analyzing unit 352 analyzes the behavior state at the corresponding positions on the inclined plane based on the behavior data of the measurement devices stored in the measurement database.

The alert controlling unit 353 outputs an alert driving signal to the alert output unit 360 based on a result of the analysis of the data analyzing unit 352. For example, it is preferable that the alert controlling unit 353 outputs differential alert signals indicating stable state, unstable state, emergency, etc, based on the result of the analysis of the data analyzing unit 352.

The output driving controlling unit 354 outputs the behavior data of the measurement devices stored in the measurement database 340 and the analysis result to the data output unit 370, for example, a display such as a monitor or an electric bulletin board, in response to an input signal from the input unit 310.

On the other hand, the alert output unit 360 outputs alert signals based on an alert driving signal from the alert controlling unit 353. In this embodiment, the alert output unit 360 includes an alert sound output unit 361 and a screen display 362. Additionally, the alert output unit 360 may include a message output unit 363.

The alert sound output unit 361 generates an alert sound to inform the manager of the behavior state of the inclined plane based on the alert driving signal outputted from the alert controlling unit 353, as described above. The alert sound output unit 361 is also able to generate the alert sound continuously or periodically depending on the behavior state of the inclined plane. The screen display 362 displays the behavior state of the inclined plane with letters on a portion of the display based on the alert driving signal. For example, the behavior state of the inclined plane is indicated as words such as stable, unstable, emergency, etc., on a certain area of the monitor or the electric bulletin board. The message output unit 363 extracts letters stored in a memory when an alert occurs, and transmits them to a manager.

With the above configuration, the system for monitoring displacement of the inclined plane in accordance with the present invention can promptly cope with the behavior state of the inclined plane by transmitting the behavior state of the inclined plane to the manager when an emergency occurs.

The data output unit 370 outputs the behavior data and analysis result outputted from the controller 350 to a screen based on the control signal from the output driving controlling unit 354, as described above.

Hereinafter, functions of the field management apparatus will be described in detail with reference to

Figs. 7 and 8.

Fig. 7 is a view showing an exemplary data input screen of the field management apparatus, and Fig. 8 is a view showing an exemplary behavior data analysis screen of the field management apparatus.

As shown in Fig. 7, the input screen provided on a monitor is generally divided into a data list, an instruction set, a state window, a control window, and an information window.

The data list indicates the measurement data for measurement devices received from the data acquisition apparatus at the remote location. Items of the data list include number, ID as the unique information for the sensors, kind of sensor, measurement data, flag to indicate "alert" when the measurement data has a value above the uppermost limit value or a value below the lowermost limit value, management reference value to indicate the uppermost limit value and the lowermost limit value as reference setting data for each sensor, etc.

The state window indicates basic data acquisition information on a field selected from the data list. In the state window, name of a field in which data is currently being acquired or a filed selected by a manager among fields registered in the field information database 330, identification information of the data acquisition apparatus installed at the field, and various data related to the data acquisition apparatus, for example, the kind of a power supply, state of the power supply, field temperature, current time, communication state, measurement period, measurement time, reception time, etc., are indicated.

The control window adjusts a mode of communication with the data acquisition apparatus and a measurement mode and shows a folder list from which a folder can be selected by the manager.

In the control window, the communication mode serves to specify a system for data communication with the data acquisition apparatus 200. The CDMA system is used when the data acquisition apparatus is installed at a remote field and the RS-242 system is used when the data acquisition apparatus is directly connected to the manager computer by a wire. That is, the field management apparatus 300 of the present invention can perform data communication with the data acquisition apparatus 200 over a wired or wireless network.

The measurement mode is divided into an automatic mode where the measurement is periodically performed and a manual mode where the measurement is non-periodically performed. In the case of the automatic mode, measurement data is acquired at predetermined automatic measurement periods for all registered fields. In the case of the manual mode, the measurement data is acquired by manually performing all works including CDMA connection.

For example, if the manager wishes to have only information on a desired inclined plane, the measurement may be performed through the manual mode. In the automatic mode, the data acquisition is automatically performed in the absence of the manager, and if a problem occurs, the manager can be warned by a text message through the message output unit 363.

The information window indicates CDMA communication mode control, current state, work processes, etc., as information with which the manager can easily determine a situation.

The instruction set includes instructions for data communication and data acquisition and management. In the case of the manual mode, the manager can acquire, manage and analyze data randomly.

The instruction set for data acquisition and management is generally divided into an instruction set 1 and an instruction set 1.

The instruction set 1 includes instructions related to the data communication and the data acquisition and the management as follows.

CDMA connection, which is a function for the manual mode, is used for connection with the data acquisition apparatus. Folder list request is a function for request of lists and list data stored in the data acquisition apparatus. Data request is a function for data reception of a list selected from the folder list. The received data is indicated on the data list window shown in Fig. 7 and is stored in the measurement database.

Position information setting is a portion in which position information of the data acquisition apparatus distributed at the remote location is inputted. The inputted position information includes names of regions in which the data acquisition apparatuses are installed, names of the registered fields, automatic mode selection during the measurement period, identification information of the data acquisition apparatuses, telephone numbers of CDMA terminals connected to the data acquisition apparatuses, storage paths of ground data acquired from the data acquisition apparatuses, measurement and transmission periods of the data acquisition apparatuses, etc. The inputted position information is stored in the field information database. The stored position information is used when the field management apparatuses are connected to the data acquisition apparatuses or the measurement data measured from the sensors is stored in the automatic or manual mode.

On the other hand, the instruction set 2 is classified into sub functions including region folder list request, recent data request, analysis 1, analysis 2, channel setting, real time graph, etc. The channel setting serves to set numbers as the unique information for the sensors currently installed at the inclined plane. The inputted unique information of the sensors is stored in the field information database 330. The analysis 1 and the analysis 2, which are used for performing an analysis using the inclined plane behavior data stored in the measurement database 340, display data stored in the measurement database in a graphical form and outputs uppermost/lowermost limit ranges, physical state of the inclined plane, and actual position of the sensors, in a photographical form, as shown in Fig. 8. In the graph, a horizontal axis is a time axis and a vertical axis is an actual displacement. As shown in Fig. 8, a reference line (indicated at a value of -10, which is the lowermost limit value, in the figure) to indicate the uppermost/lowermost limit values for the sensors. Accordingly, the manager who manages the field management apparatus is able to qualitatively analyze the sensors using a history curve of time vs. displacement indicated in the graph.

An angle sensor indicates two X and Y axes on the graph simultaneously. More specifically, the output driving controlling unit extracts coordinate values for the gradient measurement data of the sensors using the data table in which the coordinate values corresponding to the gradient measurement data stored in the memory are stored, and outputs the extracted coordinate values in the graphical form, as shown in Fig. 8.

On the other hand, measurement position/recent measurement date/ground data/current progress rate/result of investigation about safety/maximum value measurement date/ maximum measurement value/maximum progress rate/management reference value are indicated in the information window under the graph.

The measurement position indicates the installation position of the sensors, which can be confirmed in the photographical information window. The current progress rate indicates a relative difference value with respect to an initial value by percentage, together with 'tension rate' in the case of increase in a positive (+) direction and 'compression rate' in the case of decrease in a negative (-) direction. The maximum progress rate is indicated for values giving the maximum alteration in a manner similar to the current progress rate.

The result of investigation about safety serves to output the behavior state of the inclined plane based on the result of analysis by the data analyzing unit. Here, if the current ground data indicated in the graph exceeds a range of a reference set value stored in the field information database, abnormality is indicated. Otherwise, normalcy is indicated. However, in this embodiment, the result of investigation about safety may be output in various ways, including abnormality, normalcy, emergency, etc., based on the analysis result.

Accordingly, the system for monitoring displacement of the inclined plane in accordance with the present invention stores the behavior data of the measurement devices transmitted from the plurality of data acquisition apparatuses at the remote location through the field management apparatus and analyzes the behavior state of the inclined plane using the stored behavior data. Based on the analysis result, by outputting different alert sounds depending on variation of the behavior state, outputting letters to a display, or transmitting the behavior state of the inclined plane to the manager according to circumstances, the manager can more promptly cope with the behavior state of the inclined plane.

On the other hand, additionally, the field management apparatus 300 may include an image database 380, and hence, the controller 350 of the field management apparatus further includes an image data calculating unit 355.

The image database 380 stores 3-dimensional mesh data for the inclined plane to be monitored and the positions of the measurement devices installed on the inclined plane. In this embodiment, information on the inclined plane and the positions of measurement devices are stored as the 3-dimensional mesh data using a 3-dimensional laser scanning technique. Here, zones affected by the displacement of the measurement devices in the inclined plane are set on a geotechnological basis, and a fracture mode of the inclined plane, such as circular arc, plane, wedge, translation and other data, is set and stored for each inclined plane.

In this embodiment, the 3-dimensional laser scanning technique is known in the art, and therefore, the detailed explanation thereof will be omitted.

On the other hand, the image data calculating unit 355 calculates unit vectors between the measurement devices using the mesh data of the measurement devices stored in the image database 380 and calculates spatial coordinates of the measurement devices according to variation of the measurement data using the calculated unit vectors and the displacement and gradient measurement data of the measurement devices stored in the measurement database 340.

In this embodiment, the image data calculating unit 355 calculates the unit vectors between initially mutually connected measurement devices. Then, the image data calculating unit 355 recalculates the unit vectors between the mutually connected measurement devices using the displacement measurement data of the measurement devices stored in the measurement database 340. Then, the image data calculating unit 355 calculates the amount of displacement of the measurement devices moved from their initial positions using the displacement and gradient measurement data measured by the measurement devices. The spatial coordinates of the measurement devices are calculated through vector products of the calculated amount of displacement of the measurement devices and the unit vectors of the measurement devices.

On the other hand, the output driving controlling unit 354 outputs a 3-dimensional graphic for the inclined plane using the spatial coordinates calculated through the image data calculating unit 355. For example, when a spatial coordinate of a measurement device is changed from (x, y, z) to (x′, y′ z′) according to variation of the displacement and gradient, the output driving controlling unit 354 transforms space coordinates of the 3-dimensional mesh data of zones affected by the displacement of the measurement devices by amounts of x′−x, y′−y, and z′−z.

With the above configuration, the system for monitoring displacement of the inclined plane in accordance with the present invention outputs 3-dimensional images of the inclined plane and the measurement devices installed on the inclined plane, and accordingly, the manager can monitor the behavior state of the inclined plane more realistically.

Particularly, as the 3-dimensional images of the inclined plane stored in the image database are updated according to the behavior of the inclined plane, the manager can more promptly cope with the behavior state of the inclined plane.

Additionally, the controller 350 of the field management apparatus may include the state analyzing unit 356. The state analyzing unit 356 analyzes the kind of the behavior state depending on whether displacement values calculated from the space coordinates of the measurement device calculated through the image data calculating unit 355 are equal to values of previous displacement measurement data of the measurement devices stored in the measurement database 340.

For example, if the displacement values calculated through the image data calculating unit 355 are equal to the values of previous displacement measurement data of the measurement devices stored in the measurement database 340, the state analyzing unit 356 considers the behavior state of the inclined plane to be fluctuation of the surface of the ground where only the surface of the ground is moved. Otherwise, the state analyzing unit 356 considers the behavior state of the inclined plane to be fluctuation of the underground where the underground at positions at which the measurement devices is moved in a direction measured by the gradient sensor.

With the above configuration, the field management apparatus in the system for monitoring displacement of the inclined plane in accordance with the present invention can predict the behavior state of the inclined plane, which is currently progressing, more accurately by means of the state analyzing unit. Accordingly, the manager can conveniently and promptly take follow up measures against the behavior state of the inclined plane.

Additionally, the field management apparatus 300 may include the network communication unit 390 for performing data communication with the unified management apparatus 400, which will be described later. Also, the controller 350 of the field management apparatus includes the data converting unit 357.

The network communication unit 390 transmits the behavior data of the measurement devices for each data acquisition apparatus, which is stored in the measurement database 340, and the analysis result to the unified management apparatus 400. The data converting unit 357 converts communication format of data to enable data communication with the unified management apparatus 400 through the network communication unit 390.

With the above configuration, the system for monitoring displacement of the inclined plane in accordance with the present invention converts communication formats of data transmitted from the field management apparatuses to the unified management apparatus into an equal communication format. Accordingly, the unified management apparatus can transmit the behavior state of the inclined plane in real time over the Internet network.

Additionally, the system for monitoring displacement of the inclined plane in accordance with the present invention includes the unified management apparatus 400 for unitedly managing the plurality of field management apparatuses 300 installed at the remote locations.

In this embodiment, the unified management apparatus 400 stores information on the behavior state of the inclined plane transmitted from the plurality of field management apparatuses 300 and transmits the information on the behavior state of the inclined plane to the manager computers 500 according to requests for information on the behavior state of the inclined plane, which are transmitted from the manager computer 500 through the communication network.

The unified management apparatus 400 includes an input unit 410, a network communication unit 420, a unified database 430, a unified managing unit 440, an output unit 450, and a web server 460.

The input unit 410 receives manipulation signals from the manager. For example, the input unit 410 may be a known input means such as a keyboard or a mouse, and therefore, the detailed explanation thereof will be omitted. The network communication unit 420 exchanges various data with the plurality of field management apparatuses 300 distributed at the remote locations.

The unified database 430 stores the identification information of the field management apparatuses 300 and the behavior state information of the inclined plane received through the network communication unit 420. Additionally, the unified database 430 may contain identification information and geographic information of the inclined planes to be monitored.

The unified managing unit 440 outputs the behavior state information of the inclined plane stored in the unified database 430 to a display in response to the manipulation signals inputted through the input unit 410. In addition, the unified managing unit 440 transmits the behavior state information of the inclined plane to the web server 460, which will be described, in real time, in response to requests for information on the behavior state of the inclined plane, which are transmitted from the web server 460. Additionally, the unified managing unit 440 extracts the geographic information and the behavior state information stored in the unified database 430 and outputs the extracted information to the web server 460 in response to requests for information on the behavior state of the inclined plane, which are transmitted from the web server 460.

The output unit 450 outputs the behavior state information of the inclined plane stored in the unified database 430 to a display in response to a control signal from the unified managing unit 440.

The web server 460 prepares a web page with the behavior state information inputted from the unified management unit 440 and transmits the web page to the manager computers 500 requesting the behavior state information of the inclined plane. In addition, the web server 460 transmits the requests for the behavior state of the inclined plane, which are received from the manager computer 500, to the unified managing unit 440.

With the above configuration, the system for monitoring displacement of the inclined plane in accordance with the present invention allows the manager to monitor the behavior state of the inclined plane in real time through the behavior data of the measurement devices, which are transmitted from the data acquisition apparatuses installed in the field, provided by the web server accessed over the Internet network in home or in the destination of his business trip. In addition, the manager can easily manage a plurality of inclined planes distributed at the remote locations through the unified managing unit anytime anywhere.

Industrial Applicability

As apparent from the above description, the system for monitoring displacement of inclined planes in accordance with the present invention can predict and alert collapse of the inclined planes in advance by accurately analyzing behavior state of a plurality of inclined planes by means of a plurality of measurement devices installed at remote locations.

Particularly, if it is impossible to measure variation in length between measurement piles due to large scale inclined plane collapse in regions other than a region at which measurement devices are installed or due to minute movement such as translation activity, variation in activity gradients can be measured by providing information on behavior state of inclined planes accurately measured by means of measurement device containing displacement, temperature and gradient sensors to field management apparatuses. Accordingly, collapse symptoms of the inclined planes can be more precisely analyzed and predicted and the manager can promptly cope with the collapse symptoms of the inclined planes.

In addition, according to the present invention, since more precise databases for behavior data of inclined planes can be constructed through analysis of behavior state of inclined planes by field management apparatuses, high reliability on the analysis result can be attained and the behavior data of measured inclined planes can be utilized for similar inclined planes.

In addition, by measuring gradient variation occurring in an instable region using measurement devices and transmitting the measured gradient variation to field management apparatuses at remote locations, the field management apparatuses can affectively determine collapse direction of inclined planes based on the gradient variation when abnormality is detected.

In addition, by outputting various kinds of alert sounds according to behavior state of inclined planes, the behavior state of inclined planes can be detected more rapidly. In addition, in case of emergency, by transmitting the behavior state of inclined planes by letters to a manager, he can promptly cope with the behavior state of inclined planes.

In addition, by outputting 3-dimensional images of inclined planes and sensors installed on the inclined planes, a manager can monitor the behavior state of the inclined planes more realistically. Particularly, as the 3-dimensional images of the inclined plane stored in the image database are updated and outputted according to the behavior of the inclined planes, the manager can more promptly predict and cope with the behavior state of the inclined plane based on the outputted images.

In addition, since behavior data of inclined planes transmitted from a plurality of field management apparatuses and results of analysis for the behavior data can be managed by a unified management apparatus accessible to Internet, a manager can access a web server of the unified management apparatus over the Internet in home or in the destination of his business trip and monitor the behavior state of the inclined planes stored in a measurement database and results of analysis for the behavior state in real time.

In addition, by providing ground data of sensors stored in the measurement database and results of analysis for the ground data, together with geographic information of inclined planes, to the manager, the manager can more easily monitor the behavior state of inclined planes using only positional information of the inclined planes.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

CLAIMS:

1. A system for monitoring displacement of an inclined plane, comprising:

a plurality of measurement devices mounted on a plurality of measurement piles arranged in a longitudinal direction with respect to one or more reference piles installed on the inclined plane for measuring ground data at positions at which the measurement piles are installed, in response to a measurement driving signal transmitted from the external;

a plurality of data acquisition apparatuses for processing the ground data transmitted from the plurality of measurement devices to calculate behavior data of the inclined plane at positions at which the measurement devices are installed, and transmitting the inclined plane behavior data of the measurement devices in response to requests for the inclined plane behavior data from the external; and

a field management apparatus for outputting the inclined plane behavior data transmitted from the plurality of data acquisition apparatuses installed at remote locations to a display, analyzing behavior state of the inclined plane with reference to a management reference value based on a predetermined collapse characteristic of the inclined plane, and outputting an alert signal based on a result of the analysis.

2. The system as set forth in claim 1, wherein each of the plurality of measurement devices includes:

a base member mounted on a respective one of the plurality of measurement piles fixed on the inclined plane in the longitudinal direction; and

a body rotably connected to the top portion of the base member through a lower connection member and containing a measurement unit for measuring the ground data at a position at which the measurement pile is installed, an analog to digital conversion unit for converting analog data measured by the measurement unit to digital data, and a communication unit for transmitting the ground data inputted from the analog to digital conversion unit to the external and receiving control signals for the measurement unit from the external.

3. The system as set forth in claim 2, wherein each of the plurality of measurement devices includes:

a gradient measurement unit rotably arranged at an upper portion of the body through an upper connection member for measuring gradient of the measurement pile;

a displacement measurement unit for measuring displacement of a wire connected to the measurement pile;

and

a temperature measurement unit for measuring ambient temperature.

4. The system as set forth in claim 3, wherein the lower connection member includes a rotation axis for connecting the base member to the body, a bracket formed above the base member for enclosing the rotation axis, and a managing member composed of a spring and a ball and horizontally mounted on the bracket for managing a rotating angle of the rotation axis, and

wherein the upper connection member includes a rotation axis, a bracket formed at the upper portion of the body for enclosing the rotation axis, and a managing member composed of a spring and a ball and horizontally mounted on the bracket for managing a rotating angle of the rotation axis.

5. The system as set forth in claim 3, wherein each of the plurality of data acquisition apparatuses includes:

a communication unit for exchanging data with an external device;

a measurement device interface for transmitting a measurement driving signal to the measurement devices and receiving the ground data measured by the measurement device;

a memory 230 for storing a data table for extracting measurement data corresponding to the ground data transmitted from the measurement devices, and unique information of the measurement devices; and

a controller for calculating the behavior data at positions at which the measurement devices are installed, using the ground data received through the measurement device interface, and transmitting the calculated behavior data to the field management apparatus in response to requests for the behavior data received through the communication unit.

6. The system as set forth in claim 5, wherein the controller includes:

a communication controlling unit for communicating with the measurement devices through the measurement device interface with reference to the unique information of the measurement devices contained in the measurement driving signal received through the communication unit;

a data calculating unit for extracting the measurement data corresponding to the ground data of the measurement devices received through the measurement device interface with reference to the data table and calculating the behavior data of the measurement devices using the extracted measurement data including displacement, temperature and gradient data; and

a data processing unit for outputting the behavior data outputted from the data calculating unit to the communication unit in response to requests for the behavior data from the communication unit.

7. The system as set forth in claim 5, wherein the communication unit includes:

a wireless communication unit for exchanging data with the field management apparatus over a wireless network; and

a wired communication unit for exchanging data with a manager computer over a wired network.

8. The system as set forth in claim 5, wherein each of the plurality of data acquisition apparatuses includes:

an input unit for receiving manipulation signals from a manager; and

a display for displaying the measurement data of the measurement devices calculated through the controller in response to the manipulation signals inputted by the manager through the input unit.

9. The system as set forth in claim 3, wherein the field management apparatus includes:

an input unit for receiving manipulation signals from a manager;

a communication unit for exchanging various data with the data acquisition apparatuses;

a field information database for storing unique information for the plurality of data acquisition apparatuses installed at remote locations and the plurality of measurement devices and management reference values for the behavior data at the positions at which the measurement devices are installed;

a controller for storing the behavior data of the measurement devices received through the communication unit in a measurement database, analyzing the behavior state at the positions at which the measurement devices are installed with reference to the management reference values of the measurement devices stored in the field information database, and outputting an alert driving signal based on a result of the analysis;

an alert output unit for outputting an alert signal based on the alert driving signal from the controller; and

a data output unit for outputting the behavior data and analysis result outputted from the controller to a display.

10. The system as set forth in claim 9, wherein the

controller includes:

a data processing unit for storing the behavior data of the measurement devices received through the communication unit in the measurement database;

a data analyzing unit for analyzing the behavior state at the positions at which the measurement devices are installed, based on the behavior data of the measurement devices stored in the measurement database, with reference to the management reference values of the measurement devices stored in the field information database;

an alert controlling unit for outputting the alert driving signal to the alert output unit based on a result of the analysis of the data analyzing unit; and

an output driving controlling unit for outputting the behavior data of the measurement devices stored in the measurement database and the analysis result to the data output unit, in response to manipulation signals inputted by a manager through the input unit.

11. The system as set forth in claim 10, wherein the alert output unit includes:

an alert sound output unit for generating an alert sound based on the alert driving signal outputted from the alert controlling unit; and

a screen display for outputting certain letters to a screen.

12. The system as set forth in claim 11, wherein the alert output unit further includes a message output unit for extracting information on letters stored in a memory when an alert occurs, and transmitting the extracted letter information to a manager.

13. The system as set forth in any one of claims 10 to 12, wherein the field management apparatus further includes an image database for storing 3-dimensional mesh data for the inclined plane to be monitored and the positions of the measurement devices installed on the inclined plane,

the controller further includes an image data calculating unit for calculating space coordinates of the measurement devices, based on the behavior data of the measurement devices stored in the measurement database, using the mesh data of the measurement devices stored in the image database, and

the output driving controlling unit outputs a 3-dimensional graphic for the inclined plane using the space coordinates calculated through the image data calculating unit.

14. The system as set forth in claim 13, wherein the controller further includes:

a state analyzing unit for comparing displacement values calculated from the space coordinates of the measurement devices calculated through the image data calculating unit with values of previous displacement ground data of the measurement devices stored in the measurement database, and analyzing the kind of the behavior state of the inclined plane based on a result of the comparison.

15. The system as set forth in claim 9, further comprising:

a unified management apparatus for storing information on behavior state of the inclined plane, which is transmitted from a plurality of field management apparatuses at remote locations, for each field management apparatus, and transmitting the information on the behavior state of the inclined plane to the manager computer in response to requests for the behavior state of the inclined plane, the requests being received through a communication network, and

wherein the field management apparatus further include a network communication unit for transmitting the behavior data of the measurement devices stored in the measurement database and a result of analysis for the behavior data to the unified management apparatus, based on a setting signal, and

the controller of the field management apparatus includes a data converting unit for converting communication format of data to enable data communication with the unified management apparatus through the network communication unit.

16. The system as set forth in claim 15, wherein the unified management apparatus includes:

an input unit for receiving manipulation signals from the manager;

a network communication unit for performing data communication with a plurality of field management apparatuses distributed at remote locations;

a unified database for storing identification information of the field management apparatuses and the behavior state information of the inclined plane received through the network communication unit;

a unified managing unit for outputting the behavior state information of the inclined plane stored in the unified database to a display in response to the manipulation signals inputted through the input unit, and transmitting the behavior state information of the inclined plane to a web server in real time, in response to requests for the behavior state of the inclined plane, the requests being inputted through the web server;

an output unit for outputting the behavior state information of the inclined plane stored in the unified database 430 to the display in response to a control signal from the unified managing unit; and

the web server for preparing a web page with the behavior state information inputted from the unified management unit, transmitting the web page to the manager computers requesting the behavior state information of the inclined plane, and transmitting the requests for the behavior state of the inclined plane, the request being received from the manager computers, to the unified managing unit.

17. The system as set forth in claim 16, wherein the unified database contain identification information and geographic information of the inclined planes to be monitored, and

the unified managing unit extracts the geographic information and the behavior state information stored in the unified database and outputs the extracted information to the web server in response to requests for the behavior state of the inclined plane, the requests being received through the web server.

FIG.1

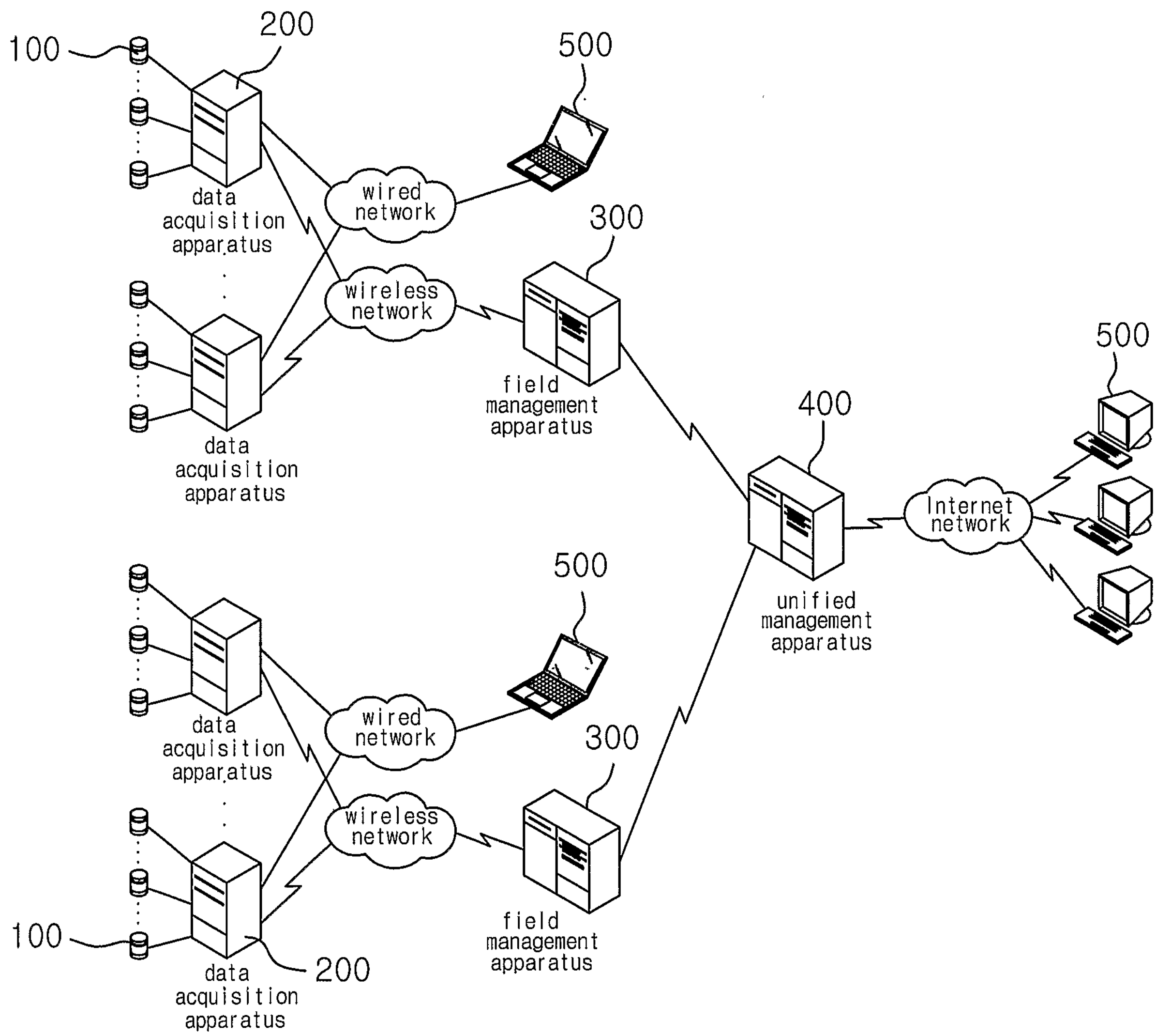

100
200
500
data acquisition apparatus
wired network
300
wireless network
data acquisition apparatus
field management apparatus
400
500
Internet network
unified management apparatus
500
data acquisition apparatus
wired network
300
wireless network
field management apparatus
100
200
data acquisition apparatus

FIG.2

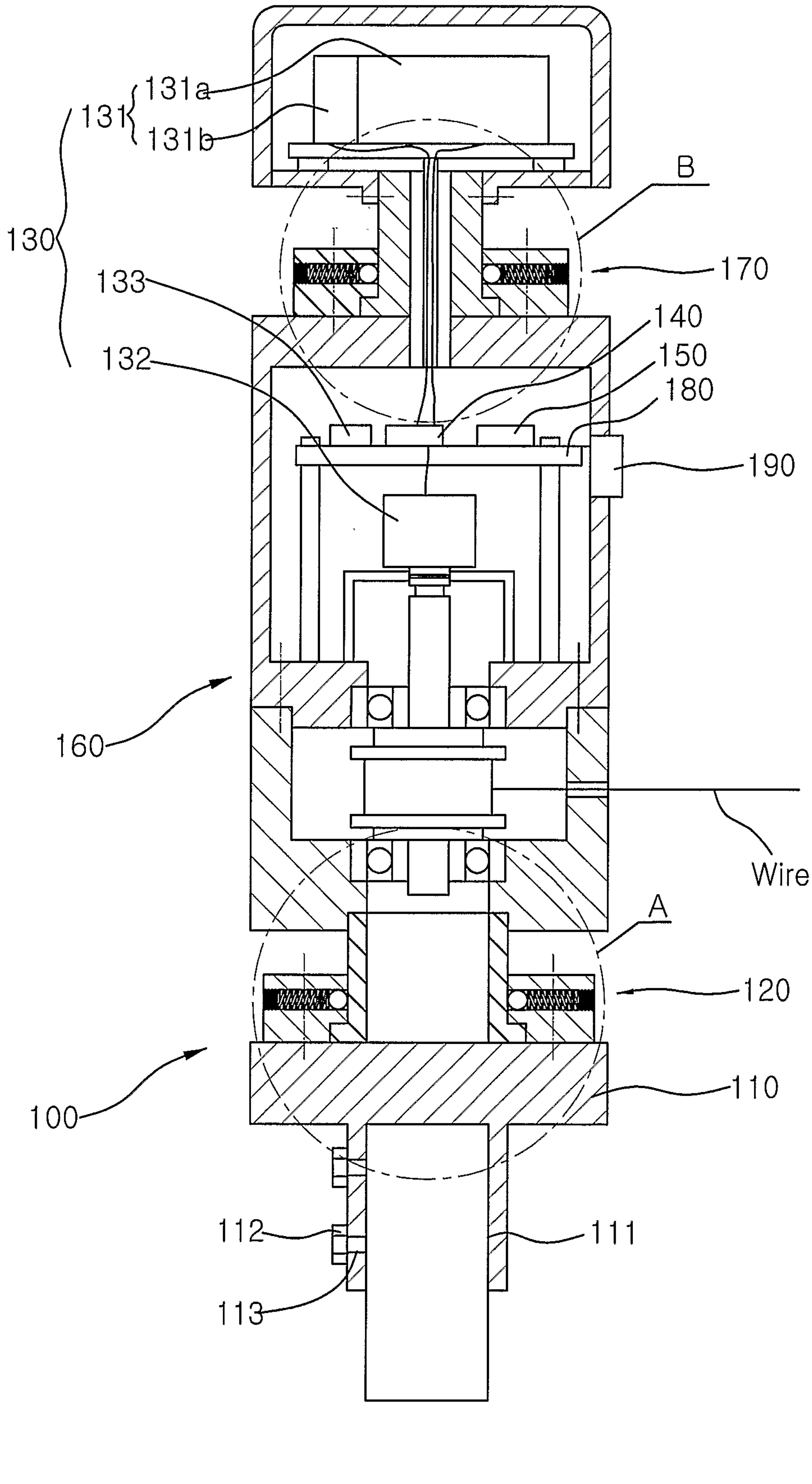

131a
131
131b
130
B
170
133
140
132
150
180
190
160
Wire
A
120
100
110
112
111
113

FIG.3

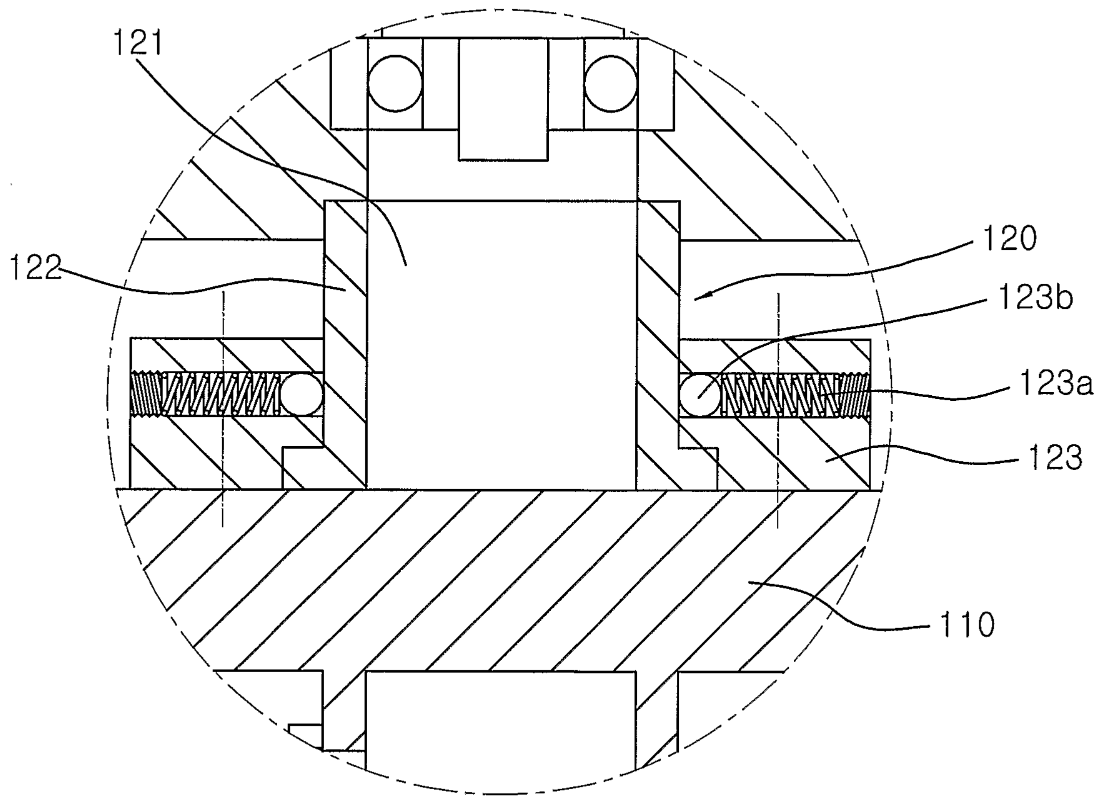


FIG.4

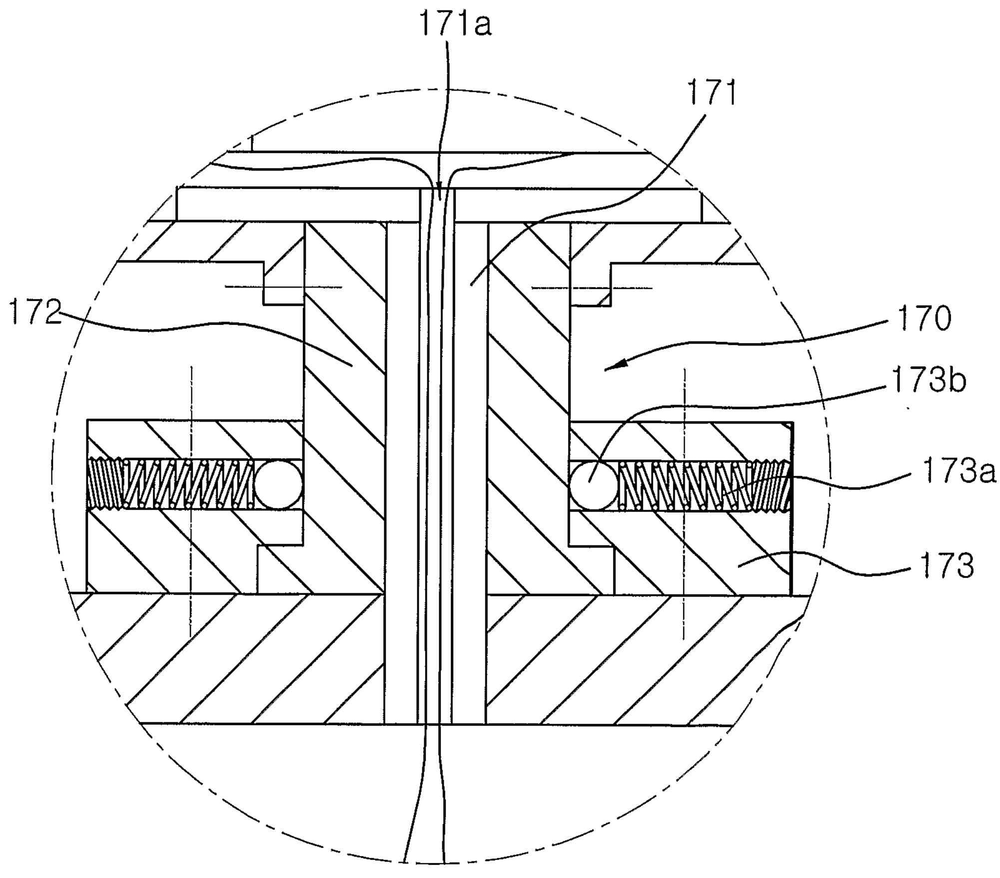


FIG.5

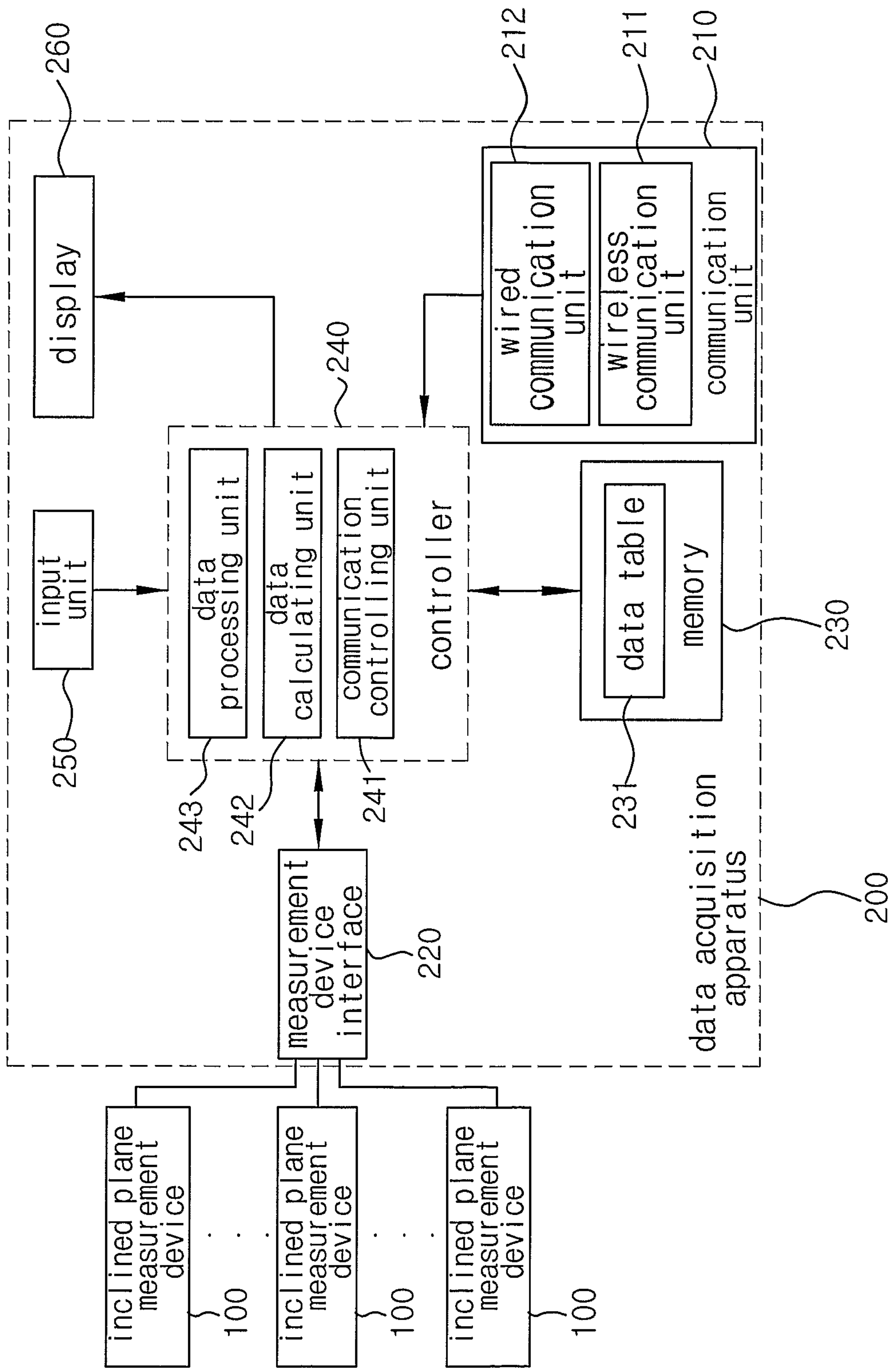

display
260
input unit
250
data processing unit
243
data calculating unit
242
communication controlling unit
241
controller
240
wired communication unit
212
wireless communication unit
211
communication unit
210
data table
231
memory
230
measurement device interface
220
data acquisition apparatus
200
inclined plane measurement device
100
inclined plane measurement device
100
inclined plane measurement device
100

FIG.6

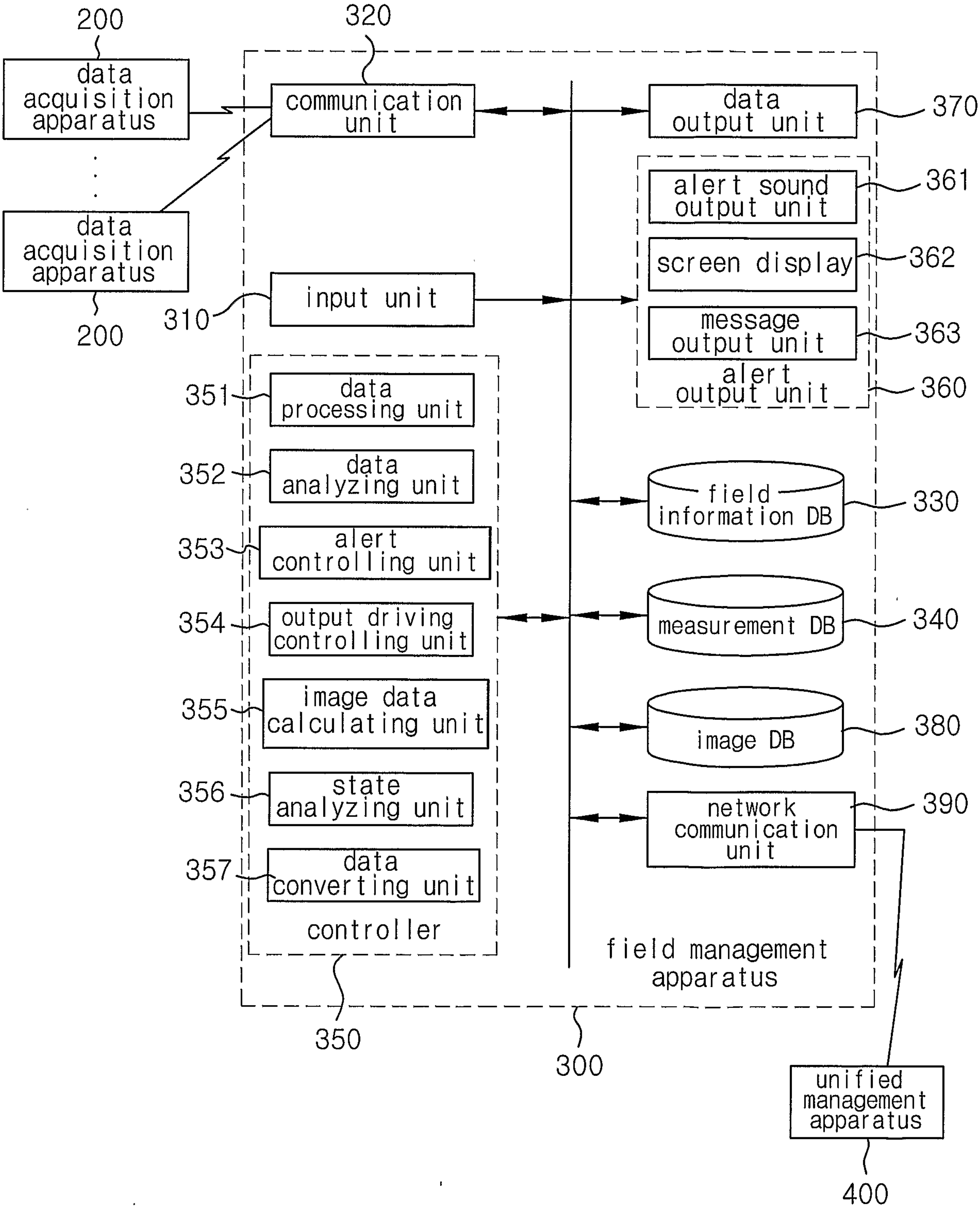

200
data acquisition apparatus
data acquisition apparatus
200
320
communication unit
310
input unit
351
data processing unit
352
data analyzing unit
353
alert controlling unit
354
output driving controlling unit
355
image data calculating unit
356
state analyzing unit
357
data converting unit
controller
350
300
field management apparatus
data output unit
370
alert sound output unit
361
screen display
362
message output unit
363
alert output unit
360
field information DB
330
measurement DB
340
image DB
380
network communication unit
390
unified management apparatus
400

FIG.7

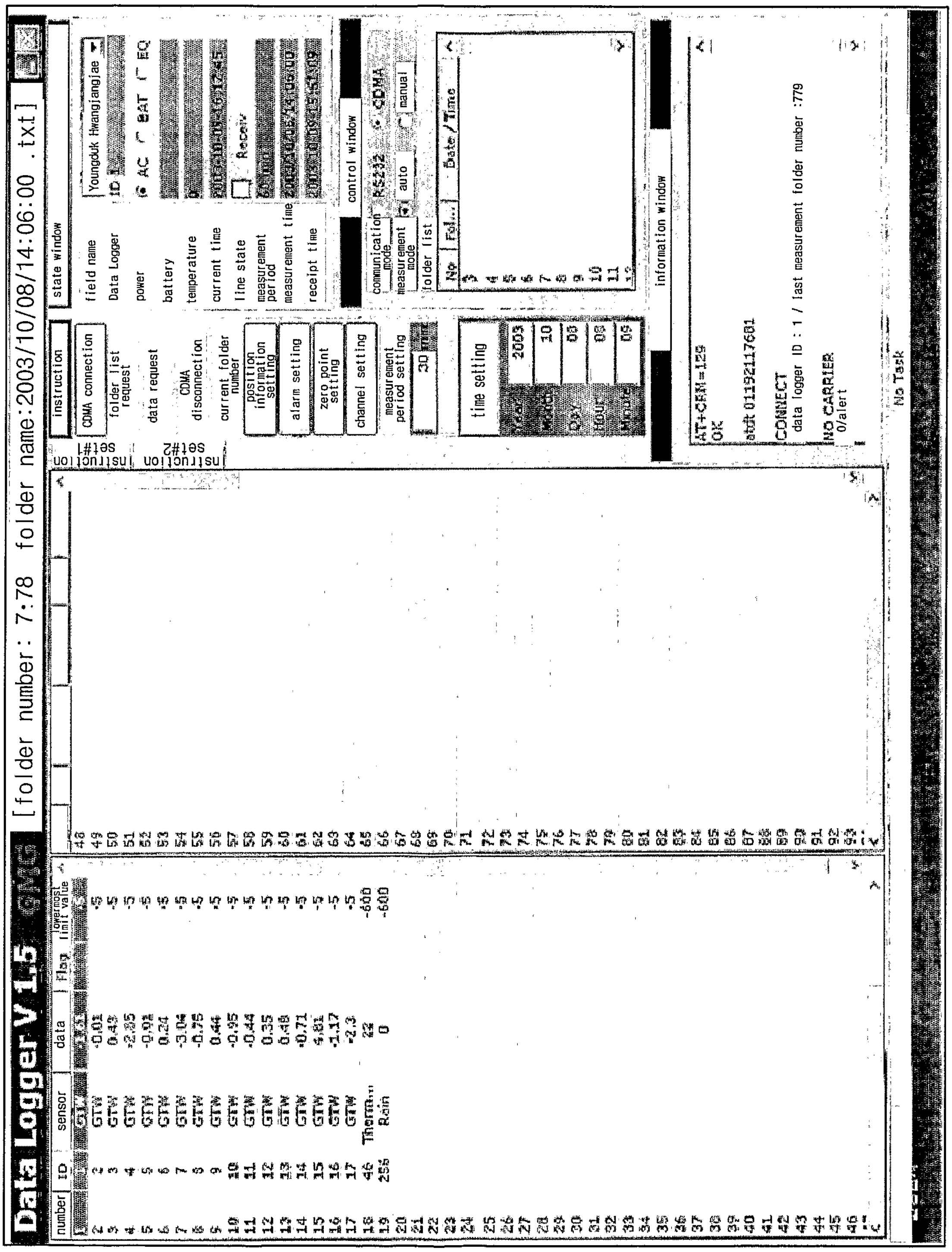

Data Logger V 1.5
[folder number: 7:78 folder name:2003/10/08/14:06:00 .txt]
instruction
state window
control window
information window
No Task

FIG.8

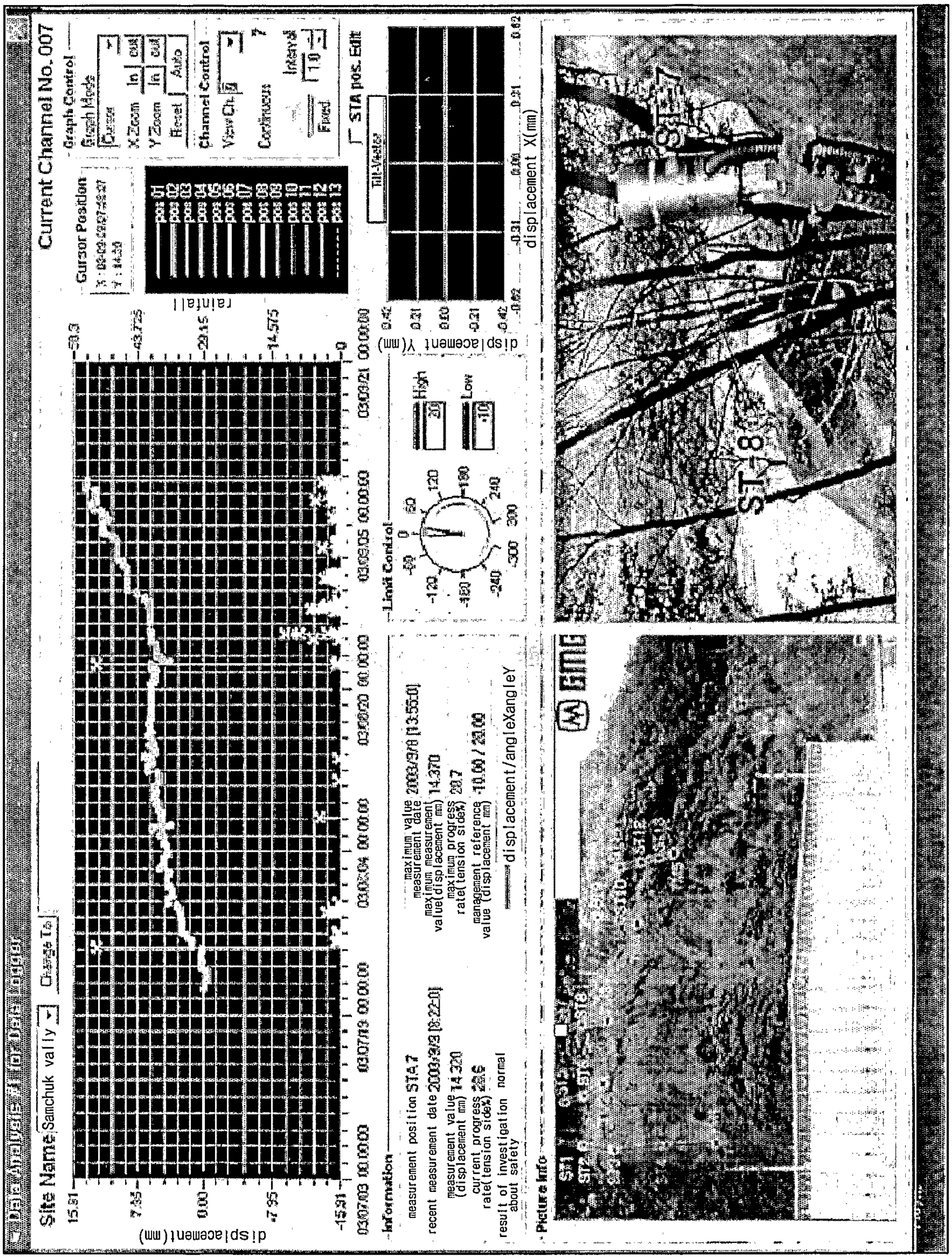
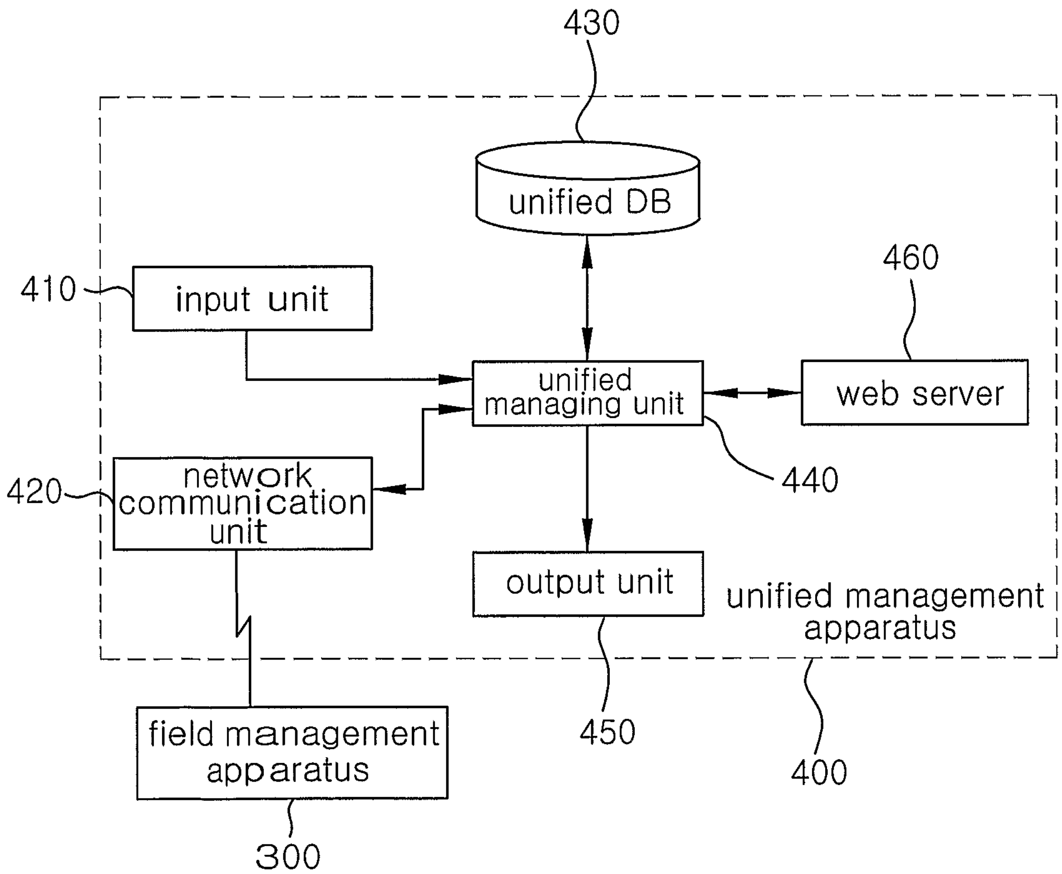

Current Channel No.007
Site Name Samchuk vally
Cursor Position
Graph Control
Channel Control
Limit Control
Information
Picture Info
displacement(mm)
rainfall
displacement X(mm)
displacement Y(mm)
STA pos. Edit

FIG.9


430
unified DB
460
410
input unit
unified managing unit
web server
440
420
network communication unit
output unit
unified management apparatus
450
400
field management apparatus
300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2004/002735

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G06F 19/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F17/60 G06F 19/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
Korean Utility models and applictions for Utility models since 1975
Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
eKIPASS "SLOPE, COLLAPSE, MEASUREMENT"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	KR 2003-27382 A (JUNG, SEUNG YONG) 7 APRIL 2003 SEE THE WHOLE DOCUMENT	1 2-19
Y	JP 8-13505 A (EAST JAPAN RAILWAY CO., et al) 16 JANUARY 1996 SEE THE WHOLE DOCUMENT	1-19
Y	KR 10-351745 B (GMG CO., LTD.) 5 SEPTEMBER 2002 SEE THE WHOLE DOCUMENT	1-19
P, X	KR 10-430026 B (GMG CO., LTD.) 4 MAY 2004 SEE THE WHOLE DOCUMENT	1-9
A	US 4962668 A (CHRISTOPHER J. PRESTON, et al) 16 OCTOBER 1990 SEE THE WHOLE DOCUMENT	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 FEBRUARY 2005 (16.02.2005)	**21 FEBRUARY 2005 (21.02.2005)**

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