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DEVELOPMENT OF THE REAL TIME TELEMONITORING SYSTEM FOR EARTHQUAKE PREDICTION DEDUCED FROM FLUCTUATIONS IN GROUNDWATER LEVELS AT YOGYAKARTA REGION-INDONESIA

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ABSTRACT

The real time telemonitoring system for earthquake prediction deduced from fluctuations in groundwater levels at Yogyakarta region-Indonesia contains the remote stations (the groundwater level transducers, signal conditioning, controller, frequency shift keying (FSK)modem, and Tx/Rx) and a base station (Tx/Rx, FSK modem, and personal computer with software). Data managements which are developed in this report are expected to be used in telemonitoring system for earthquake prediction deduced from fluctuations at Java island - Indonesia. The characteristics of data communication in this system are unguided type with air as the media, asynchronous serial mode, simplex mode transmission, with FSK modulation. The results of the communication system test at Yogyakarta region indicate that the accuracy level of the real time data measurement transmission has an average of 95 % at a distance of 0-40 km. When many fluctuations in groundwater levels occurred over specific time periods, it is possible the earthquake will be occurring in the next 4 until 50 days. It shows that the system can be used as a earthquake monitoring system based on fluctuations in groundwater levels. It can be used for earthquake prediction needs further study and development of database system.This report is expected to give valuable information for the telemonitoring system engineering development, especially for engineers who work in the field of telemonitoring system.

Keywords: *Earthquake, Prediction, Groundwater Level, Telemonitoring System.*

1. INTRODUCTION

Earthquake forecasting and prediction is a highly technical field with a rich literature and vigorous research activities in many countries. At the present time, earthquake probabilities derived from validated models are too low for precise short-term predictions of when and where big quakes will strike; consequently, no schemes for "deterministic" earthquake prediction have been qualified for operational purposes. However, the methods of probabilistic earthquake forecasting are improving in reliability and skill, and they can provide time-dependent hazard information potentially useful in reducing earthquake losses and enhancing community preparedness and resilience.A prediction is defined as a deterministic statement that a future earthquake will or will not occur in a particular geographic region, time window, and magnitude range, whereas a forecast gives a probability (greater than zero but less than one) that such an event will occur. Earthquake predictability, the degree to which the future occurrence of earthquakes can be determined from the observable behavior of earthquake systems, is poorly understood. This lack of understanding is reflected in the inability to reliably predict large earthquakes in seismically active regions on short time scales. Most proposed prediction methods rely on the concept of a diagnostic precursor; i.e., some kind of signal observable before earthquakes that indicates with high probability the location, time, and magnitude of an impending event. Precursor methods reviewed here include changes in strain rates, seismic wave speeds, and electrical conductivity; variations of radon concentrations in groundwater, soil, and air; fluctuations in groundwater levels; electromagnetic variations near and above Earth's surface; thermal anomalies; anomalous animal behavior; and seismicity patterns. The search for diagnostic precursors has

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not yet produced a successful short-term prediction scheme. [1]

This paper discusses the state of the art and the major issues in earthquake prediction deduced from fluctuations in groundwater levels at Yogyakarta region-Indonesia such as real time telemonitoring system, and secure transmission of data and design of groundwater levels transducers. This paper will conclude by discussing future challenges of the domain.

2. LITERATURE

2.1 Deterministic Earthquake Prediction deduced from Changes in Groundwater Level

A large earthquake of M7.0 occurred off-shore to the west of Fukuoka Prefecture, southwestern Japan, on 20 March, 2005. After that, more than ten aftershocks larger than M4 occurred in the submarine region. The groundwater level had been monitored since 50 days before the mainshock at an observation well with the epicentral distance of 20 km. The well revealed distinctive precursory changes in groundwater level, consisting of three stages. The first stage shows a groundwater level rise, the second stage shows a gradual decrease in groundwater level and the third stage shows a rapid rise. Similar patterns of groundwater level change were observed in associations with more than ten aftershocks of which magnitudes were larger than M4. The mechanism of the aforementioned water level changes is interpreted in terms of the dilatancy diffusion model. The total duration of the anomalous water level changes well correlates with the magnitude of the earthquake, the longer the duration, the larger the earthquake magnitude. The distinctive precursory water level changes observed in the Fukuoka area imply that it would be possible to predict the timing and magnitude of earthquakes. Earthquake prediction is a very difficult task, especially predicting the time of occurrence. The experience of the Fukuoka Earthquakes obtained in this study is considered to have been quite a rare but very useful. There must be reasons why we could detect the precursory groundwater level changes. One of the reasons is the uniformity of the underground structure with homogeneous, very shallow (20m depth) granite basement in Fukuoka area. Another possible reason is the simplicity of the stress field in the Fukuoka area, that is, almost east-west compressional stress without a vertical component. [2]

2.2 Identification of earthquake signals from groundwater level records

Coseismic signals of groundwater levels are generally obtained by subtracting the responses of atmospheric pressure, Earth tides and precipitation from the observed data. However, if the observations are conducted without nearby barometers, pluviometers or Earth tide data for correction, coseismic signals are often difficult to extract. In this case, the Hilbert–Huang transform (HHT) is used to obtain the instantaneous frequencies and amplitudes for every point of the decomposed intrinsic mode functions (IMFs) from groundwater level data for differentiating the related frequency-dependent responses without a further auxiliary input. The extracted coseismic signals show intense amplitude pulses that are clearly seen in the third IMF. In addition, two types of coseismic signals can be readily distinguished in the results from the HHT transform. One is an instantaneous short-time signal induced by the passing of seismic waves. Another coseismic signal is a sustained signal induced by the nearfield earthquake occurring near the Hualien station, Taiwan and shows a positive correlation between the earthquake distance and magnitude.[3]

2.3 Radio Communication System

Radio communication system emits an electrical signal in the form of information that serves the conversation, music, images, scientific data, and others. This signal waveform is complex and always changing, but the frequency spectrum of the signal is usually limited to a certain wide field. Radio frequency waves have a specific frequency and wavelength.An antenna of radio frequency has the same physical size to a half the wavelength or more for a reasonable efficiency. [4]

3. METHODOLOGY

3.1 The Remote Station

The remote stations were placed at remote area consisting of the Groundwater level transducers, and signal conditioning. The transducers circuit was connected to the modulator frequency shift keying (FSK) transceiver (Tx/Rx), and an antenna. The block diagram of the remote stationwas shown in Figure 1. [5]

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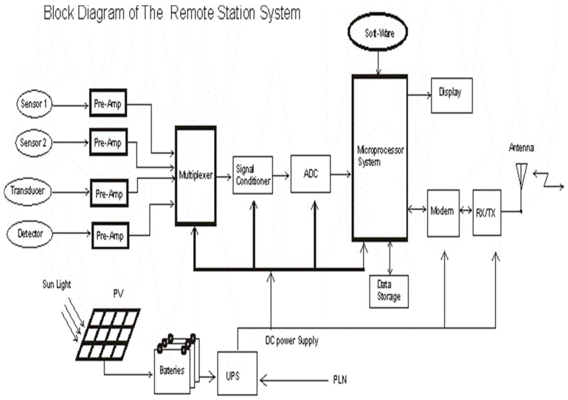

Figure1Block Diagram of Remote Station [5]

3.2 The Base Station

The base station device which is a computer-based control center was placed in Sensor and Tele-controll Laboratory. The base station consists of an antenna, Tx/Rx, FSK demodulator, a PC (personal computer) with software. The block diagram of the base station was shown in Figure 2. [5]

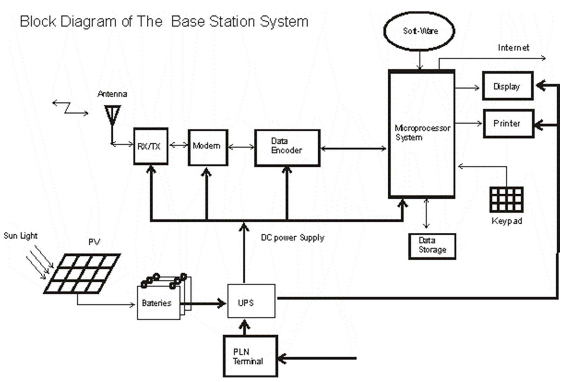

Figure 2Block Diagram of Base Station[5]

3.3 Design of Groundwater Level Sensor

Design of Groundwater level sensor was shown in Figure 3.

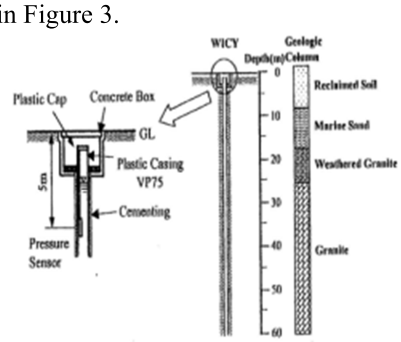

Figure 3 Design of Groundwater Level Sensor [2]

3.4 Testing and Evaluation

The stages of development are:

1) Create and instrumentation system compiled on the basis of the developed model.
2) Creating a program for the purposes of control and collection of data as well as developing a data management system.
3) Test in simulation stages to obtain the level of accuracy and speed of data access from multiple remote data sources.
4) Revise the model developed on the basis of the data obtained and re- testing the system to obtain the results as expected.
5) Reporting the results of the research is a model of the proposed system, the level of accuracy of the data and information obtained during research for development purposes.

4. RESULT AND DISCUSSION

4.1 Data Communication System Test

The characteristics of data communication system are asynchronous serial data transmission, using a transceiver device simplex transmission direction in the frequency 144.148 MHz (Amateur radio frequency band). The communication system test results indicate the accuracy level of the real time data measurement transmission reached an average of 95 % at a distance of 0-40 km.

4.2 Sensor and Data Transmission

For groundwater level sensor was used keller acculevel submersible level transmitter devices. Level transmitter submersible to 900 feet of water with RS485 and choice of 4-20mA, 5VDC, 10VDC or SDI-12 ouput.

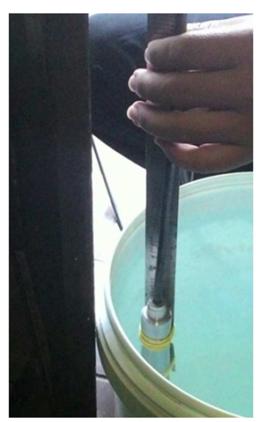

Figure 4Devices of The Accu level from Keller

The accu level from Keller is a high accuracy submersible level transmitter. In corporation all of the features of the level gage, the accu level has additional features that provide

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enhanced functionality, including dual outputs; additionally, the accu level is capable of greater accuracy than the level gage, with a standard accuracy of 0.25% FS TEB and an optional 0.1%. The accu level can be manufactured in 316l stainless steel or titanium for increased resistance to corrosion, notably from seawater.

Figure 5 Implementation of Groundwater Level Sensor

Data was sent wirelessly from remote station to the base station. The base station device which is a computer-based control center was placed in Sensor and Tele-controll Laboratory. The base station consists of an antenna, Tx/Rx, FSK demodulator, a PC (personal computer) with software.

Figure 7 Remote station of Groundwater Level Sensor

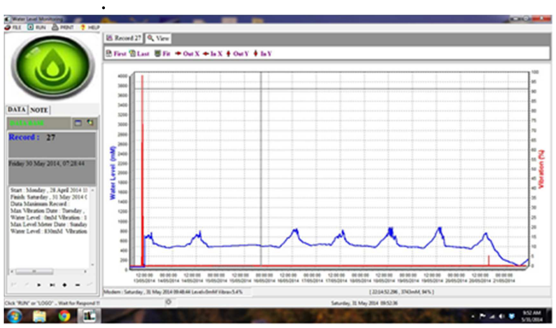

Figure 8 Software of Groundwater Level Sensor

Examples Groundwater Level Monitoring Results

- Location : 07 ° 45'59.80 "S , 110 ° 22'21.60 " E
- Range : Feb 13, - Feb 29, 2014
- Monitor the ground water level for 12 days (realtime)
- The earthquake was occurred in Tasikmalaya Java Indonesia (February 16, 2014 - Day 4)

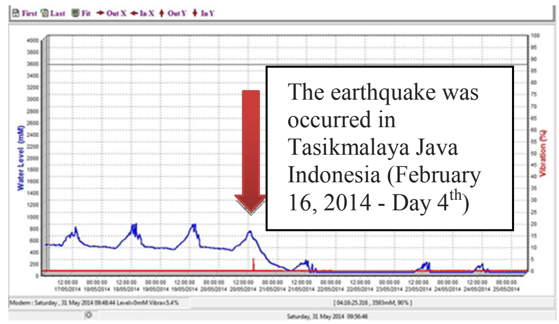

Figure 9 Fluctuations Graph in Groundwater Levels

Figure 10 Print screen of Java Indonesia Earthquake at 2014-02-16 10:50:03.4 UTC [6]

Data from GEOFON:

- F-E Region: Java, Indonesia
- Time: 2014-02-16 10:50:03.4 UTC
- Magnitude: 4.7 (mb)
- Epicenter: 106.50°E 7.80°S
- Depth: 62 km
- Status: M - manually revised

When many fluctuations in groundwater levels occurred over specific time periods, it is possible the earthquake will be occurring in the next 4 until 50 days. [2]It shows that the system can be used as a earthquake monitoring system based on fluctuations in groundwater levels. It can be used for earthquake prediction needs further study and development of database system.

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5. CONCLUSION

This research success to set up a sufficient system, which is used for real time telemonitoring system for earthquake prediction deduced from fluctuation of groundwater level in Yogyakarta-Indonesia

The real time telemonitoring system for earthquake prediction deduced from fluctuations in groundwater levels at Yogyakarta region-Indonesia contains the remote stations (the groundwater level transducers, signal conditioning, controller, frequency shift keying (FSK)modem, and Tx/Rx) and a base station (Tx/Rx, FSK modem, and personal computer with software). Data managements which are developed in this report are expected to be used in telemonitoring system for earthquake prediction deduced from fluctuations at Java island - Indonesia. The characteristics of data communication in this system are unguided type with air as the media, asynchronous serial mode, simplex mode transmission, with FSK modulation.

The results of the communication system test at Yogyakarta region indicate that the accuracy level of the real time data measurement transmission has an average of 95 % at a distance of 0-40 km. When many fluctuations in groundwater levels occurred over specific time periods, it is possible the earthquake will be occurring in the next 4 until 50 days.

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