Korean Journal of Geomatics
Vol. 4, No. 1 / November 2004
pp. 17~22

Application of Structure Maintenance and Management System Using GIS & GPS

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Abstract

It is very important to manage efficient data for safety and maintenance of those constructs. Estimation for structural safety can be evaluated by using data that surveys various structural durability and safety elements. so, it should be based on synthetic and efficient data that includes a variety of related safety elements obtained from a structure. It will subsequently be managed properly and economically. Accordingly, we will approach efficient maintenance management using a Geographic Information System (GIS) with data from structural-safety diagnosis and a Global Positioning System (GPS). In this study, we noted that by using the data that measures the factors (crack, incline, settlement etc.) of various structures as evaluate safety degree. And the horizontal coordinate variation/time of structure was monitored using the GPS easily.

Keywords : *GIS, Maintenance and Management, Structural-Safety Diagnosis, GPS*

1. Introduction

An assortment of up-to-date equipment including computers, the rapid development of GIS, and application fields have been used for traffic, disasters, urban planning, landscaping and surveying. They have been used for researching management and assessing damage which has been caused by disasters such as forest fires and typhoons (Jo et al., 2001).

Accordingly, it is time for a rapid approach to user demand for data management and application and the results of structural-safety diagnosis for structures and civil construction.

This research attempt began by applying a GIS to structures to make the process of building more efficient and enhance economic management practices.

There has been research about the use of geographic information systems in major accident risk assessment and management (Sergio et al., 2000), photogrammetry, and geographic information systems for the quick assessment, documentation, and analysis of earthquakes (O et al., 2001), on the other hand, there have also been impediments to using GIS for real-time disaster direction support.

Also, research has been done on the application of mobile GIS solutions for utility management, the application of mobile GIS for structural-safety and management (Yoo et al., 2003), and on the sharing of disaster information using web GIS technology (Kim et al., 2003).

Therefore, in this study, we will look at an efficient maintenance and management method by using GIS with data from structural-safety diagnosis.

2. Purpose of Maintenance and Management System

The purpose of a maintenance and management system can be summarized in three points.

Monitoring and surveying minute displacements and deficiencies of a structure may prevent damage before an accident happens or minimize damage.

The collapse of a high-rise structure brings about not only a loss of human life, but also immeasurable

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The manuscript for this paper was submitted for review on July 19, 2004 / accepted on September 20, 2004

direct and indirect damage to society.

Subsequently, monitor safety and counter measures that are not only structurally-related, but also infra-structurally-related by a maintenance and management system intend to minimize the damage to human life and society.

Secondly, the data from a maintenance and management system of a structure can be utilized in the design and maintenance of the structure.

Since structures are higher and larger than one another, according to the construct and type of structure, the effects of earthquake resistance and wind velocity design are different.

Thirdly, maintenance system will stimulate solutions to minute displacements and deficiencies in the structure, which could cause fatal damage, before an accident may happen.

3. Application of Data for Evaluation of Safety Structure

In this study, a structural-safety diagnosis for structures and civil constructs of Tong myong college was performed in Busan in May, 1996.

The data characteristics that were measured were carck, leakage water, settlement, incline, neutral test of concrete etc.

This measured data was applied to Arc View, which is a GIS Tool, Map Objects, a development language, and Micro Soft Visual Basic, an objects-oriented language.

3.1 Application of Structure Coordinate Variation Using DGPS

Differential GPS (DGPS) is a positioning method using existing coordinates of control points to minimize errors maximally. It obtains correction values from each satellite by surveying the satellite with a GPS receiver from a base transceiver station at control points, and it improves the positioning error of GPS receivers in moving stations with correction values.

In this study, the structures that construe GIS were small scale comparatively, so the coordinate variation (X direction, Y direction, Z direction) wasn't monitored using GPS.

Accordingly, we monitored the coordinate variation of structures of a larger scale. A high-rise structure was surveyed by DGPS mode in Busan, Metro city in Korea.

The acquired data with GPS is WGS-84 coordinates, with which we did not consider the measurement error the data was coordinate variation that includes measurement error of GPS.

3.2 Graphic and Attribute Data of Structures

In this study, the base map used a digital map of 1:1,000 to acquire graphic data through coverage of each structure. Accordingly, the data of use, areas, and floors etc. were inputted; we can see, based on the attribute data of each structure, the result in Fig. 1.

3.3 Crack Analysis of Structure

In this study, the cracks data for the structures were measured with a crack gauge with the naked eye. An aspect of cracks were measured to a crack width range of 0.04mm ~ 0.8mm and a crack length range of 20cm ~ 300cm.

The applicative method of data, as in Fig. 2, with the applied graphic and attribute data were generated by coverage of the width and length of the cracks. The width, length, horizontal slope, and vertical slope of the cracks were inputted in the attribute data, so we can easily view the aspect of the cracks. As the image file shows, like a picture, attached about the concerned crack, we could analyze the crack process of the structures.

Analysis for cracks located in interior of the

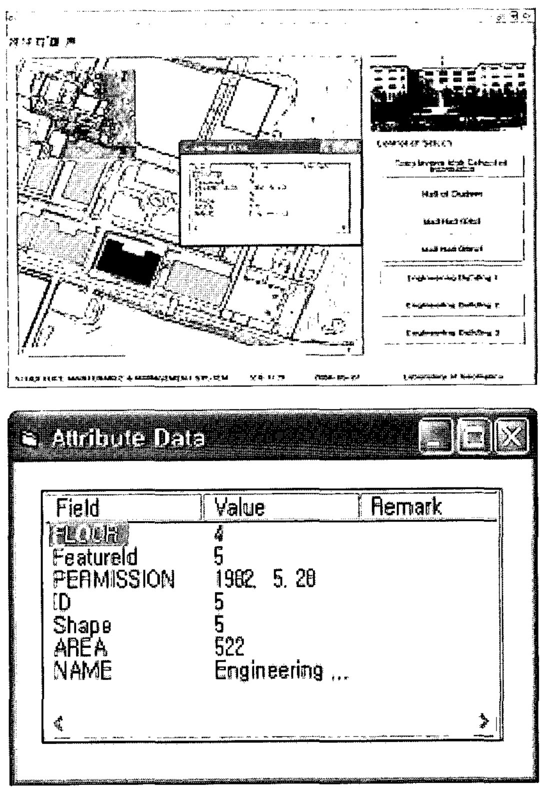

Fig. 1. Attribute of each structure.

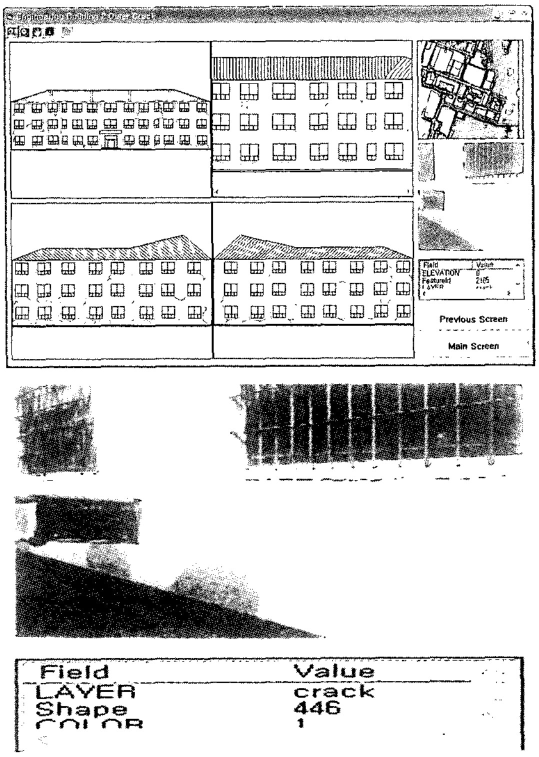

Fig. 2. Analysis of outer cracks for structure.

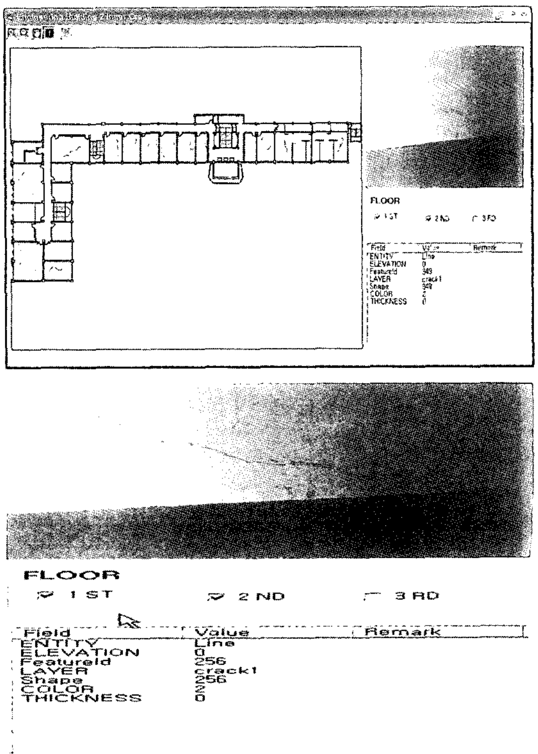

Fig. 3. Analysis of inner cracks for structure.

structures, as in Fig. 3, using data which was measured by each floor. This data was obtained by using Arc

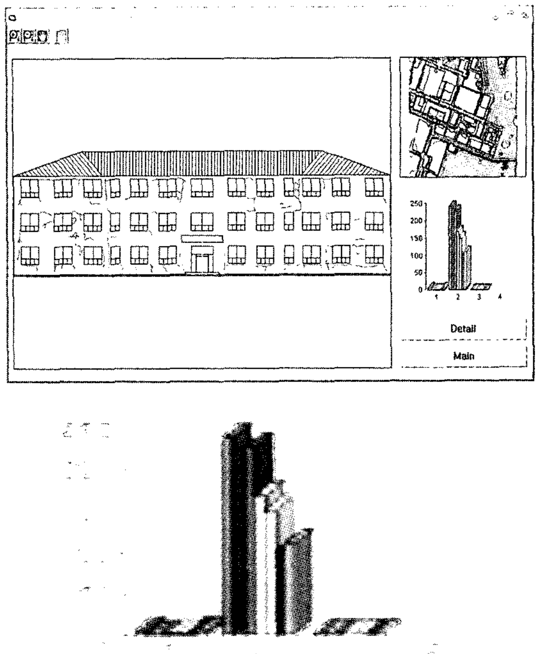

Fig. 4. Aspect of cracks for structure.

View, a GIS tool, to generate space and attribute information by each floor. We could ascertain the areas that needed reinforcement without difficulty and discern the fragility for the structures by reiterating the cracks and aspect of each floor. Also, as Fig. 4 shows, we could easily observe the crack effect structure by a graphic chart, which can be analyzed to classify the width, length, and direction of each crack.

3.4 Incline & Settlement of Structure

Application of data for incline of structure, like the Fig. 5, measuring incline of spot for each structure. Therefore, we can easily analyze it as in the present graph. With this method, we can analyze the present state of the settlement or incline of structure without difficulty like the Fig. 6. Moreover, we could analyze the structures' serious damage specific state in the present for each structure for the degree of settlement and incline.

3.5 Analysis of Safety Degree for Structure

Finally, by using the data that measures the factors of various structures, as in Fig. 7, as evaluate safety degree for each structure, we know that management for structure is efficiently and systematically.

3.6 Application of Coordinate Variation/Time for Structure Using DGPS

This data was applied to a structure displacement

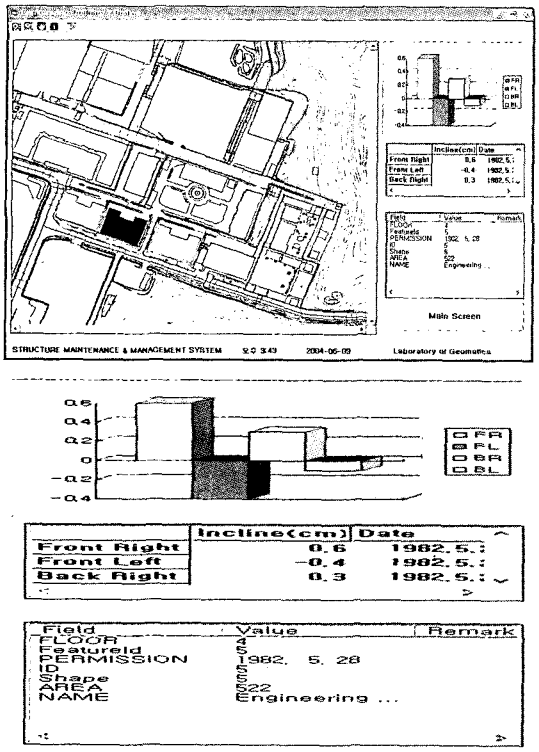

Fig. 5. Analysis of incline for structure.

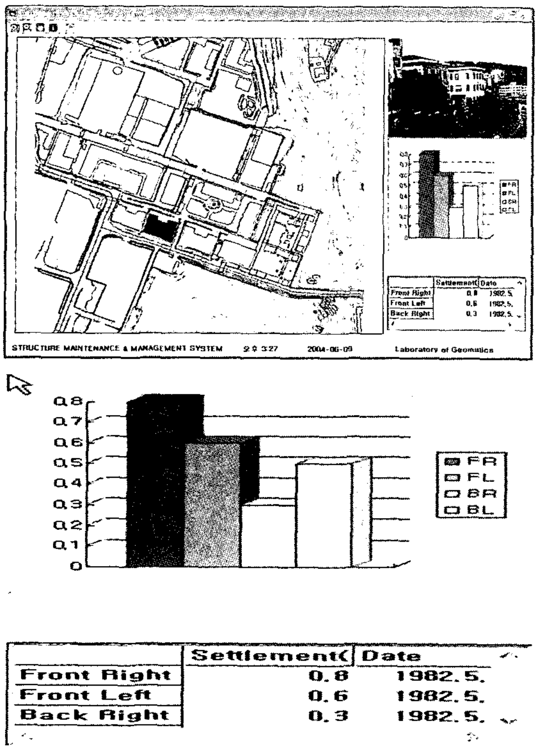

Fig. 6. Analysis of settlement for structure.

system that was developed at the laboratory of Geomatics in Pukyong National University.

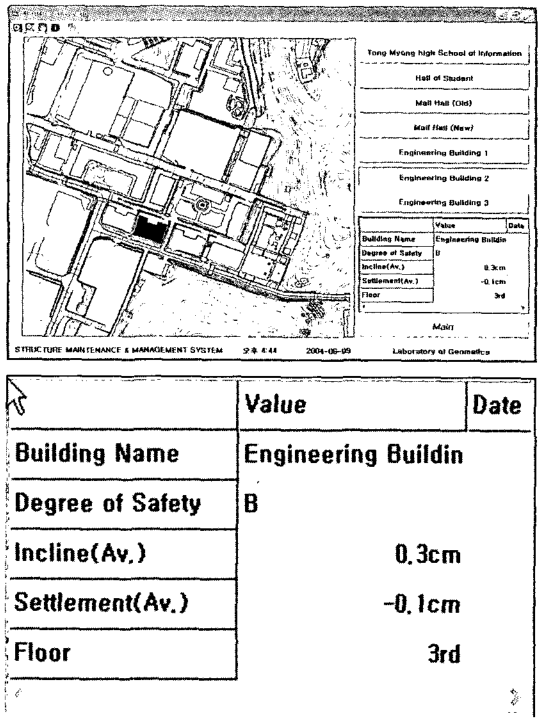

Fig. 7. Example of safety degree.

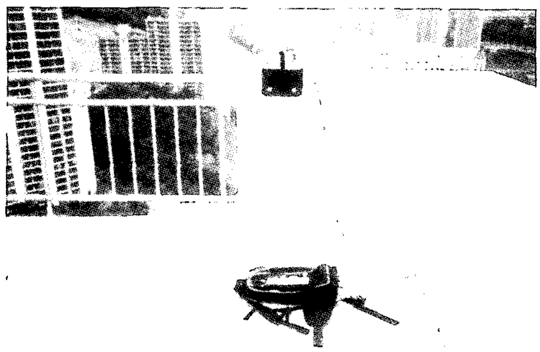

Fig. 8. Measurement of structure by DGPS.

3.7 Specification of Observation

The specification of these devices is shown in Table 1. The receiver is a JAVAD product, which can receive a carrier with 20 channels. A Legant antenna was used

Table 1. Specification of observation.

Specification	GPS	
Corporation	TOPCON	
Model	Legacy	
Accuracy	For Dual Frequency Measurment	H : 3mm±1ppm
		V : 5mm±1ppm
Measurement Mode	Static / Rapid Static / Real Time Kinematic / DGPS	
Software	Pinnacle	

as an antenna. The data processing software s Pinnacle of the TOPCON corporation.

3.8 Measurement Result for a Large Scale of Structure

In this study, the data for a structure of large scale was acquired with DGPS mode, and we measured 4 spots (A, B, C, D) of the structure like Fig. 9.

The acquired data was about 3600 with receiver (1 spot), the data is in Table 2, the horizontal average coordinate variation/time of X direction and Y direction is presented in Fig. 10 and Fig. 11.

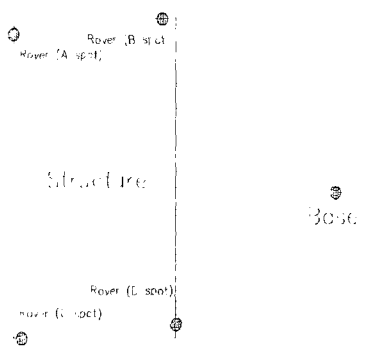

Fig. 9. Measurement spots of structure.

Table 2. Measurement result of coordinate variation/ time for structure.

Time (sec)	Measurement Value (average)		Time (sec)	Measurement Value (average)	
	X direction (mm)	Y direction (mm)		X direction (mm)	Y direction (mm)
1	2.447	-1.393	1800	4.788	-3.019
100	4.714	-6.436	1900	5.130	-2.416
200	-3.109	0.995	2000	-1.334	0.099
300	3.561	-4.534	2100	-3.173	6.570
400	0.506	-0.494	2200	-7.004	7.368
500	-1.917	2.620	2300	0.099	0.003
600	1.057	-0.090	2400	10.495	-2.589
700	5.791	-6.359	2500	-0.240	-1.910
800	-1.205	1.488	2600	-17.331	23.955
900	-1.833	-5.533	2700	-7.739	21.813
1000	-1.898	11.179	2800	-2.045	0.854
1100	-0.379	-4.288	2900	5.994	-8.761
1200	2.418	0.238	3000	-2.144	4.831
1300	0.097	0.371	3100	4.679	-1.250
1400	-7.381	13.130	3200	1.256	0.700
1500	-1.016	1.141	3300	13.148	-8.475
1600	-7.918	9.145	3400	-7.236	1.740
1700	1.157	0.334	3500	2.552	1.287

4. Development of Structure Displacement Management System

4.1 Structure Displacement Management System

We developed a structure displacement system by a type of button image handler using delphi which is an object-oriented pascal language.

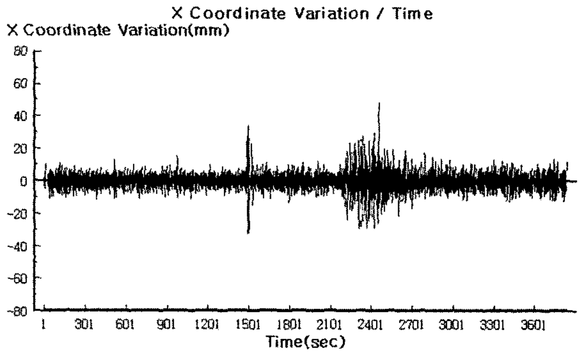

Fig. 10. Coordinate variation/time of X direction.

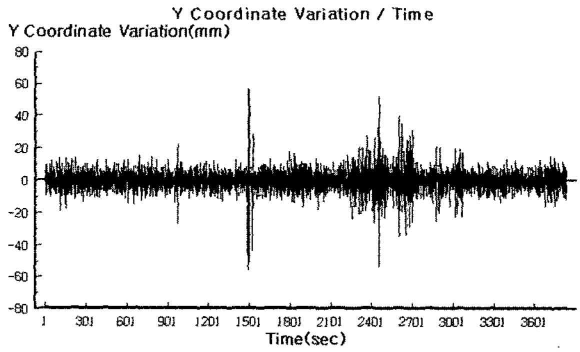

Fig. 11. Coordinate variation/time of Y direction.

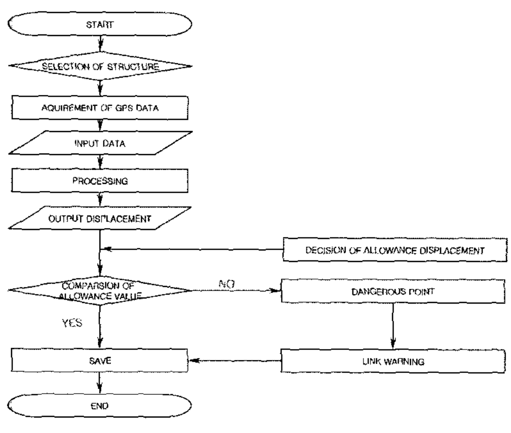

Fig. 12. Flow chart of program.

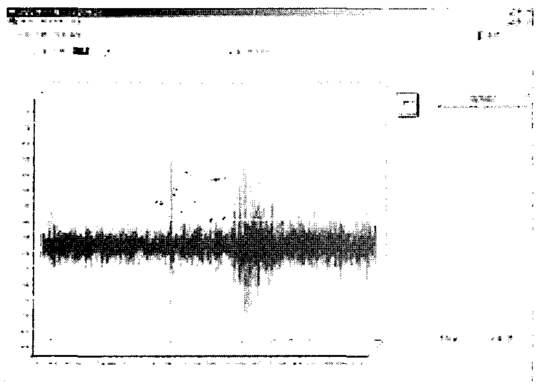

Fig. 13. Coordinate variation/time of X direction using program.

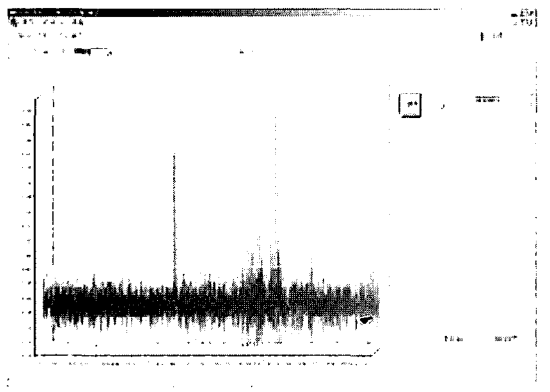

Fig. 14. Coordinate variation/time of Y direction using program.

Firstly, the acquired data with GPS is classified by X and Y coordinates, and is a handled image of each button with classified data. If the displacement reaches a dangerous point, this system will respond with a warning sound and begin counting automatically. The flow chart is shown in Fig. 12.

4.2 Application of DGPS Data

As for the results of the measurement of the object structure, the range for the upper and lower limitation of danger coordinate variation/time was set up discretionally. This result value, as in Fig. 13, Fig. 14, was extracted by the developmental structure coordinate variation/time system automatically. The acquired data was shorter than the measurement system since we could know that this structure coordinate variation/time system was both economical and reasonable.

5. Conclusion

In this study, by using a GIS from structural-safety diagnosis, we could draw our subsequent conclusion that by using the data that measures the factors (crack, incline, settlement etc.) of various structures as evaluate safety degree. And the horizontal coordinate variation/time of structure was monitored using the GPS easily. We noted that construct a 'Structure Maintenance and Management System' using GIS and GPS with data from structural-safety diagnosis and safety both efficiently and systematically.

Moreover, as the maintenance and management of structures using a photogrammetric survey method is composed, it will manage accurate and real time data.

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