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Paper No. 1604. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

DEVELOPMENT OF THE GUI ON THE VIBRATION ENVIRONMENT IN HIGASHIYAMA CAMPUS OF NAGOYA UNIVERSITY

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ABSTRACT

In this paper, the the Geographic Information System (GIS) for the vibration environment by means of the OODB on the EWS is discussed. This system integrates the data of boring logs, the data of PS loggings, the data of 158 buildings, and the data of 89 precise instruments which will be influenced by small vibration, the data of micro tremor records of ground, the data of the micro tremor records of the buildings, and the topographical map. This GIS also has the systems as follows: a) the system of indication and reference of data, b) the system of estimation of the dynamic behavior of soil and structures, and c) the wave analysis system. In addition, this will be useful for the analysis of the vibration environment by means of the addition of the structural data of the buildings and the dynamic analysis methods. Furthermore, this system is easily applied to the assistant system for the campus planning when the data of lifeline, dangerous objects etc. are added.

KEYWORDS

GIS; Disaster Prevention; GUI; Boring logs; Micro tremor; Vibration environment; Object-oriented concept; Tcl/Tk; Campus planning.

INTRODUCTION

The neighborhood of our Higashiyama campus of Nagoya University is urbanized in recent years. Especially the subway across the campus and the motorway under the north border are planned and are about to start construction now. However, there is the high pressure scanning electron microscope 23m away from the motorway, and there are 50 precise instruments involving 18 electron microscopes. Since the vibration tolerance zone of these instruments is 0.1 - 0.5 micrometer peak to peak, the vibrational obstruction is predicted under construction and in daily use of these transport facilities. Moreover, there are large experimental facilities which generate a large vibration and staying together with those precise instruments in one campus. This circumstance makes the trouble among them. Meanwhile, the possibility of earthquake occurrence in this reigion is high. The management of the earthquake disaster has been studied after the Great Hanshin Earthquake.

As Nagoya University, like most of other Japanese universities are located in urban. Therefore, precise

measuring instruments are often located near the shaking table. These situations make the trouble of vibration environment. Because of many earthquakes, the equipments for disaster prevention are also necessary in Japan. We have to analyze the disaster prevention and the environmental problem in the wide area facilities such as a campus, a hospital, or a large factory. It is necessary to integrate, link, and study many information such as buildings, soil, instruments, and vibration oscillators to be integrated, linked, and studied. In the present circumstances, these data are stored respectively in paper and are not made good use of. For these reasons, the visual interactive system is required, whose characteristics are not only close analysis of each data but also the synthetic study of the relation among data, the good efficiency of indicating and referring data, the easy renewal of data, and the easy extension of analytical methods. This system can also manages the whole data, links relative data together, and examins the whole data comprehensively.
In this paper, the seismic and environment vibration analysis system for Higashiyama campus of Nagoya University is reported (E. Ishida et al. 1995). This system offers the integration, reference, and indication of the data as follows: the land information for the planning, the environmental vibration estimation, and the seismic capacity of existing structures. This is also made as an object oriented synthetic vibration analysis system involving both the dynamic analysis system of soil or structures and the wave analysis system for the micro tremors and the earthquake motions.

CONSTRUCTION OF SYSTEM AND DATA BESE

This system is coded considering the following conditions: a) the easy use and the easy understanding of phenomena, b) the easy extension of the system and the easy maintenance, and c) the low cost. In order to satisfy the conditions a) and b), it is efficient to use the Geographical Information System (GIS) which is applied the object-oriented concept (J. Raumbaugh et al. 1991). While, the object-oriented wave analysis system, which can deal with some waves interactively, is effective to do the many-faceted wave analysis. However, there is little GIS software which can recognize any figure on the map as an object. In addtion, it is better to utilize the GUI on an Engineering Work Station (EWS) in consideration of the unification with the wave analysis system, the easy extension of faculties, the fast processing of huge data, and the small budget. Judging from the above, the object-oriented GIS is constructed on X-Window environment (K. Matsuda. 1992). It consists of systems as follows:

a) the system of indication and reference of data
b) the system of estimation of the dynamic behavior of soil and structures
c) the system of wave analysis

These systems are coded in C language and Tcl/Tk (J. K. Ousterhout. 1994) in order to transplant this system on another EWS easily. During the codification, the object-oriented concept are considered as much as possible. Tcl/Tk is an free ware which consists of Tcl as an interpreter language and Tk as a tool kit library based on X-Window. It is easily obtained through Internet and extended into Japanese version and used on personal computers like Windows. In addition, the campus GUI system is easily constructed and works efficiently. If the data is enlarged, the GUI system have to be converted to the fast and large GUI system which consists of Xt (X-Window Toolkit). Still, the system which consists of Tcl/Tk is sufficient as an prototype of the fast and large GUI system. The object-oriented concept is realized by means of the function of 'tag' on Tk, the tag simultaneously operates some items which have the same tag and are located on canvas widget.

Outline of Database

The database is made by collecting the scattered data and by converting the drawings into numerical values, Each datum, which is the datum of buildings, the topography, the ground, the vibration sources, the precise instruments, or the measured wave motions on soil or buildings, is arranged on the computer as the file which is an one-to-one correspondence with an object (Fig.1,2). Each data file is made by the editor or the GIS interactively.

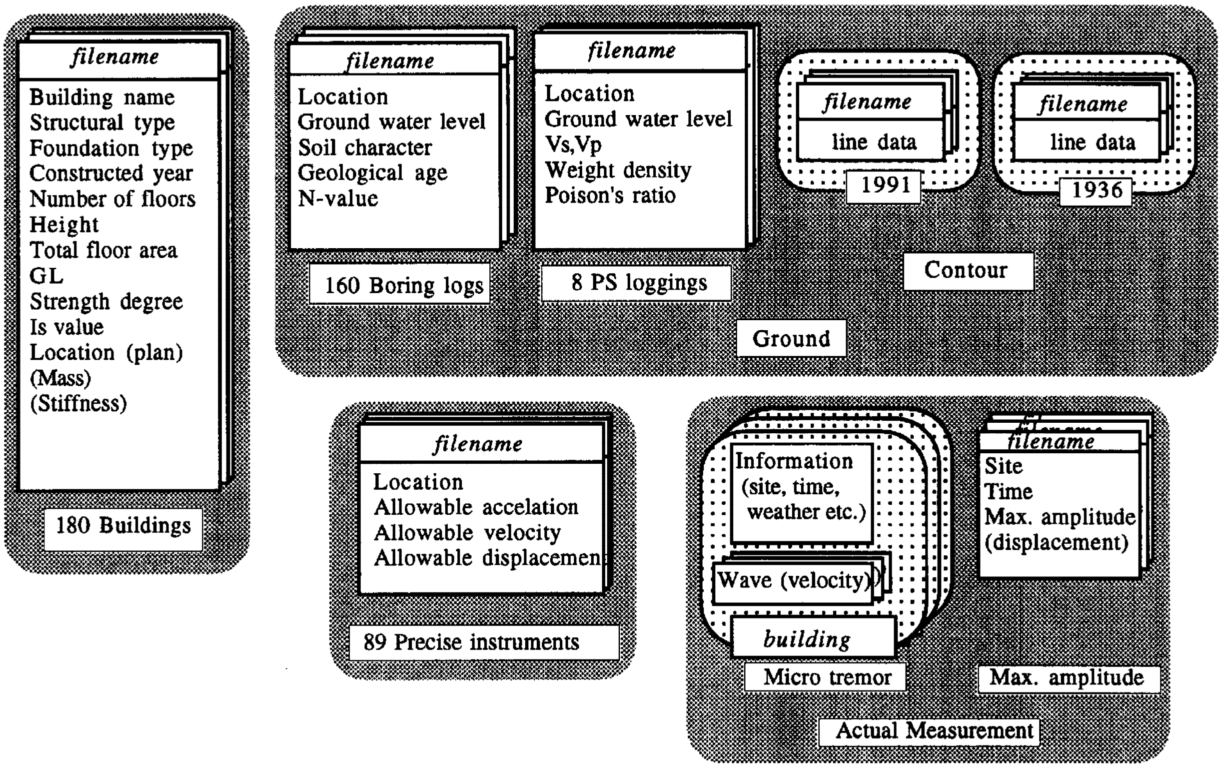
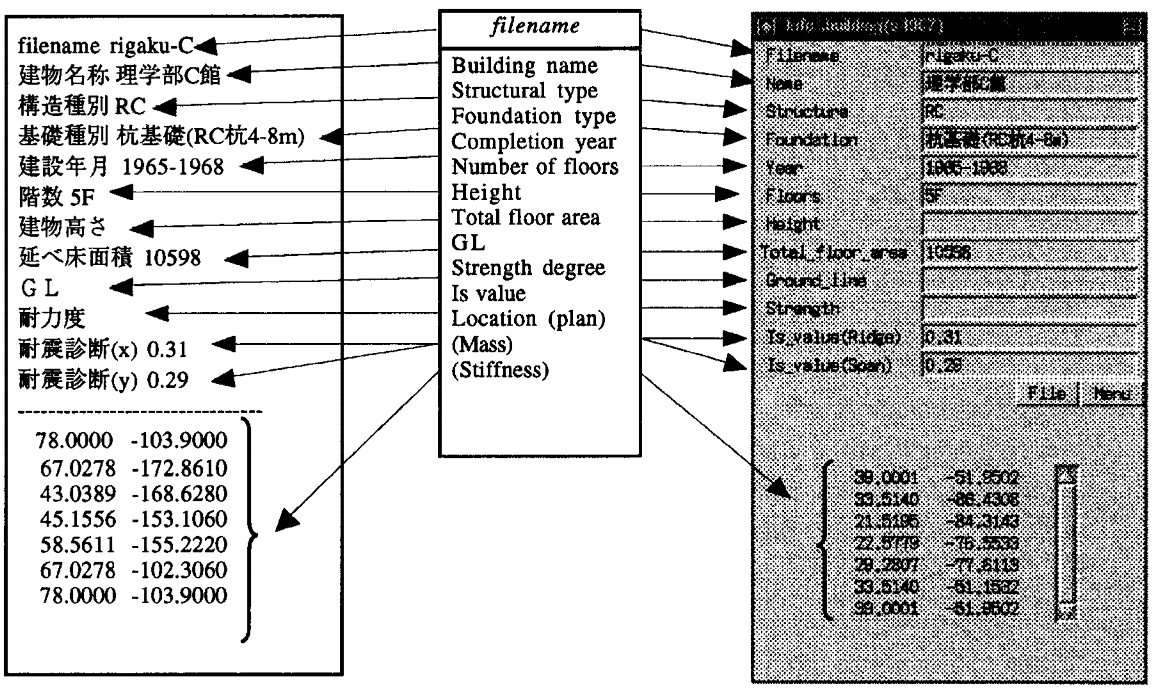


Fig.1 Files of each object data and properties of each kind of data



(a) Text file (b) Property table (c) Indication on GIS

Fig.2 Sample of the text data file and the correspodence to properties (building)

The data file of each building consists of the number of floors, the area, structural type, the existence of the underground floors, foundation type, the constructed year, and the Seismic Index of Structure (Is value) (Center Architecture leading section, Department of House, the Ministry of Construction. 1990). If necessary, other properties can be included at any time. The data files of the ground of Higashiyama campus are boring logs, PS loggings, and the altitude in 1936 (before the site preparation) and in 1991 (after the site preparation). The data file of each vibration source consists of the location of the experimental equipment for Department of Civil Engineering and Department of Architecture. The data file of each precise instrument contents of its tolerance zone and its location. the data files of actual measurement are the data of the micro tremor of 13 buildings and their surrounding ground and the data of the maximum amplitude of micro tremor during a day. On this GIS, each datum is indicated as each object based on the data of location and the shape of a polygon.

System of indication and reference of data

The system of indication and reference of data has the functions as follows: the indication of the data of each object on the map and the reference of them by means of clicking of a mouse button, and the starting up the analysis systems linked each object.

The system of indication indicates each object as an item on the map (Fig.3). The tag of each item has the data file name and the name of the class, which links the object to the file on the database and the analysis systems. For example, the item of the boring log has "boring" as its class name and "f@data_filename" as its data file name, and the item of the building has "building" as its class name and "f@data_filename" as its data file name. Thus, these tags, the "boring" class starts up the analysis system for the data of boring logs, and the "building" class starts up the system for the data of buildings.

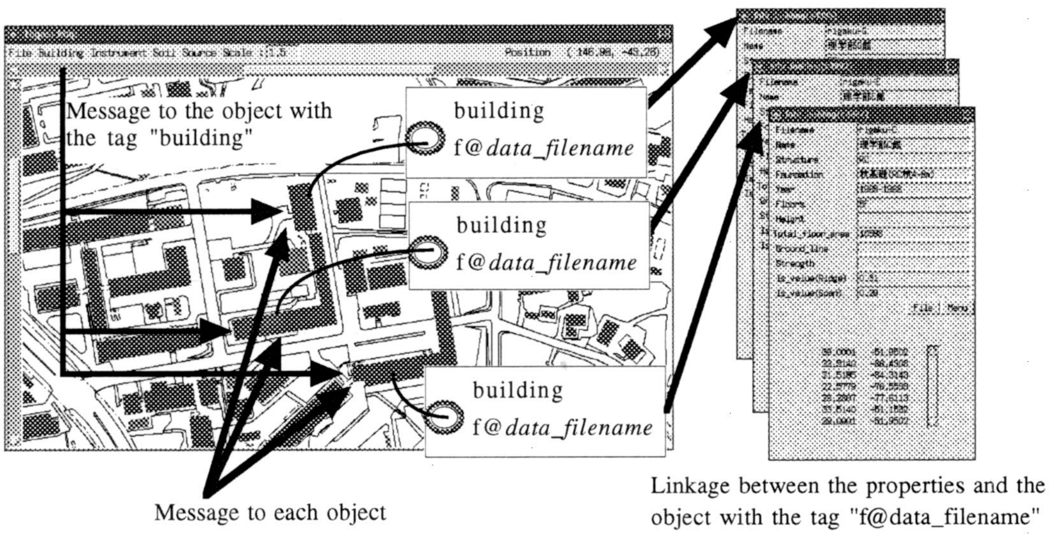


Fig.3 Indication of properties of each object using tag

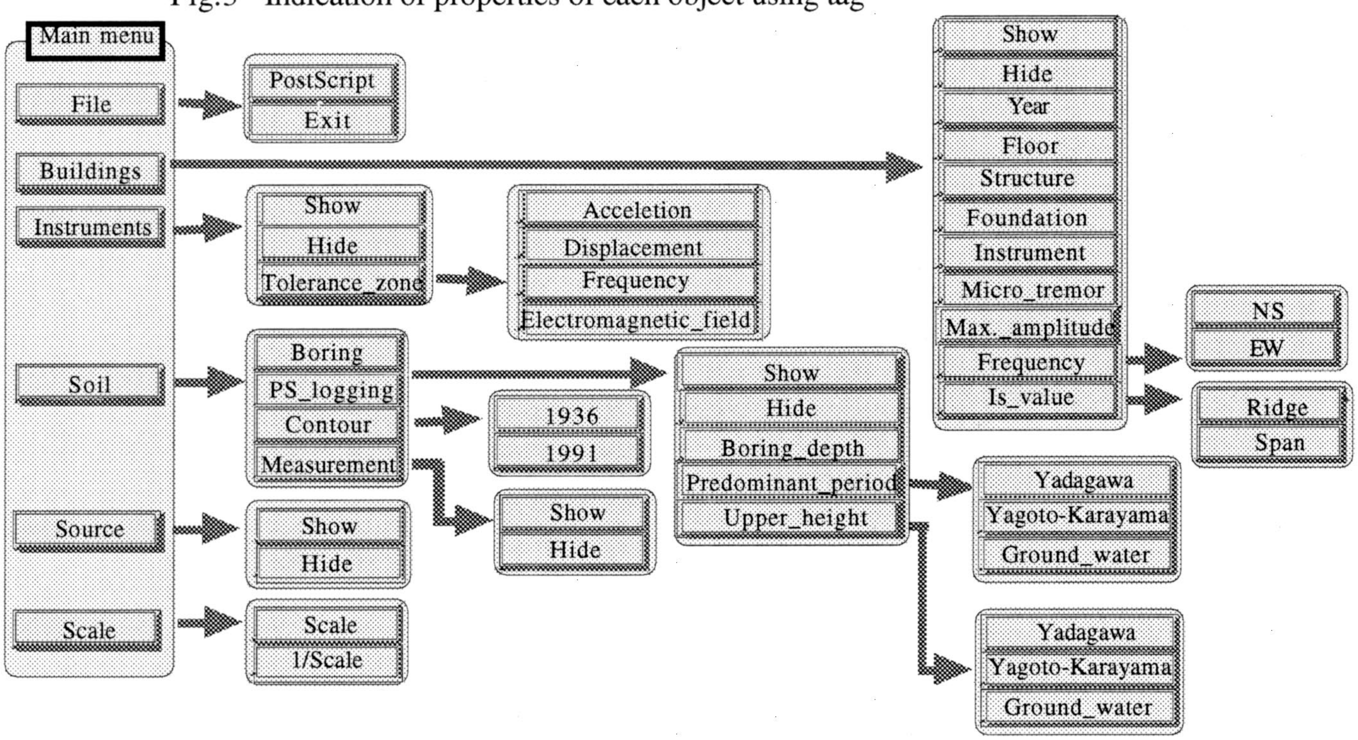


Fig.4 Classified referring menu on the main menu bar on the main window

The system of reference has the referring menu button for each class such as buildings and the ground on the main menu bar of the window (Fig.4). The menu is classified and the lower menu has the function which can selects the referring property of each class and starts up the method of reference. The outcome from the reference is shown by the changing the color of referred items. (for example, Fig.6)

System of estimation of the dynamic behavior of soil and structures

The system of estimation of the dynamic behavior of soil and structures consists of the analysis tools and the data of the dynamic behavior of a building and its surrounding ground. Both the system for surface stratums and the system for buildings are provided as examples in this paper.

The system for surface stratums indicates the data of PS loggings and boring logs at its boring site, and supports the foundation planning (Fig.7(b)). Moreover, it makes the surface stratum model at that site, and calculates the transfer function of the ground (Fig.7(c)) and the ground stiffness. It could be extended to analyze the erratic structure of soil considering the data of the surrounding ground and the surrounding topography data.

The system for structures not only indicates the basic properties of each building (Fig.7(d)) but also inputs the data of a building newly investigated. Is values and the measured data are recorded in each object file (Fig.7(e)(f)(g)). In future, the mass and the stiffness of each floor will be recorded and structural model will be analyzed dynamically.

System of wave analysis

The system of wave analysis has the functions which call up and analyze the data of micro tremors and strong motions obtained through seismic observation. This system gives us the proper information of buildings or the ground taking both the mesured data and the estimation of the dynamic behavior of soil and structures into account. Generally, the measured data is so huge that the efficiency and the simplicity of analysis systems is important. At this point, the processing types of wave analysis systems for researches may be divided into 3 types.

a) the processes by Script in order to lay out several waves on one paper.
b) the processes by which waves and analytical methods can be selected interactively.
c) the processes which requires wave data names as arguments in Command line.

Accordingly, Wavish (Wave Interactive Shell) is coded as a wave analysis system using Tcl as a script and Tk as a GUI, Wavish and the GIS are available to each other. Wavish uses the command-line call (exec or eval) as a call method, and it has execution modules which is able to deal with the input and output waves as arguments and the parameters of the analysis methods as options.

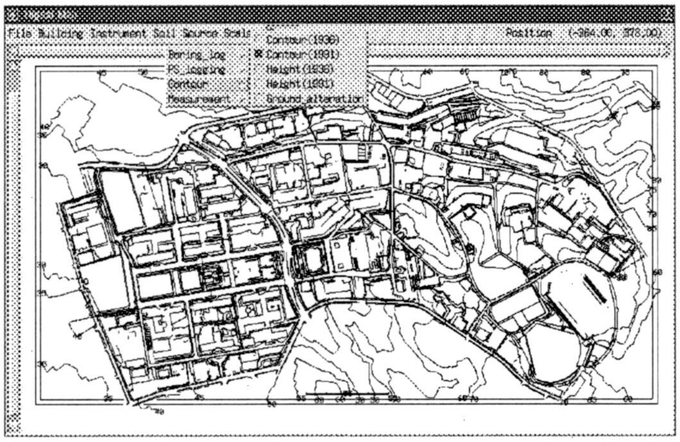
In order to analyze the measured data of micro tremors (Fig.7(g)), for instance, first, the button coded in script on both the processing and the layout is prepared (Fig.7(d)). Then the command is called from the button on the GIS (Fig.7(g)). Finally waves are analyzed futher interactively using other button for analysis (Fig.7(g)).

THE CONSTRUCTED SYSTEM

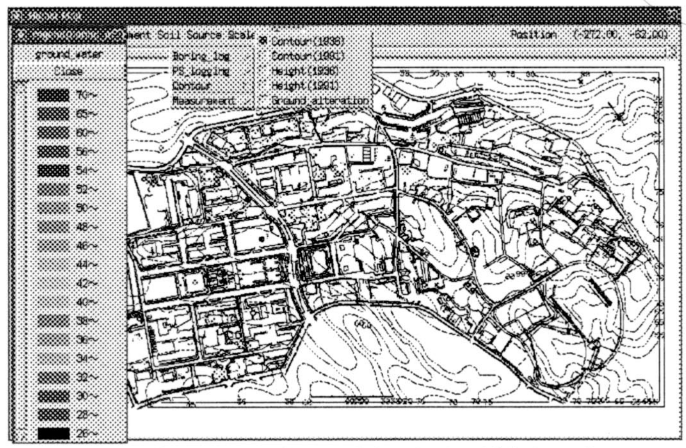
The menu in Fig.4, it is easy to know various information of ground and buildings. The applications are given as follows:

Soil Information from the Reference System

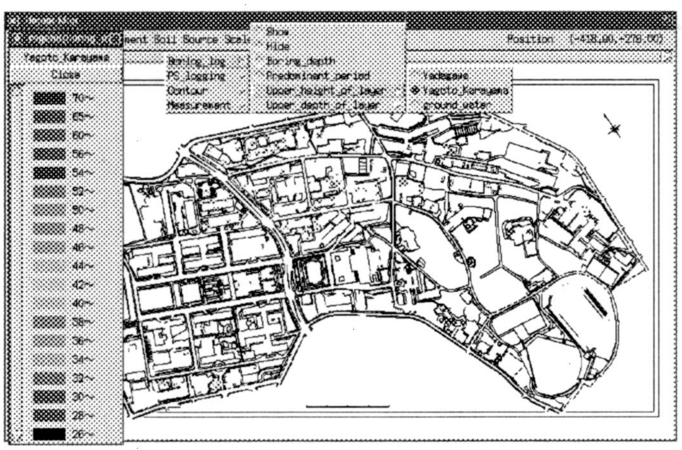
On the topography, the comparison between contour in 1936 and contour in 1991 gives the site preparation, which also shows that the maximum thickness of fill-up is about 5m (Fig.5(a)(b)). The altitude of Yagoto layer , a diluvium, is shown in Fig.5(c). It shows the depth of the bearing subsoil in Higashiyama campus. The shear wave velocity, the weight per unit volume, and the damping ratio from the data of the boring log, and the predominant period of the ground (T: $T = 4h/Vs$, h : thickness of the surface stratum, Vs : shear wave velocity of the ground) are estimated by the regression formula (Koiso, 1991)(Fig.5(d)).



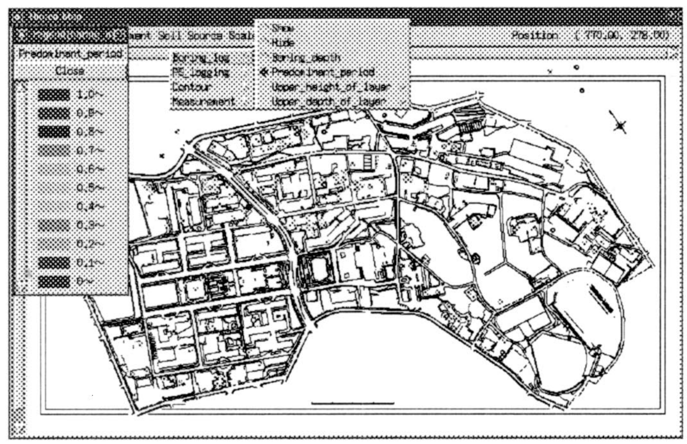
(a) Contour of the altitude in 1991



(b) Contour of the altitude in 1936 and the altitude of the ground water



(c) Altitude of Yagoto-Karayama layer



(d) Predominant period of the ground

Fig.5 Soil information from the reference system on the main window

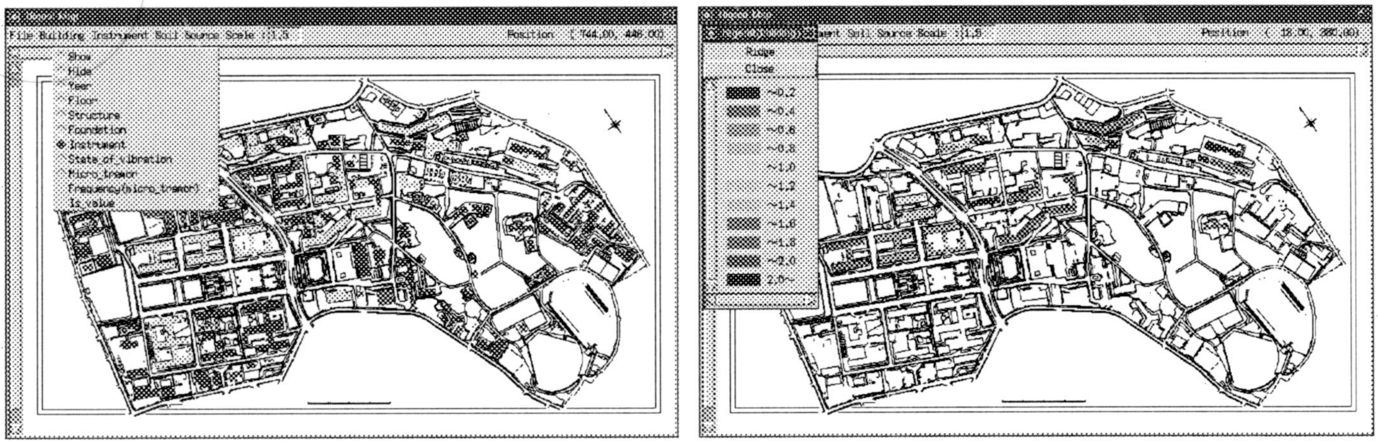
<u>Building Information from the Reference System</u>

Fig.6(a) shows the location of the buildings with precise instruments. Fig.6(b) shows the Is values of each building. The building whose Is value is over 0.6 has sufficient strength.

<u>Individual Information of Soil and Structures</u>

Clicking one of the boring sites on the Higashiyama map, the boring log at the point, the estimated shear wave velocity, and the data of PS loggings appear on the screen (Fig.7(a)). Then pushing the "transfer function" button, the transfer function of that site from the lowest investigated layer to the surface is calculated by multi-refrection method.

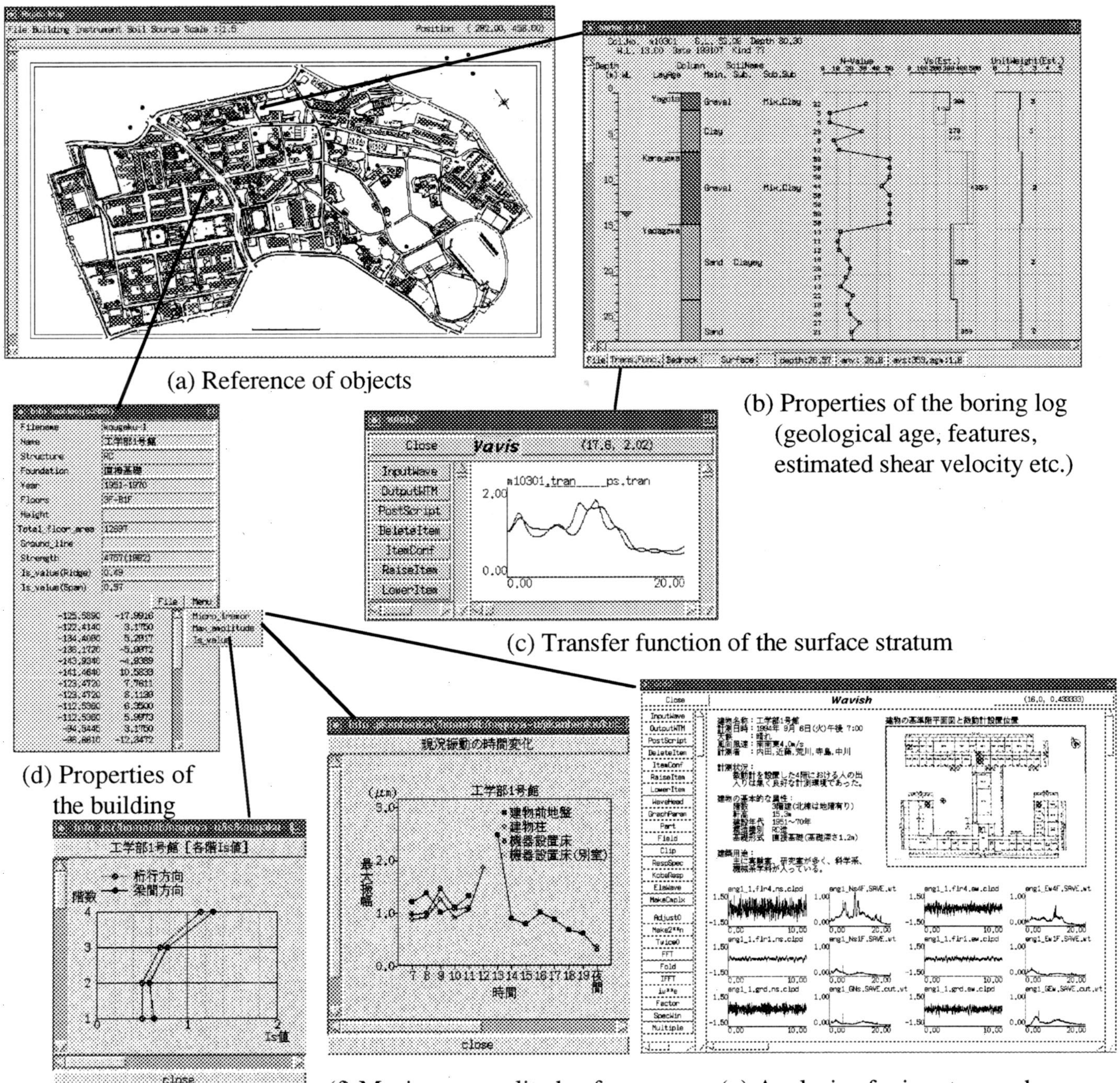
Clicking the building polygon, its properties appear (Fig.7(d)). Then pushing the "Menu" button, the Is values of each floors(Fig.7(e)), the maximum amplitude of micro tremor during a day (Fig.7(f)), and the wave of micro tremor (Fig.7(g)) appear. the wave data, for example, micro tremor, is indicated on Wavish (Fig.7(g)). The data on Wavish can be analyzed futher, the natural frequency and the damping factor of that building is identified interactively.



(a) Buildings with precise instruments

(b) Is value (Ridge direction)

Fig.6 Building information from the reference system on the main window



(a) Reference of objects

(b) Properties of the boring log (geological age, features, estimated shear velocity etc.)

(c) Transfer function of the surface stratum

(d) Properties of the building

(e) Is values of each floor

(f) Maximum amplitude of micro tremor during a day

(g) Analysis of micro tremor by means of Wavish

Fig.7 Linkage among objects and Indication of properties of each object

ADVANTAGES AND DISADVANTAGES OF THE CONSTRUCTED SYSTEM

This GIS is constructed using Tcl/Tk as a GUI and C language as a basic programming language. The GIS are inexpensive and can be easily extended and maintained. Each data is saved as a text file and can be easily renewed and supplemented.

However, the increase of objects decreases the executing speed of reference and indication, this constructing method of a GIS is not recommended for the application to the urban disaster prevention GIS because of its enormous objects over this constructed system. Moreover, the most GIS indicates data on 2-dimensional map. Therefore, the futher improvement of the methods is necessary to indicate the objects which are scattered in height direction such as instruments in a building.

CONCLUSION

In this paper, the construction of the database for the vibration environment in Higashiyama campus and the construction of the GIS using Tcl/Tk are reported. The practical system which is the same scale with this example is constructed easily with low cost. It is easily extended to the support system for the facility planning, the environmental assessment, and the disaster prevention. As this system is coded using only free soft wares, it can be distributed without any charge and it is easily applied to another facilities.This system will be combined with the strong motion observation system and the estimation system of earthquake disaster at Nagoya University, and will be linked the GIS of the disaster prevention for Japan.

ACKNOWLEDGEMENT

The author is grateful to Prof. Fukuwa at Nagoya Univ. for his indication of this study, and also to one of graduate students at Nagoya Univ. Riei Nishizaka for the construction of database.

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