Construction of Web-GIS in San'in region for integrating geophysical survey data with geotechnical information

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1 **Title page:**

2 **Title: Construction of Web-GIS in San'in region for integrating geophysical survey**
3 **data with geotechnical information**

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12

13 **Abstract**

14 Constructing a database of information on geotechnical information, such as
15 geophysical survey results and borehole data, and sharing it among researchers and
16 practitioners will be useful for the development of subsurface research and the
17 prevention of disasters such as earthquakes and landslides. In earthquake disaster
18 prevention, geotechnical information is particularly important for strong ground motion
19 prediction. The geotechnical information includes analysis results based on geophysical
20 surveys and seismic observations, and borehole data. These databases can be displayed
21 on a map using GIS, and the existing analysis results can be checked sequentially. This
22 will allow us to consider new observation plans and to improve the efficiency and
23 accuracy of the analysis of the subsurface structure model.

24 In this study, a database of geotechnical information was constructed for the San-in
25 region. The database of geotechnical information includes the results of microtremor
26 and gravity survey, analysis of ground structure by seismic observation, and borehole
27 data in Tottori and Shimane prefectures. In addition, we constructed a system to display
28 the constructed database on a map in a web browser (Web-GIS). For the base system of

the GIS, Leaflet, a Java Script library, was used to display the prepared database of geotechnical information using the GSI tiled map as the base map. The developed database and GIS system will be used to researchers and the public in the future.

Keywords

database of geotechnical information, strong ground motion prediction, Web-GIS, San-in region

Main Text

Introduction

Constructing a database of information on geotechnical information, such as geophysical survey results and borehole data, and sharing it among researchers and practitioners will be useful for the development of subsurface research and the prevention of disasters such as earthquakes and landslides. In earthquake disaster prevention, geotechnical information is particularly important for strong ground motion prediction. The geotechnical information includes analysis results based on geophysical

surveys and seismic observations, and borehole data. These databases can be displayed on a map using GIS, and the existing analysis results can be checked sequentially. This will allow us to consider new observation plans and to improve the efficiency and accuracy of the analysis of the subsurface structure model.

There are paid and free open-source software for GIS. The users of the database and GIS could be researchers and practitioners from research institutes and construction companies, and general users from municipalities and educational institutions. For general users, there will be differences in PC environments and GIS operation skills.

Recently, the PC and network environment have been improved, and many kinds of tile maps, such as topographic and geological maps, are available on the Internet, so it would be useful to develop a display system using these maps.

In this study, a database of geotechnical information was constructed for the San-in region. The San-in region is a seismic active area, earthquakes such as the 1943 Tottori earthquake, the 2000 Western Tottori prefecture earthquake, the 2016 Central Tottori earthquake, and the 2018 Western Shimane earthquake. These earthquakes have also caused damage in the region, making it an important region for promoting earthquake

disaster prevention. The geotechnical information is based on geophysical surveys and seismic observations, borehole data in Tottori and Shimane prefectures. The geotechnical information includes the results of geophysical surveys and seismic record analyses and borehole data in Tottori and Shimane prefectures. In addition, we constructed a system to display the constructed database on a map in a web browser.

Database of geotechnical information

The database of geotechnical information includes the results of microtremor and gravity survey (Noguchi and Nishida, 2002) (Ishida et al., 2013) (Nishimura et al., 2021) (Yoshikawa et al., 2002) (Adachi et al., 2006) (Adachi et al., 2007) (Adachi et al., 2009) (Noguchi et al., 2009) (Noguchi et al., 2020) (AIST, 2013) (South West Japan, 2003), analysis of ground structure by seismic observation (Noguchi et al., 2016), and borehole data (Chugoku Region foundation Research Association, 1995) in Tottori and Shimane prefectures. These data are used as point data, and along with the location information, attribute information related to the analysis results of various explorations and geotechnical information is added. Table 1 shows the list of observation areas,

corresponding research results, and data contents as of September 2021. The analysis results of the microtremor survey are the predominant period of the H/V spectrum and the layer thickness of the surface layer from the single-point three-component observation, and the phase velocity dispersion curve and the ground structure model from the array observation. In some points, photographs of the observation scenery are also included. The analysis results of the gravity survey are the Bouguer anomaly at each station and the gridded data of the basement elevation obtained from the analysis. Distribution maps (image data) of specific areas constructed using these data are also included. The analysis results of the seismic observation are the H/V spectrum of the earthquake motion and the ground structure model. The borehole data includes the soil conditions, layer thickness, and N-values at the study site. It also includes several geological cross sections (image data) estimated from these data.

Web-GIS system

As a viewer for the database of geotechnical information, we developed a system to display various information on a map using a Web browser (hereinafter called Web-

94 GIS). Figure 1 shows a map with a side menu in the initial screen of Web-GIS. As a
95 base system, Leaflet, an open-source Java Script library, was used to display
96 geotechnical information in a simple method via a Web browser. The structure of the
97 files is as follows. 1) an html file to display in a browser, 2) a pop-up display function
98 for layer settings and attribute information, 3) a Java Script file to load a tiled map, and
99 4) a CSS file to style the web page. The tiled maps for the base map and the optional
100 overlay are based on the mapping system provided by the Geospatial Information
101 Authority of Japan. The base maps were standard maps, light-colored maps, and aerial
102 photographs, and the overlaid maps were land-use maps, color-coded elevation maps,
103 landform classification maps, and geological maps (The right side menu in Figure 1).
104 The display functions and operations of Web-GIS are explained below for the display of
105 analysis results from microtremor surveys as an example. On the map of the
106 microtremor observation, the location of the three-component microtremor observation
107 point and the predominant period of the H/V spectrum at that point are shown as color-
108 coded circle symbols, and the location of the array observation point is shown as a
109 square symbol. For the display of the predominant period of the H/V spectrum, the

110 cluster display function is used according to the scale of the map because of the large
111 number of points. Figure 2 (left figure) shows an example of a map with symbols of
112 clusters. In a map of a large area, a reasonable number of points are grouped into
113 several cluster symbols, and the number of points in the cluster is displayed in the
114 center of the symbol. The range of clustering is switched in several stages depending on
115 the map scale. When the map is zoomed in further, a symbol of a circle in a different
116 color is displayed for each point. The color coding is a gradation of colors from red to
117 blue in 0.1 second increments up to a period of 1.8 seconds. Figure 2 (lower right
118 figure) shows an example of a map with symbols of circle colors. To make it easier to
119 see the changes in the short-period side for the base of the mountain, a distribution map
120 with colors changing in increments of 0.05 seconds up to 0.7 seconds can be selected
121 from the side menu (The left side menu in Figure 1). When you click on the circle
122 symbol, another window appears on the right side of the screen, showing the name of
123 the observation point, the value of the period of excellence, a link to the source, a graph
124 of the H/V spectrum, and a photograph of the scene at the time of the observation (the
125 photograph is shown for some points). Figure 3 (left figure) shows an example of

clicking on the symbol for a single point observation. In the future, we plan to display the average S-wave velocity and layer thickness of the sedimentary layer at the location (currently set as No Data). Clicking on the square symbol of the microtremor array observation point, the name of the observation point, the source of the results, the ground structure model, and the graphs of the phase velocity dispersion curve and the S-wave velocity structure model are displayed on the right side. Figure 3 (lower right figure) shows an example of clicking on the symbol for an array observation.

Use of databases and Web-GIS

The database and Web-GIS are now being used in the laboratory to which the authors belong at Tottori University. Web-GIS has an intuitive and easy-to-understand screen structure that can be accessed from a browser without complicated procedures and does not require complicated setup and operation. Even students who are not familiar with the operation of GIS can easily view the results of previous analyses, as an operation manual has been prepared. In addition, we established rules for constructing a database of the results of each student's analysis, and prepared a system that allows students to

142 update the data immediately after analysis and check the results on a map. This makes it
143 possible to compare the results of the preliminary analysis with the results of the
144 previous analysis on the map, and to perform the analysis efficiently. It is also expected
145 to improve the estimation accuracy of the subsurface structure model. If new
146 geotechnical information is added in the future, the database will be updated
147 sequentially.

148 The system and database are uploaded to a web server and are ready for public access at
149 any time. In the future, we plan to make it widely available as part of our contribution to
150 the community. First, it is expected to be used by research institutes, local governments
151 and construction companies that need geotechnical information in the San-in region. In
152 the past, Tottori Prefecture installed a system to receive information on seismic activity
153 in real time from the Disaster Prevention Research Institute of Kyoto University and
154 tried to use it as disaster prevention information, and is also studying the construction of
155 a GIS database of information on subsurface structures and earthquakes (Noguchi et al.,
156 2016). The current PC and Internet environments and data preparation conditions are
157 much more advanced than in the past, making it easier for ordinary users to install and

use the system of this research. In the future, as the system is installed, users will be able to discuss with the distributors to revise the necessary information and distribution methods after using the system. For example, for use in earthquake disaster prevention, the calculation results of ground amplification obtained from geotechnical information and the distribution of maximum seismic intensity based on the prediction of strong ground motions should be added, and the data should be made available on tablet terminals. In addition, we plan to expand the use of the information and system to include disaster prevention education for schools and the public.

Summary

In this study, we developed a database of geotechnical information for earthquake motion prediction in the San-in region, and developed a GIS system with a Web browser for its use. Microtremor and gravity survey analysis results and borehole data were used as geotechnical information. For the base system of the GIS, Leaflet, a JavaScript library, was used to display the prepared database of geotechnical information using the GSI tiled map as the base map. The developed database and GIS system will

be used to researchers and the public in the future. The database and GIS system will be used to researchers and the public, and are expected to contribute to the efficiency and accuracy of planning and analysis of geological survey.

Figure Legends and Table Legends

Table 1

Contents of the database of geotechnical information

Area	Geotechnical Information	References
Eastern Tottori	microtremor, gravity survey	Noguchi and Nishida(2002), Ishida et al.(2013)
Central Tottori	microtremor survey	Nishimura et al.(2021)
Western Tottori	microtremor, gravity survey	Yoshikawa et al.(2002)
Eastern Shimane	microtremor, gravity survey	Adachi et al.(2006), Adachi et al.(2007), Adachi et al.(2009)
Western Shimane	microtremor survey	Noguchi et al.(2009), Noguchi et al.(2020)
Tottori	seismic observation	Noguchi et al.(2016)
Tottori, Shimane	gravity survey	The Gravity Research Group in Southwest Japan(2003), Komazawa(2013)
Tottori, Shimane	borehole	Chugoku Region foundation Research Association(1995)

Figure 1

A map with a side menu in the initial screen of Web-GIS.

The menu on the left side allows users to select Web-GIS operation, microtremor

explanation, predominant period map for the foot of the mountain, and links to the

seamless geological map and the laboratory's homepage. The menu on the right side

allows the user to select various base maps and ground information to overlay.

The menu on the right side allows users to choose between three types of base-maps and

eleven types of layers of geotechnical information.

191

192 Figure 2

193 An example of a map with symbols of clusters and a map with symbols of circle colors.

194 The number of clustered points is displayed in the center of the symbol. Color symbols

195 are displayed according to the colors in the legend on the left.

196

197 Figure 3

198 An example of detailed information for a single-point observation and for an array

199 observation.

200 The right window of the single-point observation map shows basic information, H/V

201 spectra, and photos of the observation site. The right window of the array observation

202 map shows subsurface model, the phase velocity dispersion curve and graph of S-wave

203 velocity model.

204

205 **Declarations**

206 **Ethics approval and consent to participate**

207 Not applicable.

208 **Consent for publication**

209 Not applicable.

210 **List of abbreviations**

211 H/V Horizontal components over Vertical component

212 **Availability of data and materials**

213 The datasets used and/or analyzed during the current study are available

214 from the corresponding author on reasonable request.

215 **Competing interests**

216 The authors declare that they have no competing interests.

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222 **Authors' contributions**

223 IN, TN constructed the geotechnical database and IN, TK developed the

224 Web-GIS. After discussion among authors, IN drafted the manuscript.

225 All authors read and approved the final manuscript.

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227 The Web-GIS developed in this study uses map data from the Geospatial

228 Information Authority of Japan (GSI) and Leaflet as a JavaScript open-

229 source library to manipulate the map data. The authors appreciate Mr.

230 Kenryo Nishida who constructed a prototype of the Web-GIS.

231 **Endnotes**

232 None

233

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