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Development of Consolidated Sarawak Geotechnical Site Investigation for Sarawak Soil

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Abstract: The development of spatial or non-spatial digitized Consolidated Sarawak Geotechnical Site Investigation (CoGSI) database aims to enable information to be stored in a digital form with the efficient search and fast retrieving data. The CoGSI database for Sarawak Soil is a function of a database management system, which consists of the site information; includes the project name, locations coordinates (division), borehole logs, field and laboratory test results. The main objectives of the project are to collect, store & digitized all verified & approved Geotechnical SI data and the input gathered from the local authority, consultants and contractors. The digitized database would be enormous value for future planning of infrastructure developments; making preliminary design estimates for earthwork/foundation assessment; and future decision making with early identification of potential areas for construction purposes, which will produce an economic and safe design. The SI databases are important resources where the insufficient ground conditions information, will cause either a significantly over-designed or an under-designed solution, which lead to potential failures. In addition, the project is also intended to realize a web-based application to allow users to search borehole, view bore-logs and provides digital downloadable boreholes data of the available ground information in a standard format for analysis. At present most of the SI data are available in the form of hardcopy reports, which is time consuming and often frustrating, especially when the required report or data cannot be found. In summary, the Consolidated Sarawak Geotechnical Site Investigation (CoGSI) database system, which stored in a digital format are deployed as a web-based system. This platform provides exploration of the digital databases, which then can be accessed anywhere and anytime through the desktop & portable computer and smart phones with internet access facility.

Keywords: Database management, site investigation, digital web-based, construction

1. Introduction

The geotechnical site investigation (SI) is routinely performed to the commencement of any projects prior to the decent design and cost-effective construction for all civil engineering and building construction works. The geotechnical engineers will be interpreting the subsurface conditions based on the SI report for planning, design and monitoring of the designated project. It is also help to overcome any possible difficulties, delays that may arise during construction period, disputes, claims and project cost overruns due to ground and other local conditions [1], [2].

In this study, the geotechnical SI reports are gathered mostly from the Public Works Department (PWD) Sarawak and partially from consultants and contractors. The PWD has collected a large amount of the SI report in hardcopy version over the years and it keeps increasing continually, which caused lots of spaces needed and required a systematic recording system. Also, the data retrieval is time consuming and often frustrating, especially when the SI report/data needed cannot be found [3]. Following to this, the PWD Sarawak has developed a system called Geotechnical Site Information System for Sarawak (GEOINFOS) to store the boreholes, field and laboratory tests. Briefly, the system is developed through linking the existing boreholes images to a GIS map of the designated area. This GEOINFOS is a function of a document management system, which is different with CoGSI, the current system development, which function as a database management system. Ref [4] stated that because of the data are deposited as images not as digital form; thus, unable to be used for advanced analyses such as building in 3-D subsurface images, prediction of the cross-sections generated and geostatistical analyses. Therefore, the geotechnical SI information development in digital format would be beneficial to the targeted users where the exploration and dissemination of SI information over the internet can be accessed.

The present study aims to produce digitized Consolidated Sarawak Geotechnical Site Investigation (CoGSI) for Sarawak-Soil report into a database management system, which enables data to be retrieved faster and worthwhile tools to promote user-friendliness, effective dissemination, and efficient administration for current and future development of geotechnical databases. In addition, the current system developed not only focusing on the compilation of the previous hardcopy SI report, though to allow the user to key-in the new collected borehole logs that serve potential users who requiring geotechnical information. The objectives of the current study are outlined as follows:

- To collect, compile and digitized all reliable Sarawak Geotechnical SI information from the data providers; local government agencies (PWD), private developers and other civil engineering consultants and/or contractors. This SI report comprises of boreholes and laboratory testing;
- To construct intelligent software to facilitate the stored Geotechnical SI information for future decision making with minimum requirement to perform detailed SI and early identification of the potential areas for future development. The CoGSI database management system uses Microsoft Azure SQL; and
- To develop a web-based application that allows users to search, view, provide downloadable data of the available ground information and compilation of future Geotechnical SI information efficiently. This is achieved by using OpenStreetMap (OSM), Leaflet, PHP and Javascript. OSM, which is known as editable map of the world where it stored geodata with Leaflet and PHP.

2. Background of Current Study

Geotechnical site investigation helps to identify the possible geotechnical problems with the aim to provide adequate information for site assessment, in order to have safe and economical designs. Inadequate in geotechnical SI information is often the result of designer failing to properly plan and identify the type of field and laboratory testing needed to acquire soil parameters in design stage. By providing the design team and contractors with the adequate subsurface information and design parameters during the preliminary design and development stages helps a project site to save a considerable amount of time and expenditures. Based on [5], the risk of a construction failure is dependent on the information obtained through the geotechnical SI information, which aimed at identifying the underlying potential soil conditions. In Fig. 1, presents the framework on relationship between the site investigations with other related geotechnical works.

For over the last 30 years, numerous studies have been published demonstrating the needs of ground investigation and technical risks, which focusing on the civil engineering projects due to the limited characterization of ground conditions that are both inadequate and/or inappropriate. Consequently, the above situation of ground condition can cause the failure and a high level of financial and technical risk [6]. In general, good geotechnical SI information involves a proper reporting borehole logs, material sampling, laboratory and field-testing results. Thus, to utilize the benefit of geotechnical SI information, a document management system is needed to be replaced with the electronic version which can be uploaded, store and available to access, which allows the certified professionals and approved contractors to use the database system. According to [7], the geotechnical databases have been developed in accordance to the individual project sites, cities, municipal areas, counties, states, countries and regions consisting of several countries or entire continents. The Table 1 presented below an extract of geotechnical databases developed by researchers from multinational government bodies and private organizations.

3. Consolidated Sarawak Geotechnical SI Database (CoGSI) Development

3.1 Overview of the System Development

This research project consists of 3 main phases, which are the data collection interface, open street map data display and interpolation of soil stratigraphy. The data collection interface permits the user to key-in the verified and approved borehole data in the web form. This will allow the user to retrieve all the input data and to download printed data in future. Open street map data display retrieves data that user input and plot their location on the open street map
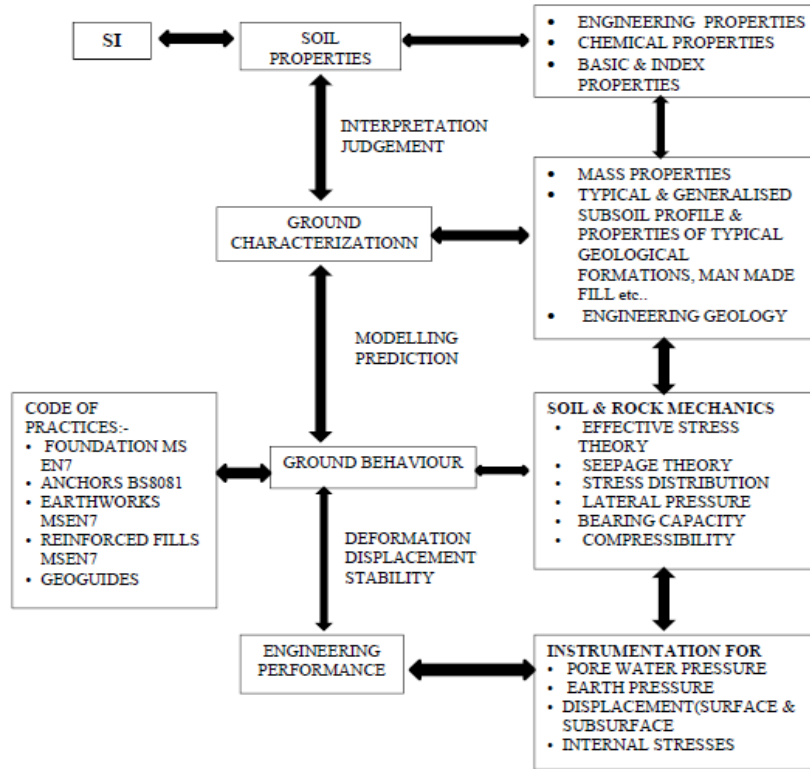
Fig. 1 - The framework on relationship between Site Investigation (SI) and other related geotechnical works [6]

Table 1 - Extract of the developed geotechnical databases by various researchers from 1994 to 2010

No.	Author (s)	Description
1.	[8]	• The North America database on the hydraulic conductivity and soil properties based on the laboratory measurement of a wide variety soils from 67 landfills.
2.	[9]	• The European Soil Geographic Database developed a soil database with a soil units system accepted by the World Reference Base for Soil Resources for Russia, Belarus, Moldova and Ukraine territories.
3.	[10]	• The Bangkok city developed a geotechnical database with GIS interface.
4.	[11]	• The Australian Soil Resource Information System (ASRI) database comprises datasets of digital soil profiling, land resources maps and climate, terrain and lithology.
5.	[12]	• The Southern Chennai, India developed a GIS-based database system of on the compilation of the soil safe bearing capacities.
6.	[3]	• A Geotechnical Site Information System for Sarawak (GEOINFOS) is a geotechnical data management system.
7.	[13]	• The city of Mayaguez, Puerto Rico developed a geotechnical database collected from local consulting firms, government agencies and researches.
8.	[14], [15]	• A compilation of 33 countries databases for over 6,200 high quality of soil samples for saturated and unsaturated soil data.

according to the coordinates using Borneo-RSO system. An interpolation of soil stratigraphy uses the soil stratigraphy information for each borehole log and visualizes the stratigraphy of the borehole logs in 2D.

The CoGSI database system is a protected website that needs the user to have a registered username and password is shown in Fig. 2. After logging in, the main web interface of the CoGSI for Sarawak-Soil, will be available with seven tabs: Home, Project, Boreholes, Map, About, Contact and Logout. Each of these tabs was designed with different functionality. These tab functions allow users to view the map and searching the borehole log data through several convenient approaches; project name, borehole list and division as presented in Fig. 3. The Map tab function displays a map containing streets, street name and the borehole location which link on the street map as illustrated in Fig. 4. The borehole logs map developed is equipped with zoom and pan functionality and access by a click on the blue balloon will open the associated Consolidated Geotechnical SI database (CoGSI) information.
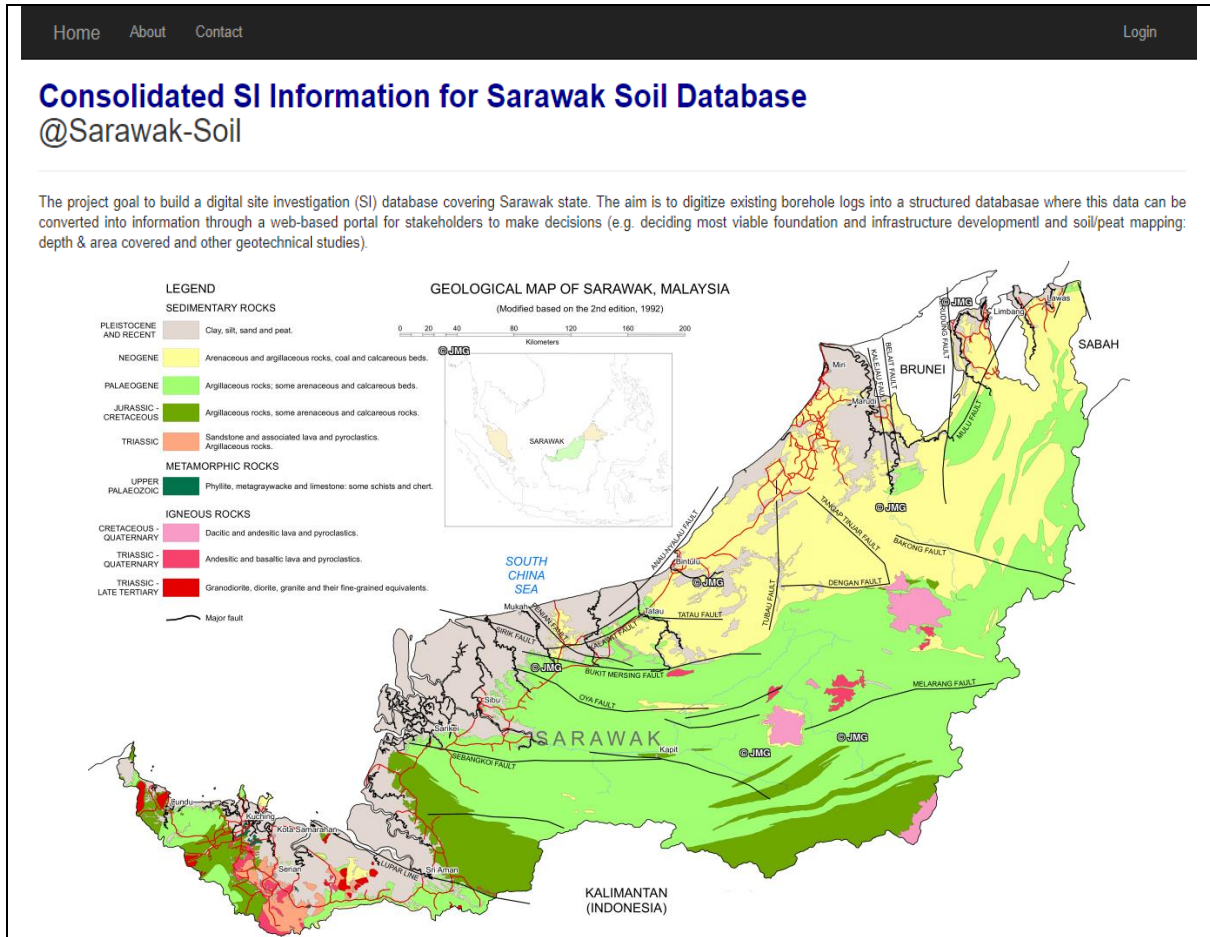
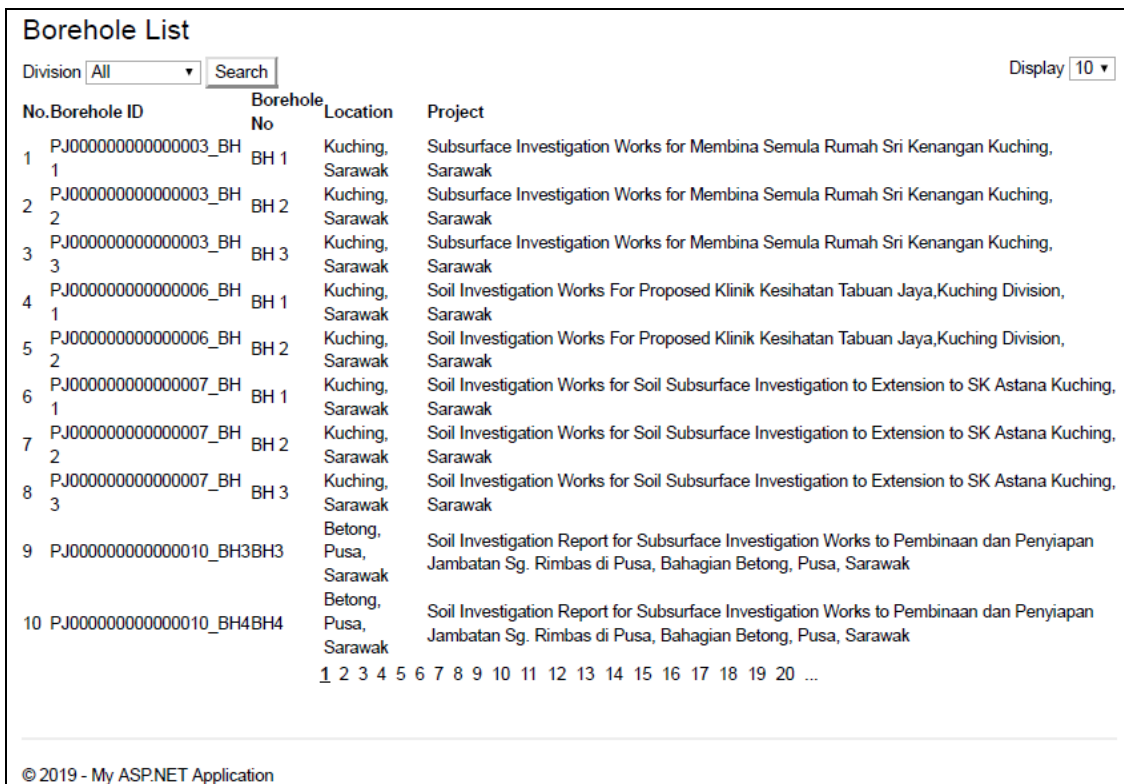**Fig. 2 - The main webpage interface of CoGSI for Sarawak-Soil**

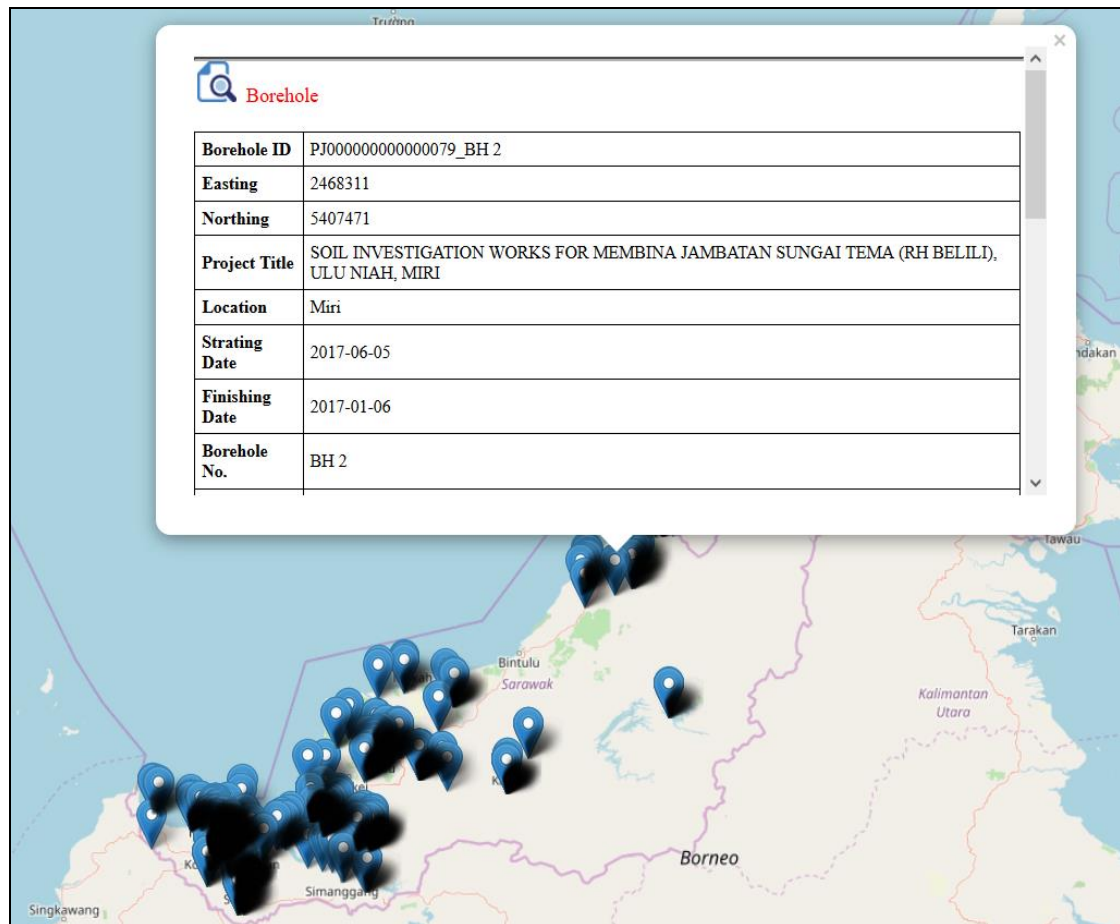**Fig. 3 - Screenshot of the interface of compilation projects in Geotechnical SI database system**

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Fig. 4 - Digitalized Boreholes of CoGSI for Sarawak-Soil

3.1 Collection of Sarawak Geotechnical SI Reports

In this present study, the current hard-copies of the Geotechnical SI information are collected from PWD Central Materials Laboratory and local consultants/contractors. All data are currently in the form of hard-copy and most of the old report do not have boreholes coordinates except for the current SI collections, where it is important to locate all borehole positions as accurately as possible. For those boreholes without the coordinates, the data-entry required to identify the borehole via Google-Map by searching the project location as the project is already completed and can be easy to identified in the map.

3.2 Data Entry for Database Development

All the current verified and approved Geotechnical SI reports are submitted in the form of hard copies to the local authorities. A data-entry template was designed for key-in data operation, where the conversion of all the existing hard copies of boreholes information into the digital database format is done. The available hard copies SI information was manually entered into the designated data-entry template. Then, a data loader to upload the data stored using the said template was established in the web-based database system. Also, through this development of digitized Consolidated Sarawak Geotechnical SI (CoGSI) database system, all SI information submissions can be submitted through this interface, where the user can key-in the new verified and approved collected borehole logs based on the associated projects thus contributes to big SI databases.

4. Design and Implementation

The geotechnical SI data collection interface for the users to input the information is completed with the designed web forms (refer Fig. 5). The areas covered 8 divisions which are Kuching, Lundu, Sematan, Sibu, Kapit, Sarikei, Bintulu, Miri, Lawas and Limbang. Users are able to view the information for each borehole log from the website. Some problems encounter during the development of Sarawak Geotechnical SI database (CoGSI) for Sarawak's soils is during data collection where the report of SI conducted are given out without copies being retained. The data entry webpage is done by filtering the data according to the district to ease the future users when they are searching for borehole logs in designated districts. Besides that, the team has completed locating the borehole logs location in the

web form based on the project detail. For the open street map data display, the team is able to retrieve the location of each borehole log from the database. A location marker is given to all borehole logs by clicking on the marker to see the details of the borehole log. Further, the location information from the data input of the existing borehole logs are in the northing and easting format instead of longitude and latitude. The team has successfully converted the northing and easting information to longitude and altitude correctly, so the marker of each borehole log can pin to the correct coordinate. Lastly, the plotting on the stratigraphy of borehole points where the users can select several points and view the stratigraphy of the points in 2D in still Phase 2 progress. In this new developed system, the database is presented in digitized information when compared with GEOINFOS [3] is a function of a document management system and the data are deposited as images or pdf formatting.

Fig. 5 - The data entry from the webpage

5. Conclusions

The Sarawak Geotechnical SI database CoGSI system comes with numerous tools; SI information: borehole logs data visualization, material sampling, laboratory and field test results, interpolations, and able to be searched in multiple platforms via smartphones, desktop computer and portable laptop through web application. This digitized database system is a secure website that will be very significant to the local government agencies, civil engineering consultants, contractors, universities, researchers and policy makers in planning, and making cost effective decisions. The system focuses on digitizing the geotechnical database management system that is spatially located using Street map. The CoGSI database management system uses Microsoft Azure SQL is successful developed for the data entry of Geotechnical SI information. A web-based application that allows users to search, view, provide downloadable data of the available ground information and compilation of future Geotechnical SI information efficiently was also successfully developed by using the OpenStreetMap (OSM), Leaflet, PHP and Javascript. OSM.

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