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The Use of Geographic Information System (GIS) for Geotechnical Data Processing and Presentation

W. N. S. Wan-Mohamad[a*] , A. N. Abdul-Ghani[b]

[a]*Faculty of Architecture Planning and Surveying,Universiti Teknologi MARA (Perak) Malaysia,*
[b]*School of Housing, Building and Planning, Universiti Sains Malaysia, Penang Malaysia.*

Abstract

Geotechnical information acquired from site and laboratory tests are vital for a safe and economical design of building and infrastructure works especially in land development projects. This paper describes the use of GIS in processing and presenting geotechnical data into formats that are useful to engineers, planners and land development professionals. A case study in Seri Iskandar, District of Perak Tengah, Perak, Malaysia is discussed in this paper. In this study, data stored in GIS systems are processed and presented into maps describing soil types and soil strengths (SPT values) at various depths. Thus, the data are always available and this can reduce a lot of time to retrieve them.

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*Keyword:*GIS, Geogrpahic Information Systems (GIS) , Geotechnical Design, Land Development

1. Introduction

Geotechnical data for site design and development is usually acquired by site investigation works utilizing site and lab tests. The site and lab tests produce information especially on the type and strength of soils. The information is vital in the economic and safe design of infrastructure and buildings. The valuable information is also often left scattered, in its original report and, in the respective project offices after completion of the projects.

* Corresponding author.
E-mail address: wannursyazwani@gmail.com

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The reports provide very useful data for overall development planning of a district, state or even region. It is because the information can be used as preliminary indicative geotechnical requirements and costs. It is also important in deciding suitable land use zoning.

A system that could provide means to efficiently stored, analyzed, and updated data, and then could produce other forms of information such as maps and tables is something that could expedite decision making and design works. These kinds of systems will be useful to engineers and planners in land development industry. GIS is known to be able to provide these facilities as it can store information in a multilayered database. Moreover, it can be used to process information in spatial data. Thus, GIS is used in a lot of engineering applications such as in geotechic, environment, human resoures, construction, transportation, and etc.

In geotechnical engineering, GIS is used in determine the location of boreholes as it helps engineers or planners to do new investigation especially for new site locations [1]. Meanwhile, for environmental engineering, many locations of waste site are selected using this software, as it is really difficult to retrieve as housing areas, production facilities and highways cover a lot of area. The next application is in construction. GIS is used for preliminary stage as to determine the site layout and also the location of temporary facilities. The decision making to select the site layout and location of temporary facilities become faster with the application of Global Positioning System (GPS). GIS become popular in transportation engineering. For example GIS is used in traffic planning to display the densities of origin/ destination, noise complaints, trip generation, routes between destinations [1] and transportation accessibility.

This paper decsribes the use of GIS for storing, analyzing geotechnical data and presenting it in a format that will be useful to planners, architects and engineers that will help them to make better decisions and to carry out safer and economical designs.

2. Geographic Information Systems

GIS is defined as "a fundamental and universally applicable set of value- added tools for capturing, transforming, managing, analyzing, and presenting the information especially in spatial data". [2] Moreover, GIS technology usage for analyzing and demonstrating makes data visualization becomes a reality. [3] Visual display data allows users to understand better compared to analytical, statistical or reporting products. Thus, in this paper, three important usage of GIS are discussed such as data integration, data visualization and data presenting.

2.1Data Integration

There are a variety of data found such as in reports, books, photos and etc and by integrating them together it will give better results. When integrating the data from various sources, it will take up less time to retrieve the data and the data will be more systematic and organized.

2.2Data Visualization

The integrated geotechnical data will be useful and easily understood by users as the data is represented into map display. Normally, site model will be created from the integrated data and the model
represented into map display. Normally, site model will be created from the integrated data and the model

will be used to visualize and analyze the site model. The model is created by the different layers and superimposed. Thus, the combined data layers can be turn on and off as needed. Moreover, the data can be represented with symbols in order to show the relationship with the features and etc.

2.3Data presentation

Data presenting is the last step when storing the data in GIS format. Normally, the data represented in the layout and can be created to be used in reports, papers, poster and etc. Infomation such as scales, labels, symbols, north arrows and text can be added to produce meaningful maps and information. A good data presentation, complete with the meaningful information and well-edited and well-printed maps will satisfy the client and consultant.

3. Geotechnical Data

Geotechnical data are usually stored in reports (hardcopy). There are a lot of risks when geotechnical data, especially soil investigation reports, are kept in hardcopy. For examples, floods, fires, earthquakes and tsunamis can contribute to the loss of data. Moreover, the reports (hardcopy) sometimes are not properly managed, according to their location, soil types, topographic areas and etc. There are two major geotechnical data usually used in site assessment and foundation designs which are the SPT values and the soil types.

3.1 Standard Penetration Test (SPT)

Standard Penetration Test (SPT) is the test that determines SPT values and then to determine the soil stiffness, load carrying capacity, density and soil settlement. The test is carried out using a standard 50mm diameter split barrel sampler which is drawn into the ground at the bottom of borehole by repeated blows of a drop-hammer [4].

3.2Soil types

The most important element in geotechnical engineering which is related to a lot of cases in the world is soil. There are a lot of soil types such as sands, silts, clays, peat, sandy, loam and etc. those types of soil give the different behavior to resist any risk occur. Therefore, it is really important to determine the types of the soil before any projects begins and that’s the purpose of soil investigation as one of the elements include in site investigation.

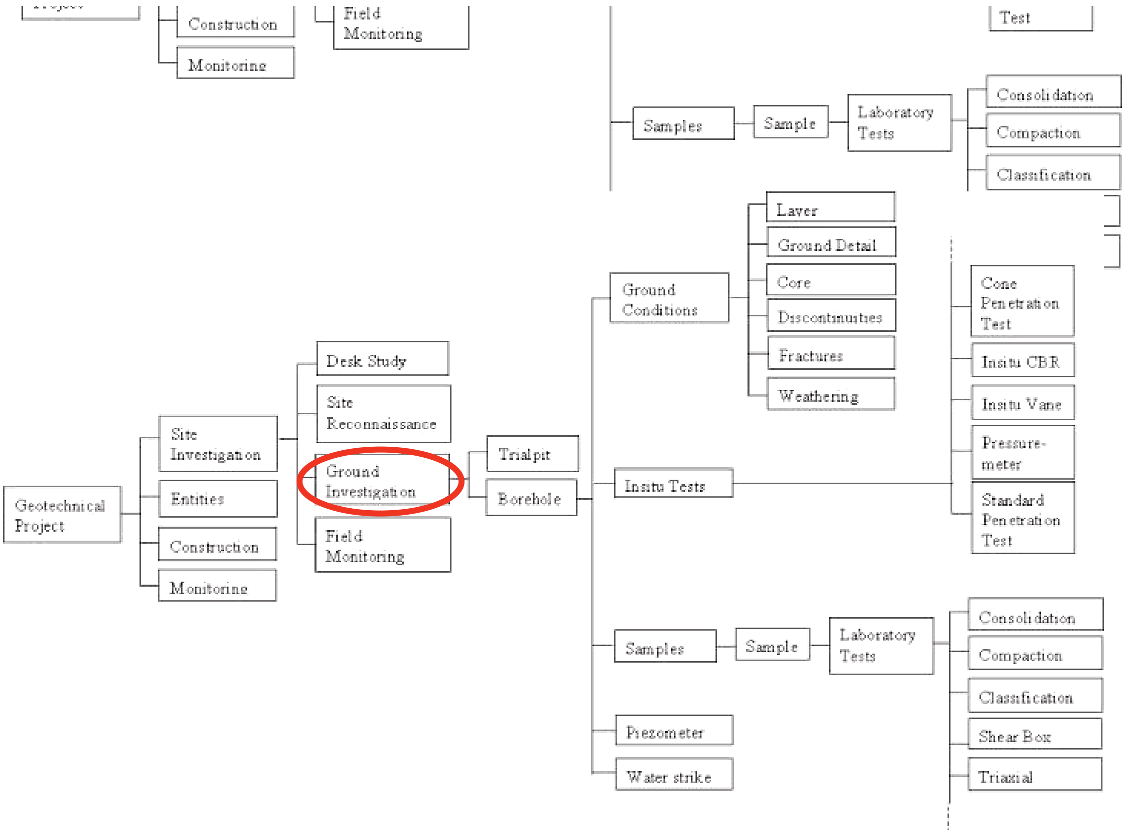


Fig. 1. Structure for ground investigation data [5]

4. Methodology

The procedures of this study can be summarized according to the following chart.

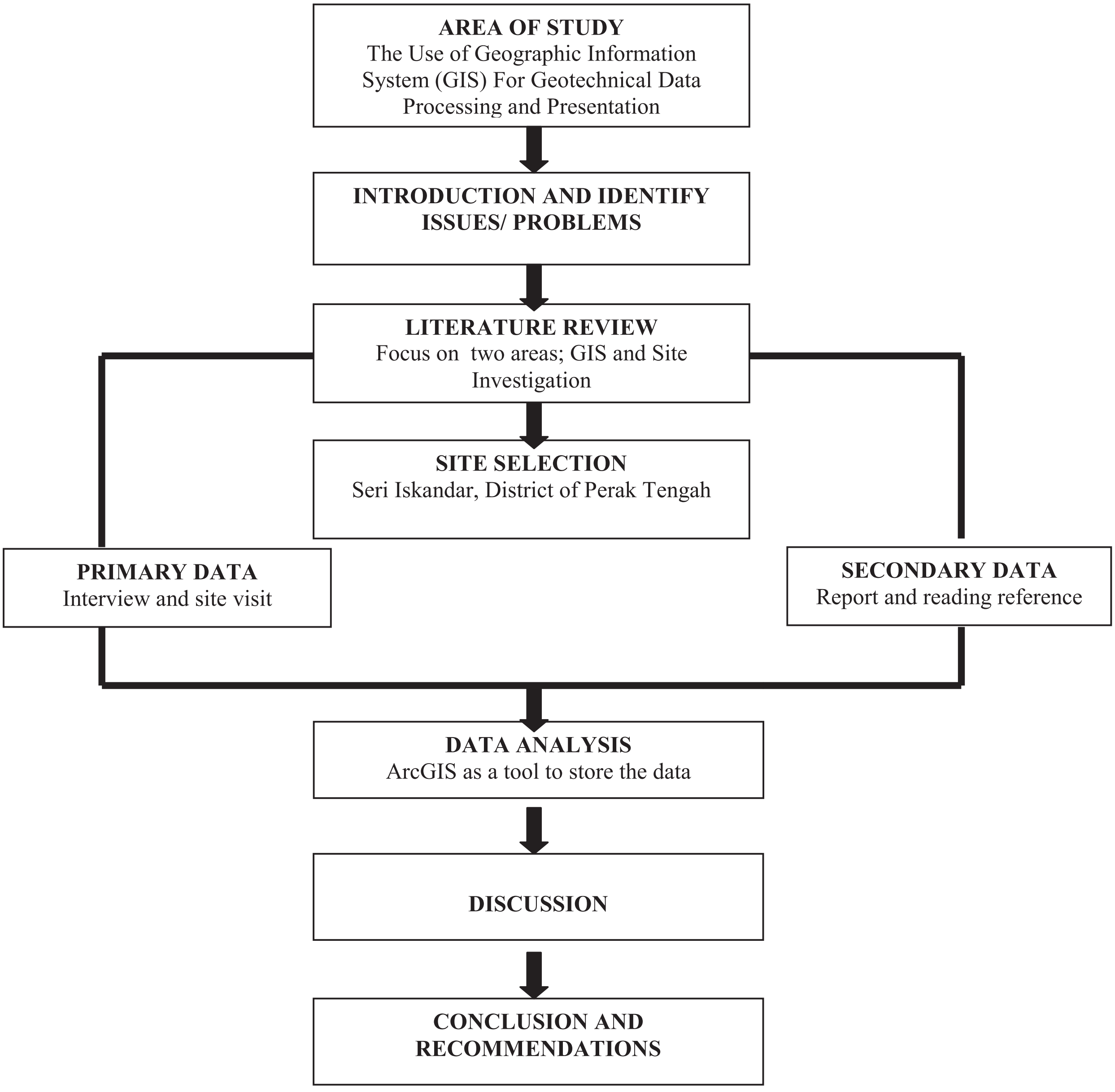


Fig. 2. Structure of the research

5. Study Area

This study covers the area of Seri Iskandar, District of Perak Tengah. There are four main site areas which is Bandar Baru Seri Iskandar (600.63 acres), UiTM Perak (11.6 acres), Latihan Kemas (ILK) Seri Iskandar (7 acres), and Government Quarters (63 acres) [6]. From these four site areas, about fifteen boreholes are produced.

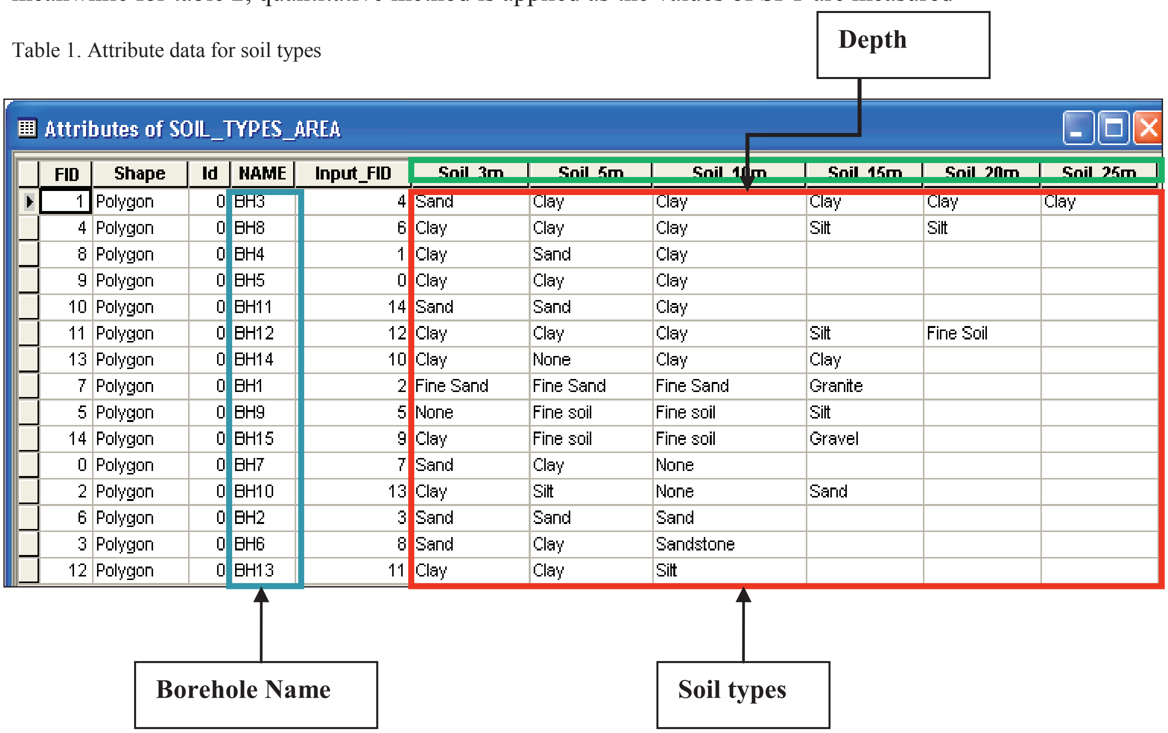
6. Results and Discussion

There are three important results used from ArcGIS which are the result from data integration, data visualization and data presentation.

6.1Data Integration

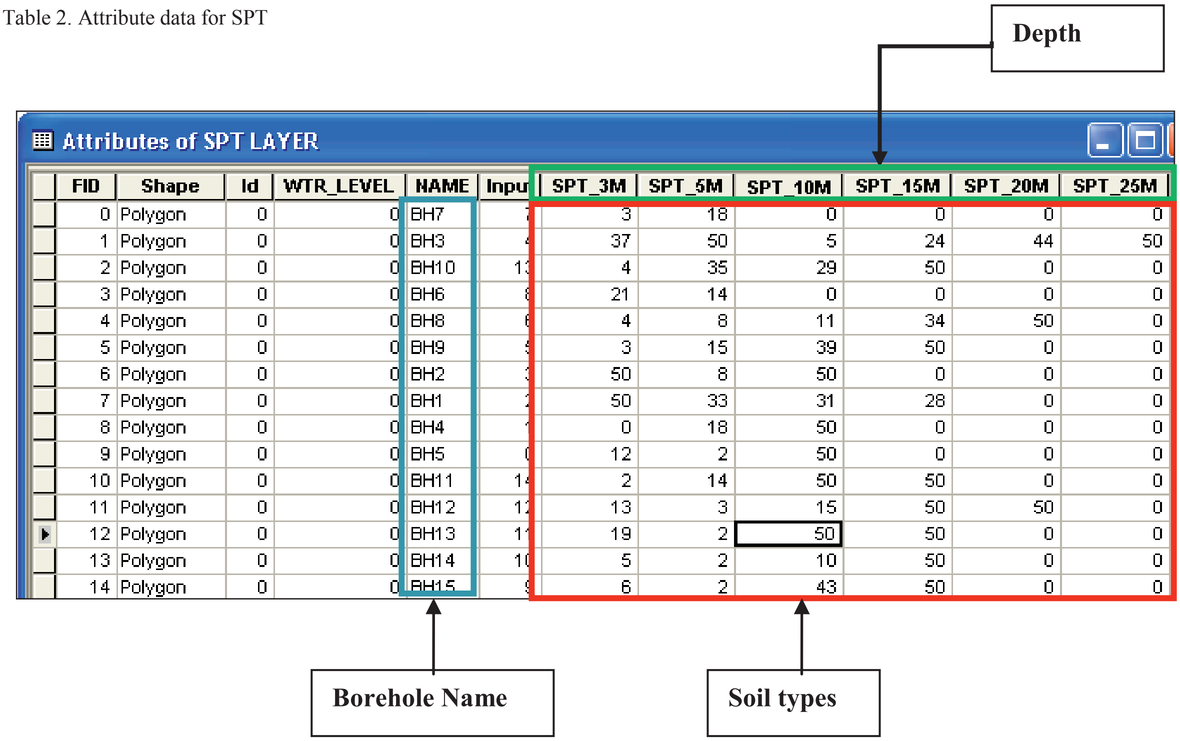
The figures below show the attribute data created using ArcGIS, one of GIS software. Table 1 and 2 represent attribute data for soil types and standard penetration test for different depth from 3m, 5m, 10m, 20m and 25m. In table 1 a qualitative method is applied as it explains the types of soil at different layers, meanwhile for table 2, quantitative method is applied as the values of SPT are measured

Table 1. Attribute data for soil types



FID	Shape	Id	NAME	Input_FID	Soil_3m	Soil_5m	Soil_10m	Soil_15m	Soil_20m	Soil_25m
1	Polygon	0	BH3	4	Sand	Clay	Clay	Clay	Clay	Clay
4	Polygon	0	BH8	6	Clay	Clay	Clay	Silt	Silt	
8	Polygon	0	BH4	1	Clay	Sand	Clay			
9	Polygon	0	BH5	0	Clay	Clay	Clay			
10	Polygon	0	BH11	14	Sand	Sand	Clay			
11	Polygon	0	BH12	12	Clay	Clay	Clay	Silt	Fine Soil	
13	Polygon	0	BH14	10	Clay	None	Clay	Clay		
7	Polygon	0	BH1	2	Fine Sand	Fine Sand	Fine Sand	Granite		
5	Polygon	0	BH9	5	None	Fine soil	Fine soil	Silt		
14	Polygon	0	BH15	9	Clay	Fine soil	Fine soil	Gravel		
0	Polygon	0	BH7	7	Sand	Clay	None			
2	Polygon	0	BH10	13	Clay	Silt	None	Sand		
6	Polygon	0	BH2	3	Sand	Sand	Sand			
3	Polygon	0	BH6	8	Sand	Clay	Sandstone			
12	Polygon	0	BH13	11	Clay	Clay	Silt			

Table 2. Attribute data for SPT



FID	Shape	Id	WTR_LEVEL	NAME	Inpu	SPT_3M	SPT_5M	SPT_10M	SPT_15M	SPT_20M	SPT_25M
0	Polygon	0	0	BH7	7	3	18	0	0	0	0
1	Polygon	0	0	BH3	4	37	50	5	24	44	50
2	Polygon	0	0	BH10	13	4	35	29	50	0	0
3	Polygon	0	0	BH6	8	21	14	0	0	0	0
4	Polygon	0	0	BH8	6	4	8	11	34	50	0
5	Polygon	0	0	BH9	5	3	15	39	50	0	0
6	Polygon	0	0	BH2	3	50	8	50	0	0	0
7	Polygon	0	0	BH1	2	50	33	31	28	0	0
8	Polygon	0	0	BH4	1	0	18	50	0	0	0
9	Polygon	0	0	BH5	0	12	2	50	0	0	0
10	Polygon	0	0	BH11	14	2	14	50	50	0	0
11	Polygon	0	0	BH12	12	13	3	15	50	50	0
12	Polygon	0	0	BH13	11	19	2	50	50	0	0
13	Polygon	0	0	BH14	10	5	2	10	50	0	0
14	Polygon	0	0	BH15	9	6	2	43	50	0	0

6.2 Data visualization

The next results are the site model of 5m depth for both soil types and SPT map. The important tool in this ArcMap such as **Arc toolBox-Analysis Tools-proximity-thiessen polygon** are selected. As a result, the point distribution will generate a polygon like the thiessen polygon. The thiessen polygon is created in the territory based on the distance. Thus, proximity analysis is selected as it divides the surface (original map) to several subdivisions.

From figure 3, at 5m depth, clay type is dominant in most of the boreholes. The various colours show the spatial data with different types of values. Meanwhile, in figure 4, the map shows SPT value. In order to classify the various numbers of SPT, the SPT classification is used. In SPT value map, the result shows that the quantitative map is produced. As shown in figure 4, there are five ranges of classes according to the value of SPT. From these two types of maps, it helps the practitioners in the decision making process as they wish to do the development on the area.

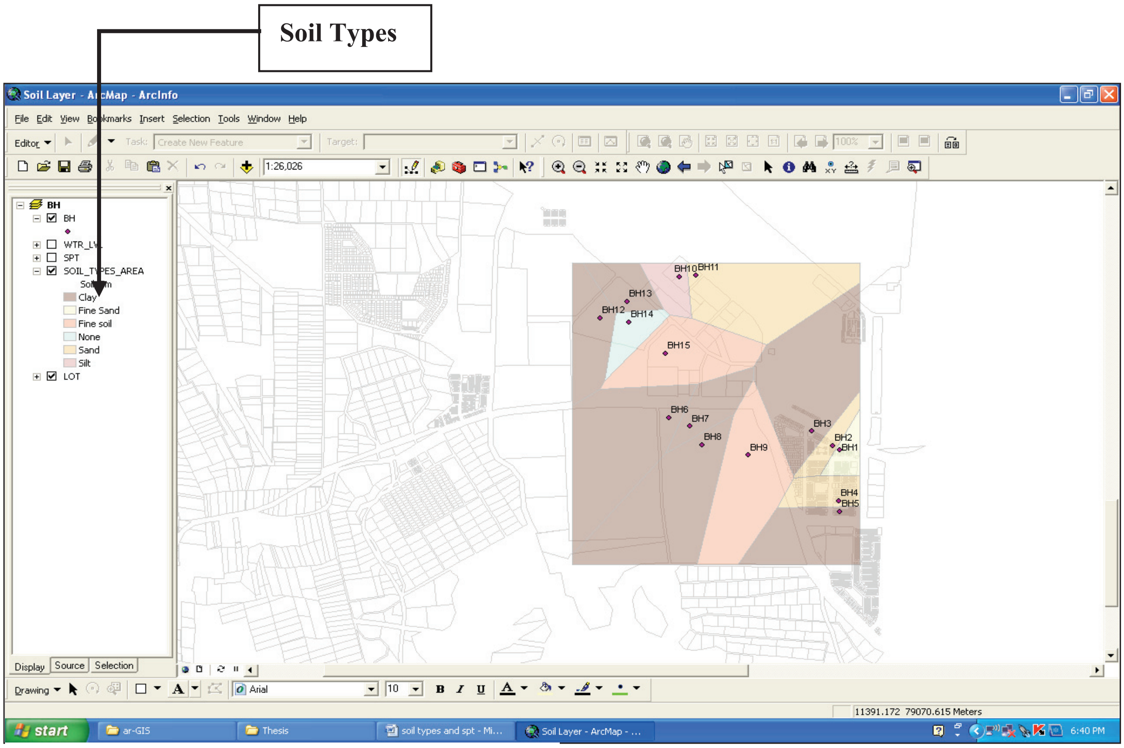


Fig. 3. Soil Types layer of 5 m depth

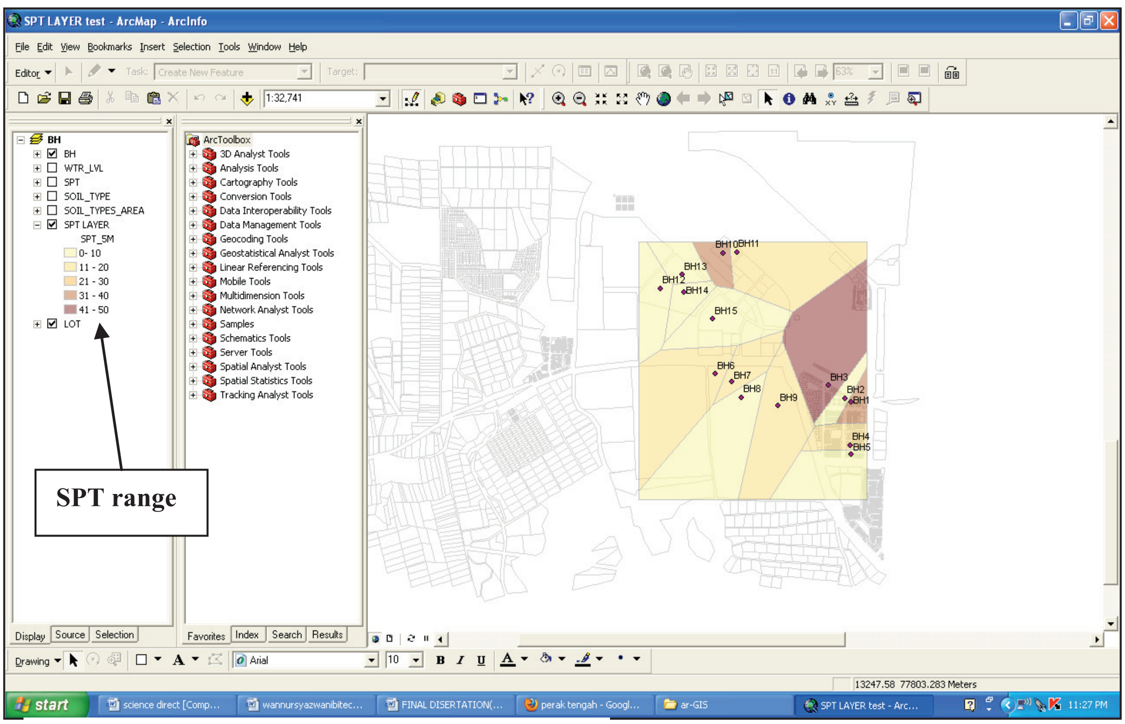


Fig. 4. SPT value at of 5 m depth

6.3Data presentation

After everything is done in terms of database and mapping, the last step is presenting the data to the client or consultant. As many layouts, sizes and designs can be generated from this software, the data can be present into posters, reports and etc. and figure 5 and 6 show the example.

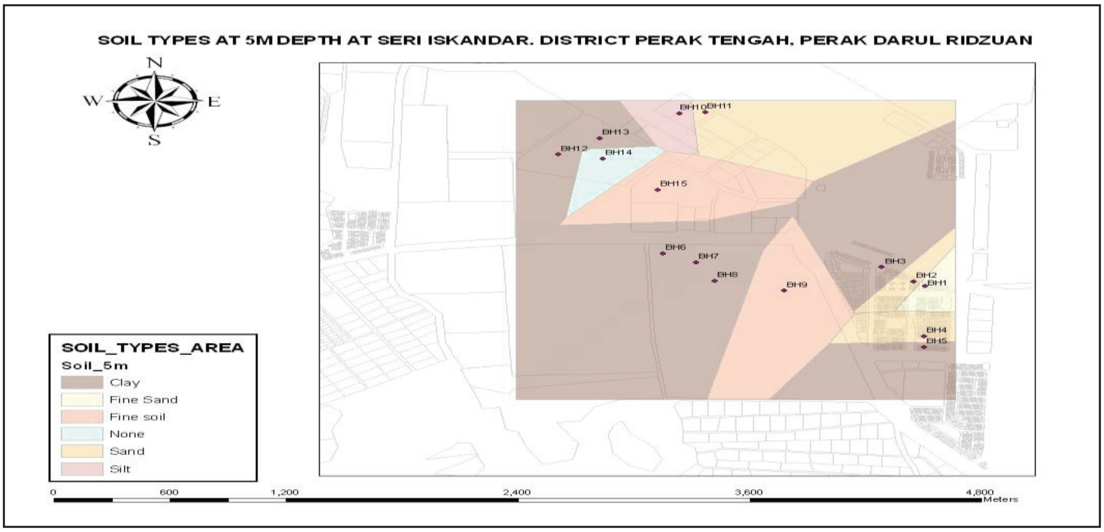


Fig. 5. Map layout design for soil types at 5 m depth

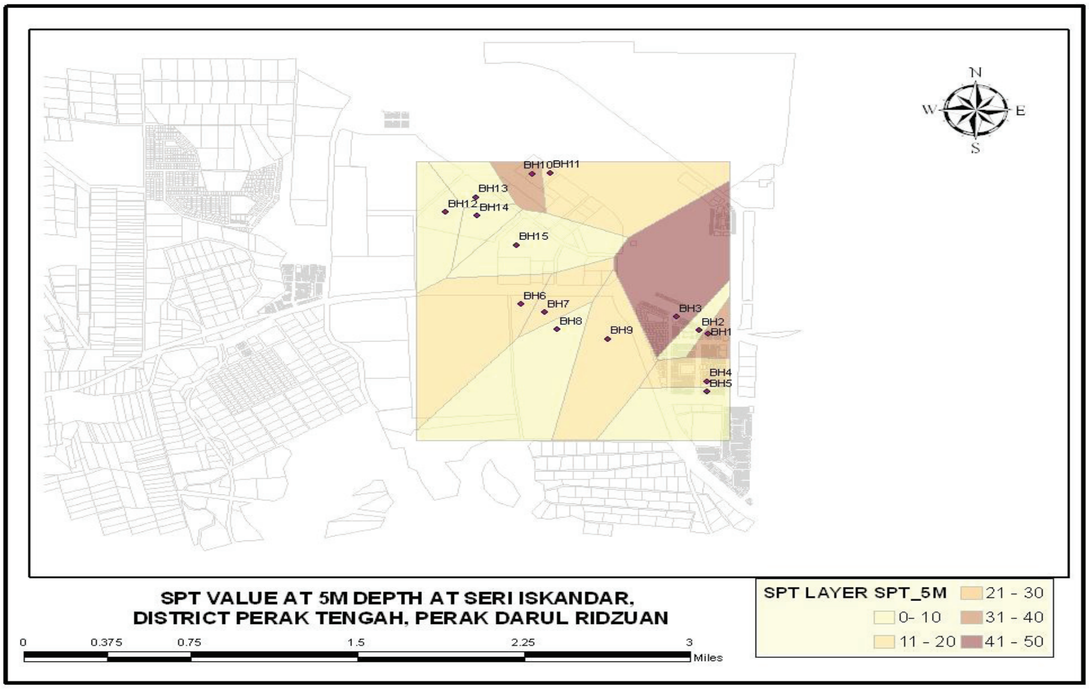


Fig. 6. Map layout design for soil types at 5 m depth

7. Conclusion and Recommendations

There are varieties of data either in text or graphic views, can be generated using this ArcGIS. This shows the use of this software is important as it helps a lot of practitioners especially right decision doing any development soon.

Since GIS is powerful or GIS in decision making, it needs to continue to other researchers to explore and evaluate the system. Moreover, other softwares such as Sketch-up and CAD are recommended to use later as CAD can produce better visualization of the design in construction processes. On the other hand, it helps the system to create 3-dimensional information and indirectly, the capability of GIS is improved.

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