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GIS Based Highway Material Information System

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Abstract : **The highway road making aggregates business significantly influences the economy and the environment and it is in the interest of everybody that cost effective utilization of aggregates occur. In addition, the diverse geographical nature of the country posed special problem in ensuring that a system useful to government, and other stake holders was devised. It is also important that information regarding road making material are collected in one control location for easy retrieval of information. In this research, the coupling of Geographical Information System and Highway Materials Management (HMM) to form HMIS-GIS is discussed in context of Nigeria. The developed system is composed of spatial database, attribute database and analysis and output modules. Example of application of the system is shown using a case study of Abuja, the Federal Capital Territory (FCT) of Nigeria. The database structure for HMIS was developed in Microsoft Access Database Format. Data retrieval maps, which are basically reproduction of the information stored in the HMIS system, were generated to illustrate the capability of developed system.**

1 INTRODUCTION

The exploitation of aggregates and lateritic soils for highway construction has a considerable impact on the economy and the environment, it is therefore important that the utilization of these materials will be cost – effective. However obtaining and maintaining good records is costly and requires professional expertise. But with modern computer technology it is possible to store information systematically and compactly [1]. For example, if Data is available in one central locality, better planning of road construction and maintenance and better management of materials resources can be realized.

In the developed World, aggregate utilization currently averages about 5 tonnes per person per year. In developing countries the figure is less, possibly between 1 and 2 tonnes per person [2]. For Nigeria, with an estimated population over 180 million, an annual aggregate utilization thus is substantial. The location, exploitation, and movement of large tonnages of stone have a considerable impact on the economy and environment. Construction aggregates are of low value and most of their cost to the consumer is for transport from the source to the point of application. Aggregate prices in the United Kingdom average around £6 per tonne, and haulage is of the order of £0. 1 per tonne per km [2].It is thus advisable to locate quarries as close as possible to the construction site, but this is not always feasible and depends on geological conditions.

Highway material availability is determined before commencement of highway construction. A review of the records generally is undertaken before embarking on field surveys but such records often are dispersed, out of date, or of uncertain reliability. Records kept by companies often are commercial secrets. Obtaining good records is costly because it requires professional expertise [3].

Highway Material Information System (HMIS) is a device that allows information to be systematically and compactly collected on desktop PCs, [4]. The information can be analyzed according to specific needs and the results can be produced and distributed effectively. Spreadsheet or database software systems can be used but databases are more efficient at storing and manipulating large amounts of data [4]. Centralization of these data facilitates cost-effective planning of road construction and maintenance and enables better management of existing natural resources. Geographical information system database lends itself well to highway material information, because highway is spatial in nature. Highway Material Information System (HMIS) is a technique that can enable assembling vital information on soil and other road making materials [5]. It is an innovative endeavor in effectively recognizing the significance of spatial information. HMIS provides a base or structure of practices and relationships among data producers and users, which facilitate data sharing and use and it, is also a set of actions and new ways of accessing, sharing and using geographic data [6].

The information about Nigeria soil is scattered in published and unpublished papers, bulletins and journals as well as official and unofficial reports [7].And it needs to be assembled in central location using GIS to show the spread of the information. The lack of a coherent source of information has retarded progress in Engineering in Nigeria, as most lecturers prefer to give easily accessible foreign examples to students and foreign consultants wanting to do businesses in Nigeria go from one organization to another in search of information, [8]. The major aim of this work is to provide Highway Material Information that is accessible to lecturers and professional in a single location.

The research undertaken is to create a Highway Materials Information System (HMIS) in Nigeria using FCT ABUJA as case study. Accordingly, liberal extraction is made from Nigeria Building and Road Research institute (NBBRI)'s report on Engineering properties of subgrade soils in FCT, whichhas comprehensive soil data collected from 63 sample location in FCT. The Database structure for HMIS was populated with NBBRI study results. The developed system is simple to use, can be updated when necessary, and provides the basic information required by highway engineers. It is also transferable to other state in Nigeria.

1.1 Study Area

The Federal Capital Territory (FCT) occupies a land area of 8,000 square kilometers in the central portion of the country. It is situated approximately between latitude $8^0 26^I$N and $9^0 20^I$N. It is divided into 5 phases and sub divided into 6 number Area council each consisting of numbers of Districts. Federal Capital Development Authority (FCDA) is a governmental organization responsible for the development of the Federal capital city (FCC). There is thus a programme for the construction of many new or upgrading of roads in the Federal Capital City. Apart from this, however, there is a need to maintain and from time to time, rehabilitate the existing roads network. It is recognized that value of a highway materials information system will assist in planning of highway constructions.

2 AIM AND OBJECTIVES

The aim of this research is to develop a GIS based Highway material Information System, HMIS. While the objectives of HMIS are:

- ✓ Select appropriate GIS software and creating of a database structure for the information system.
- ✓ Digitization of the map of the study area and
- ✓ Generating data analysis map for given scenarios

3 MATERIALS AND METHOD

3.1 Development of Highway Material Information System (HMIS)

The development of GIS based highway material information system for FCT Abuja is divided into three major phases. The first phase includes planning and design phase in which resources and limitations are examined and then the potential GIS activities are identified and selected. Second phase is implementation phase which consists of developing the various components of the HMIS-GIS based on the implementation plan developed in the first phase. Implementation assumes "ideal state" that is evolved from current state with a visionary view of the future that is not limited by constraint. The final phase is operation phase where application of the developed system is demonstrated.

3.2 Major Activities

Five major activities were involved during the design /implementation phases of the highway material information system. The activities are:

- ✓ Specification of the study region (case study)
- ✓ Development of the base map
- ✓ Database development
- ✓ Development of the HMIS-GIS system modules
- ✓ Selection of the GIS software

The manner in which these activities have been applied in the case study reported herein is described in the subsection that follows.

3.2.1 Study region

For this work, the geographical region considered for development of data base is the Federal Capital Territory (FCT) Abuja Nigeria. The map of FCT is shown in Figure 1

3.2.2 Development of the base map

A base map contains geographic was feature used for referencing location. The base maps obtained for the case study are Digital (AGIS 2004) FCT map in Auto Cad format (AGIS) and soil/sample location maps in PDF format (NBRRI 1987) as shown in Figure 1, 2 and 3 below. These base maps were scanned, digitized and geo-referenced to a standard geographical referencing system U T M (Universal Transverse Mercator) coordinate system.

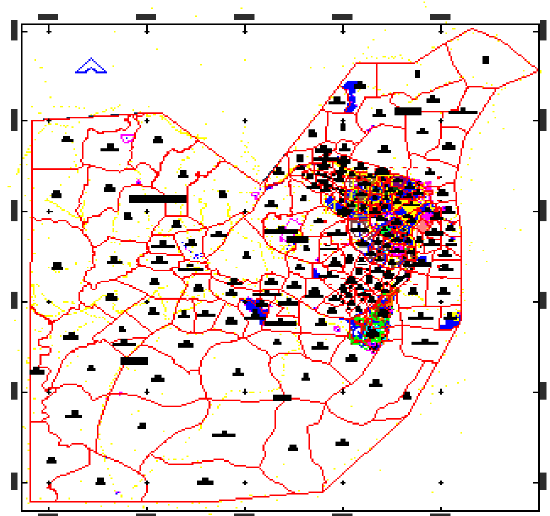


Figure 1:Federal Capital Territory Abuja, Nigeria Map

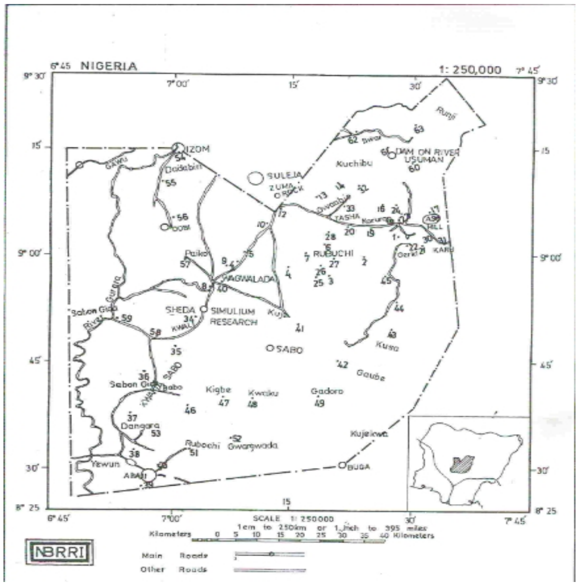
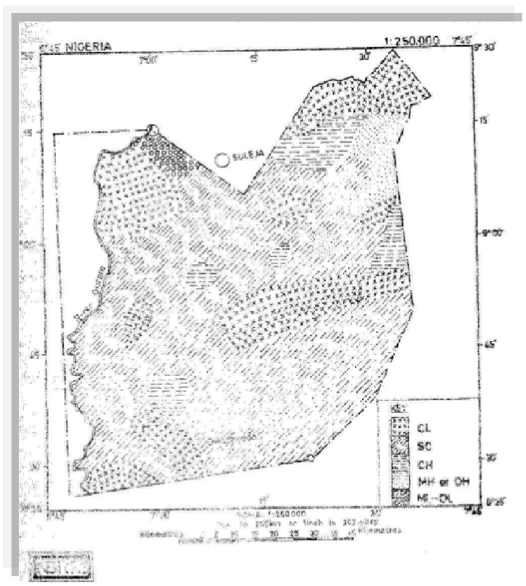


Figure2: Sample Location Map of soils from FCT



Source: NBRRI

Figure 3: Simple Engineering Geological map ofFCTshowing Subgrade soil distribution in pdf format

3.2.3 Data base development

The highway material information system basic design requires the development of a Geographic Information System data base. Four carefully prepared data forms were used to generate data items, namely, Highway construction material inventory, laboratory Test results, Borrow pit material data, sample location and Highway construction material inventories.

3.2.4 Development of the HMIS-GIS system modules

The system consist of several modules that interact with each other to carry out the required analysis and presentation, these modules are:

- ✓ Spatial database module
- ✓ Attribute database module
- ✓ Analysis and
- ✓ Output generation modules

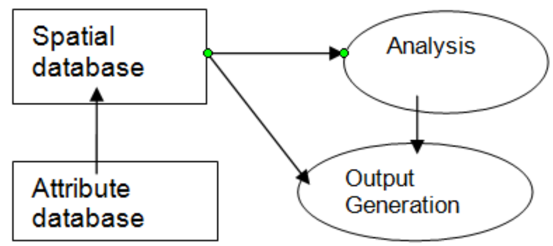


Fig.4 HMIS-GIS System Modules

3.2.4.1 Spatial data base module

The spatial data base module includes data describing the distribution of geographic features in the study area. The land base in the system consists of the following feature:

- ✓ Region border (FCT boundaries)
- ✓ District's boundaries
- ✓ Material sections (area) boundaries, Roads line and
- ✓ Sample location points.

Each of the features were digitized and stored in a separate layer by appropriate feature class that is **point**, **line** or **polygon**. The boundaries are digitized as polygon features and in the case of sample locations, points are used as the features while lines were used for roads.

3.2.4.2 Attribute database module

This module includes the representative non-geographical information associated with each administrative area and material sections. These are represented by the feature described below.

Administration area: **-** This is represented by District names and sample location. All of these attributes were entered and saved in one data base file.

Material sections: **-** These are represented by material area and types of data

HMA properties: **-** These are attached to a road system; in this scenario road A2 of Federal road systems that intercept FCT area was used.

The sets of data are entered and stored in the separate database files. This separation of data records reduces the burden of maintaining and using files with large amount of data.

4 DATA ANALYSIS AND DISCUSSIONS OF RESULTS

4.1 DEVELOPMENT OF HMIS-GIS SYSTEM MODULES

The HMIS-GIS System was designed in modular form which permits data to easily be updated when available. For illustration purposes, the HMA properties for a typical road pavement have been attached to Route A2 of the Federal Roads Trunk System. Liberal extractions of HMA properties have made from TRL (1993). The database structure is scalable to quality of information available. The following sections discuss the analysis and application of HMIS-GIS System using the NBBRI data only.

4.2 Querying HMIS-GIS Database

4.2.1 Identifying objects

Features in the database can be identifying using identifying tool in the ArcMap. Figures 5 and 6shows screen short of material being identified and sample locations in all sixty-three sample point collected (NBBRI) respectively.

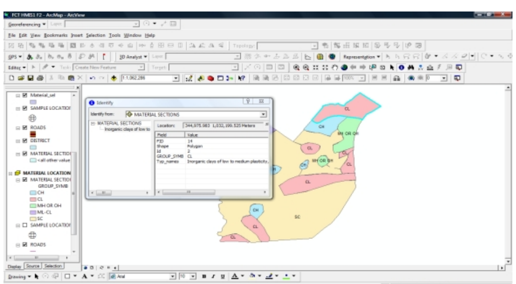


Figure 5: Screenshot of Identifying Tool Displays

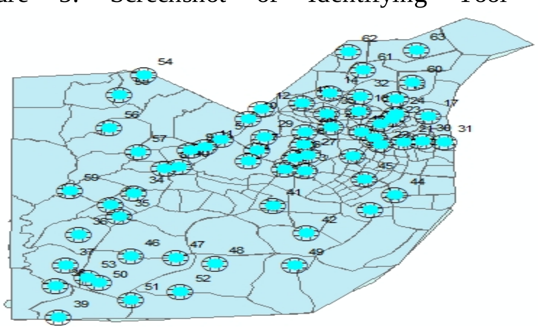


Figure 6:Screenshot of Identifying Tool Displays

4.2.2 Finding objects

Features in the database can be found using finding tool in the map. Figure 7 shows screen short of materials being found. Type in the string that you want to search for the window this expands to reveal the findings.

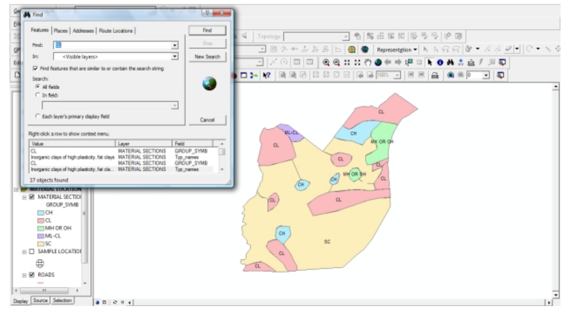


Figure 7: Screenshot of Finding Tool Display

4.3 Available Selection Tools

There are four ways to select graphics in ArcMap

- ✓ interactively
- ✓ by Attribute,
- ✓ by Location
- ✓ by Graphics

Interactive selection method:

This option offers different selection methods, including 'create a new selection', 'add to current selection', remove from 'current selection'.

Option further refine the interactive selection methods, which includes selecting features that are spatially or completely within the box or graphic, selecting features that are completely within the box or graphic, and selecting features that the box or graphic are completely within.

Select by attribute

With this option, one can write a selection statement; using a 'where clause' from Structured Query Language (SQL) in the selection menu's select By Attributes dialog. For example, in a material database, and you want to find districts that A-2-7 group soil classification system falls. We could select the district with this expression:

Sample location layer for 'AASHTO_CL' = 'A-2-7'. Figure 8 shows the display.

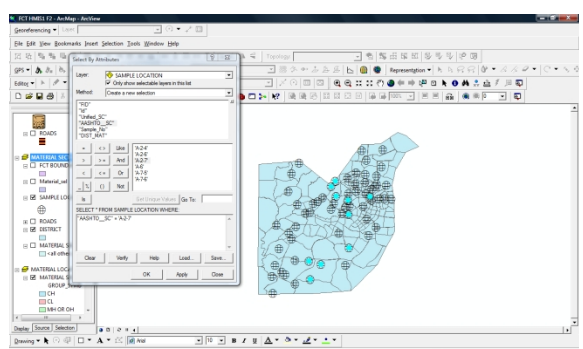


Figure 8: Screenshot of Selection by Attribute display

Selection by location

Here, feature from a certain layer can be selected by features from another. This is considered a spatial query tool.

Suppose we want to know how subgrade material types intercept the roads alignments. If the selection by location tool is used, you could then locate all the type of materials along the roads alignment. This is as shown in figure 9 below.

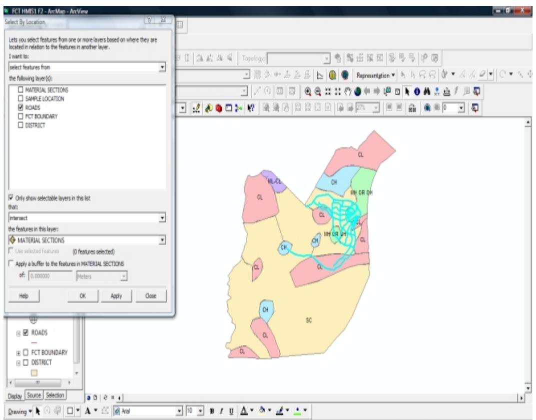


Figure 9: Screenshot of Selection by location display

4.4 Working with Attribute Database tables

Tables

A table contains formation descriptive information. In ArcGIS, the information in a table is generally associated with spatial data, such as a feature attribute table but can also be independent of any spatial data)e.g. non spatial statistical data.

The feature attribute table consists of fields (also known as column or items). Each field represents one type of descriptive information. Each row (also known as a record) contains the attributes of one feature in the data set.

4.4.1 Joints and relations

ArcMap provides two methods to associate data stored in tables with geographic features: 'joins and relates'. When joining two tables, 'joins' the attributes from one onto the other based on a field common to both tables. In the case of 'relate' the relationship between the two tables are defined based on a common field but attributes of one to the other are not appended.

Two tables are joined when the data in the tables has a one – to- one or a many – to –one relationship. And two tables are related when the data in the table has a one – to – many or many – to – many relationship (e.g. our map displays a parcel database, and have a table of owners; a parcel many have more than one owner, and an owner may own more than one parcel).

Joins and relates are reconnected whenever map are opened.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research discusses the coupling of GIS and HMIS in Nigeria with a case study of Federal Capital Territory (FCT) Nigeria. HMIS-GIS modules consisting of spatial data base module, Attribute databasemodule, Analysis and Output generation modules.

HMIS of the Federal Capital Territory developed would be found invaluable by the highway engineers, planners, contractors and consultants'and other stake holders working in the area. The system is user friendly as the numerical data and maps are combined via Geographic information system software packages. The benefit of a comprehensive database system is that it promotes cost effective utilization of construction materials.

5.2 Recommendations

Base on the result of coupling of HMIS and GIS to HMIS-GIS system, the following recommendations are made

1 The HMIS-GIS system developed in this research represent a framework for material information system. A more robust system that will incorporate material classification system is recommended.

   There is scanty information available for material in Nigeria. It is also recommended that research into road making material should be undertaken.

2 The soil map produce in this research was based on results of experiment carried out by NBBRI in the 1980's. It is recommended that these experiments be updated by NBBRI.

3 A limited application of HMA properties in HMIS-GIS was made. It is recommended that a more extensive application of HMA properties be carried out, as well as research developments in HMA are incorporated in the HMIS-GIS System.

REFERENCES

[1] Olowosulu A. T. (2005) Geographical Information System as a Tool for Highway Pavement Management *Technical Paper for National Civil Engineering Conference and Annual General Meeting* No. 3 (2005), pp. 49-53 Abuja – Nigeria

[2] Woodbridge, M E (1997). The Development and Value of a Construction material Information System.*Annual Roads Convention on Road Transport:* The key to Development, Dar essalaam, 24-26 september 1997.

[3] Clare K. E, B. Sc, A. R. I and Beaven P. J. (1962) Soils and other Roadmaking Materials in Nigeria *Road Research Technical paper* No. 57. Pp. 1-4

[4] Rioux M T, T W and Woodbridge, H. (1998) Review of Current Geographic Information Systems Technology for Txt DOT Pavement Management System *Research Report Number 1747-1, by Centre for Transportation Research,The University of Texas at Austin*

[5] Seth Pelepko, (2008), Geographic Information System (GIS)-Based Management *Construction Aggregate Resources in the Common Wealth of Pennsylvania,* A Research Proposal, 18 May, 2008.

[6] ESRI (2007), GIS for Public works, Building a Public Works Information System, ERSI Company, California, USA.

[7] Omanges G. N., Nnamna S. K., Ayodeji A. O. and Aitsebaomo F. O..(1987) Engineering Properties of Subgrade Soils in Federal Capital Territory of Nigeria.*NBBRI Report* No. 15 (1987), pp.26.

[8] Ogura T. M. (2006). Pavement Design, Construction And Maintenance. Malthouse press limited, Lagos, pp 264