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Applicability Aspects of Geoinformatics in Geotechnical Engineering

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***ABSTRACT** : This paper deals with the Geoinformatics applications used in various Construction technology in Civil engineering as well as Geotechnical engineering.Geographic Information Systems (GIS) have been used in many fields of Science; one of these fields is civil engineering. Geographical Information System is a very effective tool for capturing, displaying and analyzing geographically referenced data. GIS has shown a very important role in various aspects of geotechnical engineering including preliminary site investigations, identification of potential project barriers (like mines etc), interpolation for obtaining data at inaccessible locations, data visualization, data processing as well as preparation of post processing graphs and charts. Geographic Information System (GIS) is a Computer based tool used to solve engineering problems related to spatial data. GIS, its complete potential to construction industry has not been realized. GIS technologies have the potential to solve space related problems of construction involving, integration of information, urban planning, and project site selection, soil studies, Hydrology and environmental studies. Proper use for these tools necessitates training the GIS techniques. This paper reviews the primary components and capabilities of GIS technology and shows how it is used in many civil engineering applications including infrastructure management, transportation, land use planning, water resource engineering and environmental engineering*

***Keywords:** Geoinformatics, Geographic Information Systems (GIS), fine sand, permeability, ceramic tiles*

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I. INTRODUCTION

Geoinformatics is the science and the technology which develops and uses information science infrastructure to address the problems of geography, cartography, geoscienceslocations and related branches of science and engineering.

Geoinformatics has been described as "the science and technology dealing with the structure and character of spatial information, its capture, its classification and qualification, its storage, processing, portrayal and dissemination, including the infrastructure necessary to secure optimal use of this information" or "the art, science or technology dealing with the acquisition, storage, processing production, presentation and dissemination of geo-information".

Geomatics is a similarly used term which encompasses geoinformatics, but geomatics focuses more so on surveying. Geo-informatics has at its core the technologies supporting the processes of acquiring, analyzing and visualizing spatial data. Both geomatics and geoinformatics include and rely heavily upon the theory and practical implications of geodesy.

Visualization for easier understanding: Two most confusing terminology are; Geomatics and Geoinformatics. If we transform two terminologies into figure: 1, it will be like following:

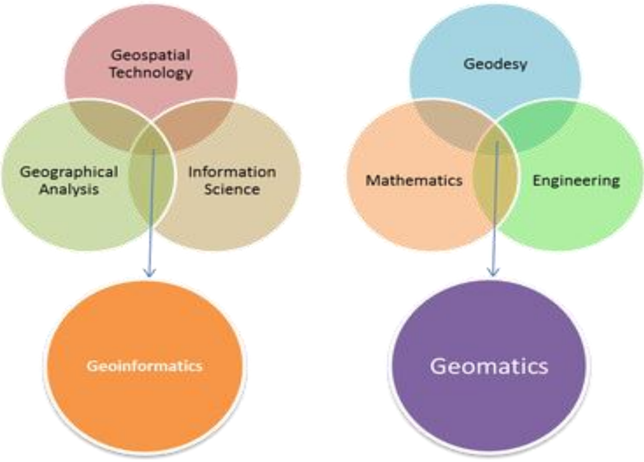

Figure 1: Geoinformatics and Geomatics

Geioinformatics research involves using modern information methods andtechnologies, application programs, databases, the internet and software development constitute the foundation for the deployment of Geoinformatics. In time-line, GIS is the oldest brother, following by Geomatics, and the youngest is Geoinformatics, as shown in the figure: 2 below.

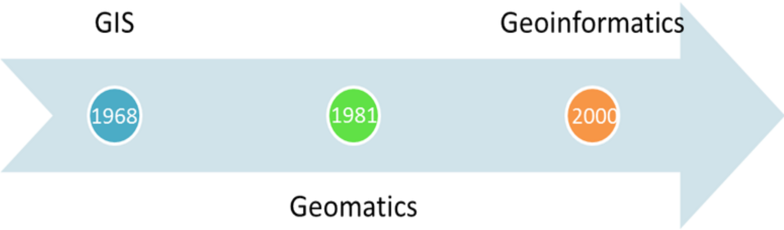

Figure 2: Time-line ofGeoinformatics, Geomatics and GIS

Fine sand stabilization with the use of ceramic tiles as admixture has great scope for the construction of embankment. The aim of present work is the beneficial and economical utilization of such wastages for improving properties of fine sand. Utilization of ceramic tiles waste for improvement of soil propertiesis a sustainable and cost-effective technique. Due to warping, a huge amount of broken ceramic tile waste is produce every year from manufacturing unites.Hence it was thought to be utilized of ceramic tile waste as an admixture with which fine sand can bestabilized. On the other hand, the problem of the disposal of Ceramic tiles waste can be overcome by using it for stabilization of fine sand.

II. VIEWS OF THE GIS

2.1 Database View

The Database View: A GIS is a unique kind of database of the world-a geographic database (geo database). It is an "Information System for Geography." Fundamentally, a GIS is based on a structured database that describes the world in geographic terms.

2.2 Map View

A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Maps of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information.

2.3 The Model View

A GIS is a set of information transformation tools that derive new geographic datasets from existing datasets. These geo-processing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets.

III. APPLICATION OF GIS

An advanced information system like GIS plays a vital role and serves as a complete platform in every phase of infrastructure life cycle. Advancement and availability of technology has set new marks for the professionals in the infrastructure development areas. Now more and more professionals are seeking help of these technologically smart and improved information systems like GIS for infrastructure development. Each and every phase of infrastructure life-cycle is greatly affected and enhanced by the enrollment of GIS.

3.1 Planning

In planning its major contribution is to give us with an organized set of data which can help professionals to combat complex scenarios relating to the selection of site, environmental impact, study of ecosystem, managing risk regarding the use of natural resources, sustainability issues, managing traffic congestion, routing of roads and pipelines etc.

3.2 Data Collection

Precise and accurate data is the core driving factor of any successful project. GIS is equipped with almost all those tools and functions that enables user to have access to the required data within a reasonable time.

3.3 Analysis

Analysis is one of the major and most influential phases of infrastructure life cycle. Analysis guides us about the validity or correctness of design or we can say that analysis is a method which supports our design. Some of the analyses that can be performed by GIS are:

- Water distribution analysis
- Traffic management analysis
- Soil analysis
- Site feasibility analysis
- Environment impact analysis
- Volume or Area analysis of catchment
- River or canals pattern analysis
- Temperature and humidity analysis

3.4 Construction

It is the stage when all layout plans and paper work design come into existence in the real world. The GIS helps the professionals to understand the site conditions that affect the schedule baseline and cost baseline. To keep the construction within budget and schedule GIS guides us about how to utilize our resources on site efficiency by:

- Timely usage of construction equipment.
- Working Hours
- Effects of seasonal fluctuations.
- Optimizing routes for dumpers and concrete trucks
- Earth filling and cutting
- Calculation of volumes and areas of constructed phase thereby helping in Estimation and Valuation.

3.5 Operations

Operations are controlled by modeling of site data and compared by the baselines prepared in planning phase. Modeling of site may be in the form of raster images or CAD drawings. These can help us to keep track of timely operations of activities.

IV. GIS APPLICATION IN GEOTECHNICAL ENGINEERING

In geotechnical practice, GIS can be used in at least four ways: data integration, data visualization and analysis,planning and summarizing site activities, and data presentation (Player, 2006).

4.1 Data Integration

In geotechnical practice, the conventional approach to data integration for working site model creation can be anarduous task. Existing data sources are found in a variety of hard copy, electronic, and paper formats such asmaps, plans, reports, books, aerial photos, etc. Integrating these data together with photos, notes, borings, andother site-specific data can require a significant effort. Less time may be spent on data analysis and acquisitionthan on data integration. Also, making copies of the work may take as much time as the initial production andyield unprofessional looking or illegible results. Using GIS as a tool can greatly improve the efficiency andeffectiveness of these efforts.

GIS provides tools for integrating these multiple data types such as raster format data (e.g. photos and scannedmaps) and vector format data (e.g. computer-aided drafting (CAD) files, northing and easting point files,drainage lines, etc.). This data may consist of readily available existing information such as soil surveys andtopographic maps, or project specific information such as proposed centerlines, project extents, survey points,aerial photos, and site investigation results. Many federal, state, and local agencies provide wide-ranging typesof GIS data for download on the Internet.

When integrating data from various sources, two important considerations are data limitations and datacoordinate systems. Each data set has inherent limitations. The source of the data must be considered; positionalaccuracy may vary from tenths to hundreds of meters, and the applicability of the data to their intended use alsoneeds to be considered. The site model is only as accurate as its components. In some cases, the data accuracymay be inadequate for detailed design, however it may be more than adequate for preliminary investigations.

For disparate data sets to be integrated, each must be converted to the same base coordinate system. Readilyavailable data sets may utilize a coordinate system such as the Universal Transverse Mercator (UTM) withvarying datums. Project specific data sets may use a standard coordinate system (such as State Plane) or aproject specific system. Most GIS programs contain routines for performing coordinate transformationsrelatively simply to enable integration of data sets having different coordinate systems.

4.2 Data Visualization and Analysis

After data has been integrated into a working site model, the model can be used to visualize site data andanalyze the site. This model is continually refined as more information is gathered and integrated into theexisting model. One of the primary benefits of using GIS in this effort is its flexibility. Data layers can becombined and turned on and off as needed. Data can be symbolized to graphically represent relationships andqueried to filter out extraneous information. Spatial queries can be performed to identify the relationshipsbetween features and help to determine engineering conclusions. For example, buffers of varying distancesaround features can be created to identify other features within critical proximity (e.g. drinking water wellswithin a specified distance from a leaking underground storage tank) or create an exclusion zone (e.g. notadvancing soil borings within 8 meters of a sensitive wetland).

GIS can be used to identify project constraints and potential barriers to successful project completion early inthe design process. Early identification of these barriers can avoid costly and time-consuming changes aftersignificant site design has been completed. Depending on the data sets, some potential geotechnical issues thatcan be identified include weak and/or compressible soils (e.g. from soil surveys); potentially unstable slopes(e.g. from topographic maps); distance to and type of borrow sources (e.g. from road networks and soil surveys);geologic hazards (e.g. from aerial photos, geologic and topographic maps, soil surveys); environmental hazards(e.g. from underground storage tank location maps); etc.

4.3 Planning and Summarizing Site Activities

After identifying in the office potential problem areas or areas needing further study, GIS can be used for bothplanning site activities and to integrate data collected during these activities into the site model, thus furtherrefining it. In the GIS site model, boring and test pit locations can be planned, field reconnaissance locationsnoted, and maps, layouts, and figures can be created for use by field personnel. Global Positioning System(GPS) coordinates and/or project specific coordinates for investigation locations can be exported to guidesurveyors and field staff in locating features and laying out investigation programs.

During field work the locations of features can be captured using GPS, swing ties, offset distances from knownfeatures, etc., which can then be imported to GIS for integration into the site model. Digital photos taken duringfield activities can be linked to map features. Descriptive database tables can be created and linked to boringlocation maps to provide searchable features or scanned boring logs can be linked for retrieval through GIS.

4.4 Data Presentation

Another benefit of using GIS is data presentation. Layouts can be created for use in reports, papers, posters, andpresentations in varying page sizes and formats. Labels, symbols, scale bars, north arrows, and text can be addedto maps to provide clarity and improve information transfer. This capability provides an excellentcommunication tool between office and field staff, consultants and their clients, field crews and utility locators,etc. Professional looking figures can be created for reports that are editable and reproducible (Player, 2006).

V. CONCLUSIONS

Geographic Information System (GIS) and satellite-based Remote Sensing (RS) have greatly improved our ability to collect, store, analyze and utilize geographical information. GIS and RS is a system of hardware, software and procedures designed for support, capture, management, manipulation, analysis, modeling and display of spatially referenced (geographical) data. GIS and RS professional's finds career opportunities in environmental impact assessment, biodiversity assessment, natural resource management, environmental modeling, town planning, public utility work and many socio-economic development programmes. GIS professionals make the geographic information accessible to scientists, planners, decision makers, managers and to general public. Knowledge of geo-informatics is becoming a driving force behind the overall socio-economic development of the nation. There is a wide gap in demand and supply of GIS professionals. India is the one of the most preferred outsourcing destination for GIS related work in the world.

Geo-informatics services are growing by 10-15% per annum. There is great demand for GIS professionals GIS companies in India and many other global companies. Geo-information system have a variety of uses viz. agriculture, archaeology, environment, geology, health, land information system, military, urban and rural development, transpiration, telecommunication, power, water resource, natural and manmade disasters, oil and natural gas, banking and insurance, business geographics, mobile mapping, etc. GIS and RS have application in resourcemanagement especially of water, land, soil, vegetation, etc.

A few generalized conclusions are summarized below:

The advantages of GIS in this paper are

- It is provides the accuracy and saves time in the production of map for the project. And it enables to have special maps with different scales at low cost. And these maps act as document for the project, which produced to it and is, used in the design stage, per- tender and estimated cost. This is what the construction manager needs in his job.
- The features of GIS enable the engineer to operate the model by incorporating any non-uniform data. And GIS is used in performing the analysis of large amount of data and Decision making .The database which built (created) in the GIS is very useful for the project especially In the planning stage because the large amount of information save and easy Manipulate with specially accrue for it.
- The use of the digital map which is produced in GIS for the project saves the time and up-date the information at any time if there is any change in it.
- The data which is digitally treated and saved as a digital reference for the project can be used as reference for another project.
- There is always a trend to verify the time and the effort in any civil engineering project. From this fact suggested advice to the civil engineering department to widen the Information about the remote sensing techniques and GIS.
- It is important to start teaching the GIS techniques in department of civil engineering because these techniques are very useful for the information which any civil engineering project needs such as, urban planning, project site selection, soil studies, Hydrology and environmental studies.

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