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Advances of Space Technology in Geotechnical Studies

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ADVANCESOFSPACETECHNOLOGYINGEOTECHNICALSTUDIES

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Advances of Space Technology in Geotechnical Studies

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Abstract- Geographical Information Systems (GIS) is the technology where geospatial data can be represented in the graphic form integrated into the geotechnical, geologic and hydrologic information routinely used by geotechnical engineers. A GIS makes available a wide of forms of spatial data to be integrated, selected and sorted with any number of physical, chemical or any possible environmental factors.

I. Introduction

There is no doubt that Remote Sensing method is the instrument for development of GIS. It is obvious that GIS technology developments need collection of initial data based on aero and space information. A Remotely Sensed information required for GIS technology applications needed to be processed depending of kind of problem necessary to be solved.

Major areas of space science and technology applications in study of soil are following:

- Geotechnical Investigations;
- Foundations;
- Earthquake;
- Landslide Studies;
- Application of remote sensing & GIS;
- Geological & Geophysical Investigation;
- Industrial waste & contaminated soil.

Some of the important areas in geotechnical investigations can be classified as [1]:

- Geotechnical instrumentation for performance evaluation;
- Mobile drilling rig for soil and rock exploration;
- Sub-surface profiling by Engineering Seismograph, Resistivity meter and Georadar;
- Total Station for surveying & monitoring;
- Computer controlled Triaxial and Consolidation Testing System;
- Computer controlled Laser Particle Size Analyzer;
- Petrological microscope;
- Foundation Pile Diagnostic System;
- Strong Motion instruments;
- Digital Image Processing and Geographical Information System;

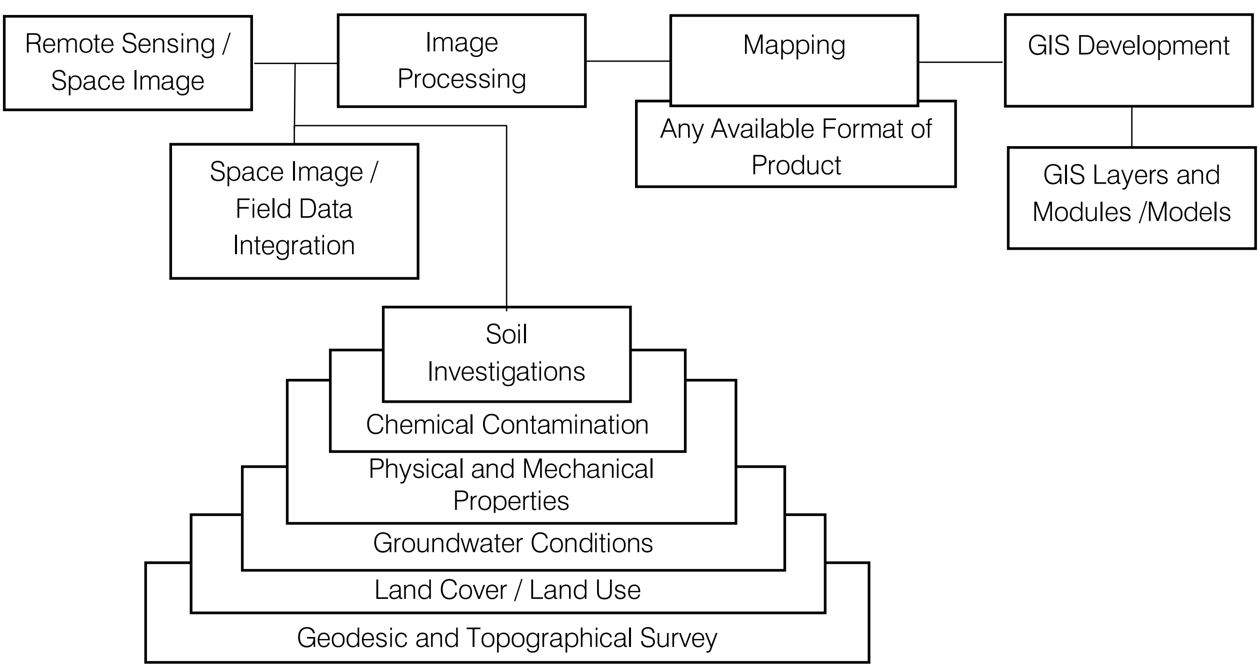

Figure 1 : A GIS development in geotechnical study

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II. Data Access in gis Developments

It is important stage of GIS developments to start from the segments of data collections based on Remote Sensing method use (Figure 1). A quality of final product in geotechnical investigations depends how correct and right Remote Sensing data shall be used for GIS technology application.

The fact is that the most expensive and time consuming component of GIS has been data access due to the lack of sufficient information in the area for the reason of limited store of geotechnical information in electronic format. There is number of problems even with available information which needed to be edited as some objects on older maps has to be corrected and specified. Some paper maps can be scanned electronically as raster images, which convert map lines to a series of points and digits. Many GIS were formulated to emphasize spatial relationships between mapped objects and such boundaries are usually represented by a line. The line may be a road, mapped boundary, or some sort of link between two other points of interest. Civil infrastructure elements, such as roads, may not be reflected accurately, in terms of absolute scale, but simply represented by a default line width(s) coded into the mapping software. This condition creates limitation in application mainly in GIS developments especially in dynamic change studies where necessary correct base information for correlation and comparison old and existing current situations.

III. Stage of Data Integration

GIS makes possible to mix or integrate information that would otherwise be difficult to associate through other means. These could be soil chemical contamination, physical-mechanical properties in the form of scanned, geo-referenced and sandwiched with other kinds of data, such as topographic and geologic maps.

IV. Data Structures

Digital geospatial data is collected and stored in many different formats. A GIS must be used to convert data from one type of structure to another. Satellite data can usually be "read" into the GIS in a raster format. Raster data files consist of rows of uniform cells coded according to data values. Raster files can be manipulated quickly by computer, but they are often less detailed and may be less visually appealing than vector data files. Vector digital data files have been captured as points, lines (a series of point coordinates) or areas (shapes bounded by lines). A typical vector file would be tax assessor's parcel maps [1, 2].

V. Data Modeling

GIS allows two and three-dimensional characteristics of the Earth's surface, subsurface or atmosphere from geospatial data. Some common examples of data modeling would be creating isohyets based on different initial information sources. These data models can then be combined with other types of information layers in the GIS [3,4]. Some common examples would be combining measured different information sources with elevation, or the thickness of a certain geologic formation (isopach) as compared to the depth to its upper surface (isopleth) where available.

VI. Outcomes

One of the important issue of GIS is its ability to produce pleasing graphics that convey analyses to decision makers and the public at-large. These analyses usually begin with entering any codified restrictions, such as structural setbacks. An attributes included can then be electronically combined and weighted according to arbitrary values set by the body ordering the analysis. Such kind of developed hybrid data in the form of maps frustrate many engineers because they can arbitrarily be weighted to restrict or even eliminate development from areas where the project's detractors reside on adjacent parcels with all the same attributes.

VII. Geotechnical Investigations

Filed measurements in geotechnical investigations are very important in development of GIS technology. It is considering number of implementations in the selected areas needed to be investigated.

a) Area selected for geotechnical investigations

It has been selected area of Sangachal district, Baku, capital of Azerbaijan located on the coast of the Caspian Sea 45 kilometres (28 mi) south of Baku, Azerbaijan. There is the Sangachal Terminal is an industrial complex consisting of a natural gas processing plant and oil production plan. It makes very attractive and vital to monitor of the area with contamination as more as possible information in point of environmental and ecological condition assessment. In this case geotechnical investigations can be play a significant place in collection and processing of data based on use of modern technology applications.

Remote Sensing method and GIS technology is key instrument in consideration of approaches of data collection for decision makers as well as suitable way in data storage for the future access.

Shah Deniz flare area is located adjacent to the Sangachal Terminal and lies within the Garadagh District, which includes Baku and then extends south along the Caspian coast to the south of Alyat. The Garadagh District was established in 1923 and comprises five city settlements including Lokbatan, which is the District's administrative center. The four communities in the immediate vicinity of the Terminal (Sangachal Town, Umid, Masiv3 and Azim Kend) are

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likely to be the most directly affected by the socio-economic impacts of Shah Deniz flare project.

b) Field Geotechnical Works

i. *Drilling and sampling*

Drilling at the Shah Deniz flare area started immediately after realization of detailed geodetic and topographic investigation. During the drilling process, the samples were obtained and the whole information about the site, depth of boreholes, date and number of samples were recorded.

ii. *Standard penetration test (SPT)*

The SPT method covers the determination of the resistance to soils at the base of a borehole to the penetration of the split-barrel sampler when driven dynamically in a standard manner, and the obtaining of a disturbed sample for identification purposes.

iii. *Soil electrical resistivity test*

Soil resistivity is dependent on moisture content and temperature as well as on soil constituents, so that it can vary seasonally and progressively due to the hydrological trends such as changing water tables or continuous drainage.

Soil resistivity is generally measured by driving three equally spaced test spikes to a depth of up to 1m, the depth not exceeding 5% of their separation a. It's important to ensure that their resistance areas do not overlap. Current is passed between electrode X, the one being tested, and an auxiliary current electrode Y. The voltage drop between electrode X and a second auxiliary electrode Z is measured and the resistance of the electrode X is then the voltage between X and Z divided by the current flowing between X and Y. The source of current and the means of metering either the current and voltage or their ratio are often, but not necessarily, combined in one device.

VIII. Laboratory Tests

There is no doubt that collected field data for geotechnical investigation required to be processed in laboratory condition. The following tests have been conducted for soil samples collected from investigated area.

a) Moisture Content

The water content is determined by drying selected moist/wet soil material (the mass of moist soil material is not less than 30g) for at least 18 hours to a constant mass in a drying oven at 105°C up to 110°C. The difference in mass before and after drying is used as the mass of the water in the test material. The mass of material remaining after drying is used as the mass of the solid particles. The ratio of the mass of water to the measured mass of solid particles is the water content of the material.

b) Particle size analysis

Particle size analysis can be performed by means of sieving and/or hydrometer readings. Sieving is carried out for particles that would be retained on a 0.063mm sieve, while additional hydrometer readings may be carried out when a significant fraction of the material passes a 0.063mm sieve.

c) Bulk density

The bulk density of a soil, ρ is the mass per unit volume of the soil deposit including any water it contains. The dry density ρ_d is the mass of dry soil contained in a unit volume. Both are expressed in Mg/cm^3.

d) Atterberg limits

Atterberg limits are determined on soil specimens with a particle size of less that 0.425mm. If necessary, coarser material is removed by dry sieving. The Atterberg limits refer to arbitrarily defined boundaries between the liquid and plastic states (Liquid Limit, w_L), and between the plastic and brittle states (Plastic Limit, w_p) of fine-grained soils. They are expressed as water content, in percent.

e) Unconsolidated–undrainedtriaxial compression test

This test method covers determination of the strength and stress-strain relationship of a cylindrical specimen of either undisturbed or remolded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. No drainage of the specimen is permitted during the test. The specimen is sheared in compression without drainage at a constant rate of axial deformation.

f) Direct shear test

The soil is dried and sieved with 5mm sieve, wetted and placed in the ring of the shear device. Key parameters that can be obtained from this test are angle of internal friction φ (grad) and cohesion C (kPa) determined from the plot $\tau = f(P)$ for three points.

g) One-dimensional consolidation properties of soils (Oedometer test)

The Oedometer test covers determination of the rate and magnitude of consolidation of a laterally restrained soil specimen, which is axially loaded in increments of constant stress until the excess pore water pressures have dissipated for each increment. The key parameters obtained from this test are voids ratio e, deformation modulus E, preconsolidation pressure and the compression index C_c.

h) Collapse potential of soils

This test method is used to determine the magnitude of potential collapse that may occur for a given vertical (axial) stress and an index for rating the potential for collapse.

The test method consists of placing a soil specimen at natural water content in a consolidometer, applying a predetermined applied vertical stress to the specimen with fluid to induce the potential collapse in the soil specimen. The fluid should be distilled water

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when evaluating the collapse index, I_e. The fluid may simulate pore water of the specimen or other field condition as necessary when evaluating collapse potential I_c.

i) Determination of permeability of soils

The permeability of a soil is a measure of its capacity to allow the flow of water through the pore space between solid particles. The degree of permeability is determined by applying a hydraulic pressure gradient in a sample of saturated soil and measuring the consequent rate of flow. The coefficient of permeability is expressed as a velocity.

j) Maximum dry density and optimum water content (Proctor test)

An indication of the state of compaction of a cohesionless (free-draining) soil is obtained by relating its dry density to its maximum and minimum possible densities (the limiting densities). The tests described in this section enable these parameters to be determined for cohesionless soils.

k) Soil chemical analysis

Chemical analyses of soil is carried out to determine chloride, sulphate, calcium carbonate content, pH.

Soil pH is one of the most common measurements in soil laboratories. It reflects whether a soil is acid, neutral, basic or alkaline.

Depending on the amount of sulphate in contact with the concrete, it may be necessary to protect the concrete with a plastic liner, sulphate resistant concrete mix, or a protective adhesive coating.

IX. Data Processing Stage

Figure2 shows location of areas selected for geotechnical investigations. It reflects of points (red color) conducted measurements into the mapping system. The number of points required to be investigated on geotechnical parameters definitions depend of engineering task and scope of work reflected in the project requirements. This circumstance finds of accuracy of conducted engineering service. In some cases it become very expensive in conducting huge numbers of geotechnical investigations. It relates of the scale of area needed to be investigated and type of engineering facilities intended to be constructed.

Figure 2 : Map of the selected area

In the map have been demonstrated sensitive area in point of view engineering importance of conducted geotechnical measurements. As it seeing from the Figure there are a big numbers of ground samples have been taken from the area.

It is highly important definition of the process of GIS development in geotechnical investigations. Figure 1 describes segments of data collection from different sources and that integration[7].

It has been considered to develop layers for GIS presentation following performance:

- Soil investigation data;
- Chemical contamination;
- Physical and mechanical properties of soil;
- Ground water condition of soil
- Land Use/Land Cover;
- Geodetic and topographic data.

It can be integrated into GIS layers a more geotechnical data depends of requirements of engineering solutions for the selected. The main available information is tied to various forms of georeferenced information. It is required accurate merging topographic map with space image for

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selected area to achieve demanded cartographic corrections. Anexcellent advantage of GIS is its incorporate processing subroutines that can transform older data to modern coordinates if a sufficient number of georeferencing points can be co-located on both the old and new maps. These georeference points may be established and constructed benchmarks (state or installed), old structures, roads, or even above-ground power lines; anything that can be identified on both maps in the GIS.

In Figure 4is shown results of data imposed on the space image for selected area.In the figure has been used a space image with spatial resolution of 1m. It is enough high resolution which is more than enough for the case of geotechnical studies of selected area.

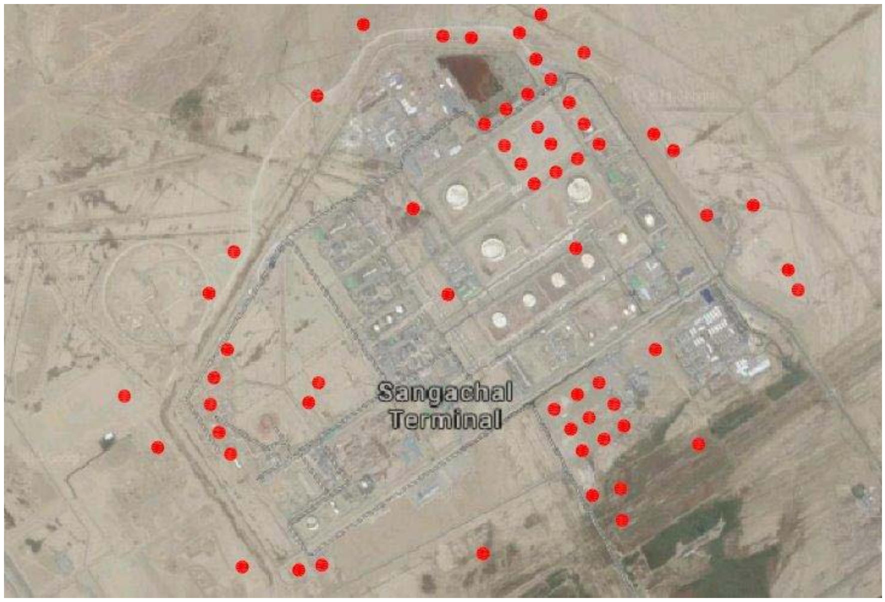

Figure 3 : Integration of geotechnical data and processed space image data

X. Conclusion

This paper describes geotechnical investigations of selected area in Absheron peninsula, Azerbaijan. It contents of measurements of geotechnical data such as standard penetration test, soil electrical resistivity test, laboratory processing of filed data, moisture content, particle size analysis, maximum dry density and optimum water content (proctor test), determination of maximum density of sands, determination of maximum density of gravelly soils, derivation of density index, bulk density, atterberg limits, unconsolidated–undrainedtriaxial compression test, direct shear test, one-dimensional consolidation properties of soils (oedometer test), collapse potential of soils, determination of permeability of soils. There is no doubt that it is an excellent source reflecting soil condition which can be used for engineering solution in any stage of implementation< tender package preparation, design and construction.

At the same time integration of geotechnical data into the GIS developed on the base of space data collected by method of remote sensing is an advantage of application of outcomes in a wide areas of engineering such as project coordination and management, construction, supervision where is required to use suitable and simplicity of data access.

In the meantime the use of data integrated into GIS makes possible to link of existing information to the coordinate system which is very important in all stages of achievements.

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