

# Application of GIS In Soil Mapping

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**Abstract:-** The boundaries of Goa are surrounded by Maharashtra in the north, Karnataka in the east and south, and the Arabian Sea along the west coast. Goa is one of the popular tourist destinations in India. As the population in Goa is increasing, the construction activities have also increased.

The soil is the most important yet most neglected in a construction project. All structures, buildings, roads, bridges, dams and even life itself is based on the soil. The soil is the natural foundation that supports all structures and investment. Most clients see soil investigation as a waste of fund despite being the cheapest in the construction process, hardly is the cost of soil test up to one percent of the cost of construction. Some contractors too ignore the importance of proper soil investigation and analysis and base their design on assumed bearing capacity and rate of settlement.

Index properties of soil such as specific gravity, moisture content, dry density, wet density etc. are the important parameters in geotechnical engineering and they are changing from place to place both along the depth and width of the stratum. It is important for the geotechnical engineers to know about variation of the index properties of soil before carrying out design and construction of any geotechnical structure. Any field or laboratory soil testing will provide result which is too specific for a particular location to generalize over an extended area.

In this project, an attempt is made to develop a methodology to map the important index properties of soil by using Geographical Information System (GIS) and Global Positioning System (GPS) using existing soil exploration reports. The method suggested in this paper will help all the soil exploration agencies and practicing geotechnical engineers for immediate decision making process about soil suitability as foundation materials.

## OBJECTIVE

- To determine the various soil properties of the different locations in Goa.
- To map these soil properties using GIS software (ArcGIS) & GPS using existing soil exploration reports.
- To obtain different data required for determining the bearing capacity and suitable foundation in a particular location.

## SCOPE OF THE PROJECT

- To create updated database of various borelog across Goa.
- To use these borelog data's for Stratigraphic modeling of soil.
- To maintain updated information regarding soil index properties.
- To reduce time for decision making as all information is in one system.
- To help contractors in knowing about the soil profile before the start of their work.
- To use GPS that can be used for mapping, positioning of boreholes during night shift or any weather condition.
- To make use of database and GIS to conduct seismic hazard study of the selected study area.
- To carryout liquefaction studies of the area using the database.
- To help all the soil exploration agencies and practicing geotechnical engineers for immediate decision making to check the soil suitability as foundation material.

## I. INTRODUCTION

Soil is a natural material having variety of physical properties, most of which are not constant and it is varying from place to place. Index properties of soils are those properties which are mainly used in the identification and classification of soils and help the geotechnical Engineer in predicting the suitability of soils as foundation/construction material. Specific gravity of soil particles, particle size distribution, Consistency limits and moisture content etc. are the index properties of soil. Apart from that permeability, compressibility and shear strength are the engineering

properties of soil. Moisture content of soil is one of the important factor depending upon which the shear strength of soil will change. Geographic Information System (GIS) is a computer based information system capable of capturing, storing, analyzing, and displaying geographically referenced information, i.e. the data identified according to a particular location/region. And Global Positioning System (GPS) is a satellite-based navigation and surveying system for determination of precise position and time, using radio signals received from the satellites, in real-time or in post-processing mode.

The use of GIS, which is capable to analyze regional areas based on spatial distribution, is well known. As more and more data become available in a digitized format it is possible to develop software routines that can perform identification of Index soil properties and preparation of Thematic maps of soil type, moisture content, ground water depth, SPT value etc. in conjunction with a GIS. The use of GIS, which is capable to analyze regional areas based on spatial distribution, is well known. As more and more data become available in a digitized format it is possible to develop software routines that can perform identification of Index soil properties and preparation of Thematic maps of soil type, moisture content, ground water depth, SPT value etc. in conjunction with a GIS.

Traditional methods of mapping soil index properties by using any other information system fail to provide information pertaining to the spatial aspects in geotechnical Engineering. The application of geographic information system in geotechnical will be new in the Indian Construction industry. GIS will allow soil investigators and different people involved in project with different backgrounds to get the information about soil properties on a single click. The integration of GIS, GPS and database of index properties of soil will be very helpful to the soil investigators and contractors working in Mumbai region for understanding the soil strata and deciding the correct soil strata for resting the foundation of structure.

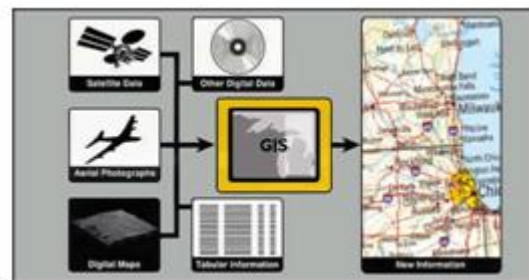
**Geographic Information System (GIS)**

Geographic Information System provides efficient tools for inputting data into database, retrieval of selected data items for further processing and software modules which can analyze or manipulate the retrieved data in order to generate desired information on specific form. The components of a GIS are pictorially represented.



*Basic components of geographic information system*

GIS stores spatial and non-spatial data in two different databases. The geocoded spatial data defines an object that has an orientation and relationship with other objects in two (2D) or three dimensional (3D) space. GIS uses three types of data to represent a map or any geo-referenced data, namely, point type, line type, and area or polygon type. It can work with both the vector and the raster geographic models. The vector model is generally used for describing the discrete features, while the raster model does it for the continuous features. One of the major advantages of the GIS is that it incorporate all type of relevant data either available in aerial photographic data, remote sensing images data, tabular data etc. These and other information are viewed as individual coverage that may be simultaneously overlaid depending on the desired detail of the analysis. Data integration is the linking of information in different forms through a GIS



*Data Integration is the Linking of Information in Different Forms through a GIS*

**Global Positioning System (GPS)**

The Global Positioning System is being used all over the world for numerous navigational and positioning applications, including navigation on land, in air and on sea, determining the precise coordinates of important geographical features as an essential input to mapping and Geographical Information System (GIS), along with its use for precise cadastral surveys, vehicle guidance in cities and on highways using GPS-GIS integrated systems, earthquake and landslide monitoring, etc.

The Navigation Satellite Timing and Ranging Global Positioning System (NAVSTAR GPS) developed by the U.S. Department of Defense (DOD) to replace the TRANSIT Navy Navigation Satellite System (NNSS) by mid-90's, is an all-weather high accuracy radio navigation and positioning system which has revolutionized the fields of modern surveying, navigation and mapping. The GPS, which consists of 24 satellites in near circular orbits at about 20,200 km altitude, now provides full coverage with signals from minimum 4 satellites available to the user, at any place

on the Earth. By receiving signals transmitted by minimum 4 satellites simultaneously, the observer can determine his geometric position (latitude, longitude and height), Coordinated Universal Time (UTC) and velocity vectors with higher accuracy, economy and in less time compared to any other technique available today.

GPS is primarily a navigation system for real-time positioning. However, with the transformation from the ground-to-ground survey measurements to ground-to-space measurements made possibly by GPS, this technique overcomes the numerous limitations of terrestrial surveying methods, like the requirement of intervisibility of survey stations, dependability on weather, difficulties in night observations, etc. These advantages over the conventional techniques and the economy of operations make GPS the most promising surveying technique of the future. With the well-established high accuracy achievable with GPS in positioning of points separated by few hundreds meters to hundreds of km, this unique surveying technique has found important applications in diverse fields.

#### **Properties Of Soil**

The properties of soil can be divided as Index properties and Engineering properties. The main Engineering properties are permeability, compressibility and shear strength. The brief description of few engineering and index properties of soil are given below

- Permeability indicates the ease with which the water can flow through soils.
- Compressibility is related with the deformations which soil undergoes when subjected to compressive loads.
- The Shear strength helps in determining stability of slopes, bearing capacity of soils and the earth pressures on retaining structures.
- The specific gravity of soil solids is the ratio of the density of a given volume of soil solids to the greatest density (at +4°C) of an equal volume of pure water.
- The principal soil grain properties are the size and shape of grains and the mineralogical character of the finer fractions. The most significant aggregate property of cohesion less soils is the relative density, whereas that of cohesive soils is the consistency.

- Moisture content is that amount of water which is contained in the voids of the soil. It is one of the important factor depending upon which the shear strength of soil will change.
- Consistency is the property of materials which shows its resistance to flow. When referred to soil, it means, the degree of resistance offered by fine grained soil to deformation. The water content at which the soil changes from one state to another state termed as consistency limits.
- Dry density of soil mass is the ratio of mass of soil solids to the volume of soil mass.

Therefore the properties of soil such as specific gravity, moisture content, dry density, wet density and consistency limits such as liquid limit, plastic limits and shrinkage limits are the essential for determination of engineering properties of soil, which will help to geotechnical engineer for decision making process of suitability of soil as foundation materials or construction materials. If the properties of soil are properly studied and the results of soil exploration correctly understood and intelligently applied to the design and construction of earthworks and structural foundations, failures usually can be avoided.

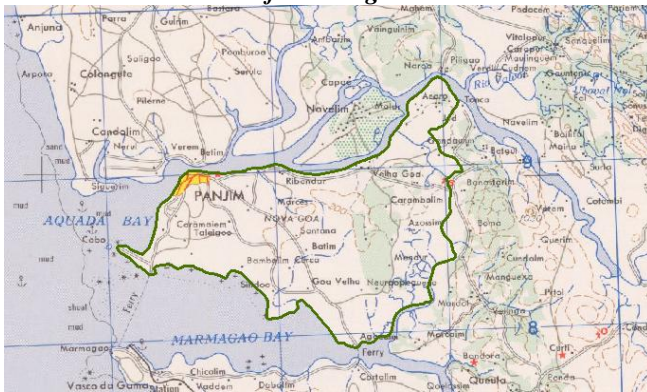
#### **Study Area**

The Mormugao and Tiswadi taluka of state Goa is taken as a study area. Mormugao is located in South Goa district in the Indian state of Goa. Mormugao is located at 15°15'N 73°59'E . It has an average elevation of 2 meters. According to the old census Mormugao has a population of over one crore and is continuously growing at a very rapid rate. Mormugao is chosen as one of our study area due its importance in state of Goa in Real estate industry. Mormugao Port is one of the important ports of India. Right now the only airport in Goa is in Mormugao taluka. Due to all these reasons there increase in construction activities in Mormugao.

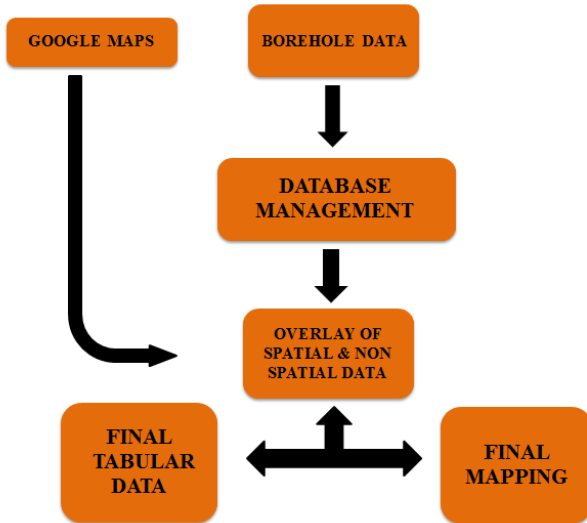
Tiswadi is a taluka of North Goa district in the state of Goa. Tiswadi is located at 15°29'55"N 73°49'46"E. The present capital of Goa, Panaji, lies in the Tiswadi taluka and is one of most popular tourist destinations in Goa receiving tourists across the globe. Most of important structures in Goa are situated in Tiswadi and is an important for real estate and construction industry.



Outline of Mormugao taluka



Outline of Tiswadi taluka



Flow chart

**Soil Investigation**

The work in general was carried out in accordance with the following Indian standard specification.

- a. **I.S. – 1892** - Code of Practice for Sub Surface Investigations for Foundations.

- b. **I.S. –1498** - Classification and Identification of Soils for General Engineering Purpose.
- c. **I.S. – 2131** - Method for Standard Penetration Test for Soils.
- d. **I.S. – 6926** - Code of Practice for Diamond Core Drilling for Site Investigation.
- e. **I.S. – 5313** - Guide for Core Drilling Observations.
- f. **I.S. – 12070**- Design and construction of shallow foundation on rock.

The safe end bearing load carrying capacity at 23.00 m 30.00 m depth is worked out by following methods.

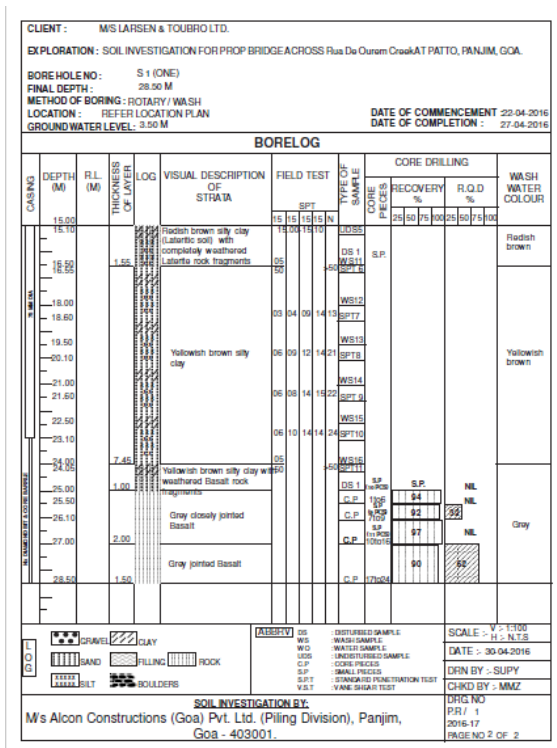
- I. I. S. Method (IS:14593-1998 and IS:12070-1987)
- II. Ganpule’s method

**Preparing Borelogs**

Based on the results of soil investigation, Bore logs are prepared showing various layers of soil with respective depths and other related data such as SPT-N values etc.

CLIENT : M/S LARSEN & TOUBRO LTD. GOA													DATE : 10/06/2016								
PROJECT : SOIL INVESTIGATION FOR PROP. MAJOR BRIDGE ACROSS RUA DE QUREM CREEK AT PATTO, PANJIM, GOA.													SOIL TEST DATA SHEET								
SOIL NO. / PT. NO.	DEPTH IN METRE	SAMPLING TYPE / CODE	DENSITY			MECHANICAL ANALYSIS				CONSISTENCY LIMITS			SHEAR STRENGTH TEST		CONSOLIDATION TEST		Natural Moisture Content %				
			WET (g/cm <sup>3</sup> )	DRY (g/cm <sup>3</sup> )	BULK (g/cm <sup>3</sup> )	GRAVEL %	SAND %	SILT %	CLAY %	LIQUID %	PLASTIC %	SHRINKAGE %	PI	TYPE	Cu (kg/cm <sup>2</sup> )	CS (kg/cm <sup>2</sup> )		Sw (%)	Cr (%)		
S1	3.00-3.40	UDS 1	1.51	0.73	1.32	0	5	95	-	-	-	-	-	-	Tuu	0.05	7.63	0.78	2.46	2.53	80
S1	6.00-6.40	UDS 2	1.32	0.85	1.35	3	12	85	-	-	-	-	-	-	Tuu	0.17	8.58	0.82	2.51	2.59	56
S1	9.00-9.40	UDS 3	1.51	0.75	1.33	2	8	90	-	-	-	-	-	-	Tuu	0.07	7.75	0.80	2.48	2.55	83
S1	12.00-12.40	UDS 4	1.35	0.80	1.37	0	4	96	-	-	-	-	-	-	Tuu	0.04	6.89	0.71	2.44	2.53	85
S1	18.00-18.60	SPT 7	-	-	-	2	6	94	-	-	-	-	-	-	-	-	-	-	-	-	2.60
S1	21.00-21.60	SPT 9	-	-	-	0	5	95	-	-	-	-	-	-	-	-	-	-	-	-	2.60
S2	4.50-4.90	UDS 2	1.55	0.97	-	3	30	67	-	-	-	-	-	-	Tuu	0.13	11.90	0.56	1.69	2.63	59
S2	7.50-8.00	UDS 3	2.60	1.61	-	0	22	78	-	-	-	-	-	-	Tuu	0.07	10.30	0.55	1.65	2.60	62
S2	10.50-11.00	UDS 4	1.80	1.21	-	0	15	85	-	-	-	-	-	-	Tuu	0.10	8.96	0.49	1.59	2.59	65
S2	13.50-13.90	UDS 5	1.60	1.01	-	2	17	81	-	-	-	-	-	-	Tuu	0.11	9.01	0.51	1.60	2.59	61
S2	19.50-20.10	SPT 8	-	-	-	2	8	90	-	-	-	-	-	-	-	-	-	-	-	-	2.58

AGENCY: M/S ALCON CONSTRUCTIONS (GOA) PVT. LTD. (PILING DIVISION) PANJIM, GOA – 403001.



Borelog based on soil investigation

Preparing Database

The results of soil investigation reports from various locations are used to prepare the database. This database serves as reference for mapping in GIS software. The database in this project will consist of locations which are to be mapped with latitude and longitude. Also the various soil properties of those locations and SBC are listed.

Sr.no	Location	Site description	Latitude	Longitude	Groundwater level	Moisture content	SOIL PROPERTIES				S.B.C (@ 1.5m depth) kg/m <sup>3</sup>
							Plasticity index	Dry density	Cohesion	Angle of internal friction	
					m	gm		kg/m <sup>3</sup>			
1	Panjim	Proposed construction of buildings for CBI	15.211	73.83							21000.00
	Parvorim	M/S Karmat real estate developers at least site	15.47	73.808							
	Panjim	Hotel Nirma	15.498	73.823		49.98	14.92	1.196	1.16		11.8 3201.89
	Panjim	M/S Aces Pato	15.497	73.823		52.8	7.4	1.11	2650		5.875 6104.03
	Neogi Nagar	Proposed hotel building	15.49	73.84		70.08	39	0.998	1180		10.9 3266.79
	Campal	Proposed school	15.489	73.818		36.38	10.675	1.353	1487.3		16.1 5042.39
	Tonca	Proposed M/S Prudential groups	15.495	73.825		35.6	26.5	1.41	625		20.67 2546.65
	Kadamba 2 Vasco	Kadamba road in old goa	15.486	73.903							
	vasco	Police station	15.396	73.807					2725		24
	Baina	Raviadora Bhavani	15.391	73.807		27.38	9.28	1.475	193557		20.88 7954.47
	Saumolem	Near Raviadora Bhavani	15.392	73.809							

Database to be used in GIS software

The following Laboratory tests were carried out

1. Soil moisture content
2. Dry density (Core cutter)
3. Sieve analysis
4. Box shear test
5. Atterberg's limits

Results

- The value of moisture content at Baina beach was found to be **7.86%**.
- The value of moisture content at KMC Baina was found to be **5.24%**.
- The value of moisture content at KTC Vasco was found to be **15.45%**.
- The value of moisture content at Harbour Vasco was found to be **29.73%**.
- The value of dry density of soil at Baina beach was found to be **1.61 kg/m<sup>3</sup>**.
- The value of dry density of soil at KMC Baina was found to be **1.45kg/m<sup>3</sup>**.
- The value of dry density of soil at KTC Vasco was found to be **0.12kg/m<sup>3</sup>**.
- The value of dry density of soil at Harbour Vasco was found to be **0.05kg/m<sup>3</sup>**.
- The values of Cohesion & angle of friction of soil at Baina beach was found to be **0& 45**.
- The values of Cohesion & angle of friction of soil at KMC Baina was found to be **0& 45**.
- The values of Cohesion & angle of friction of soil at KTC Vasco was found to be **0& 45**.
- The values of Cohesion & angle of friction of soil at Harbour Vasco was found to be **0& 25**.
- The value of liquid limit of soil at Baina beach was found to be **N=25 is 18.5%**.
- The value of liquid limit of soil at KMC Baina was found to be **N=25 is 18.2%**.
- The value of liquid limit of soil at KTC Vasco was found to be **N=25 is 19.90%**.
- The value of liquid limit of soil at Harbour Vasco was found to be **N=25 is 46.4%**.

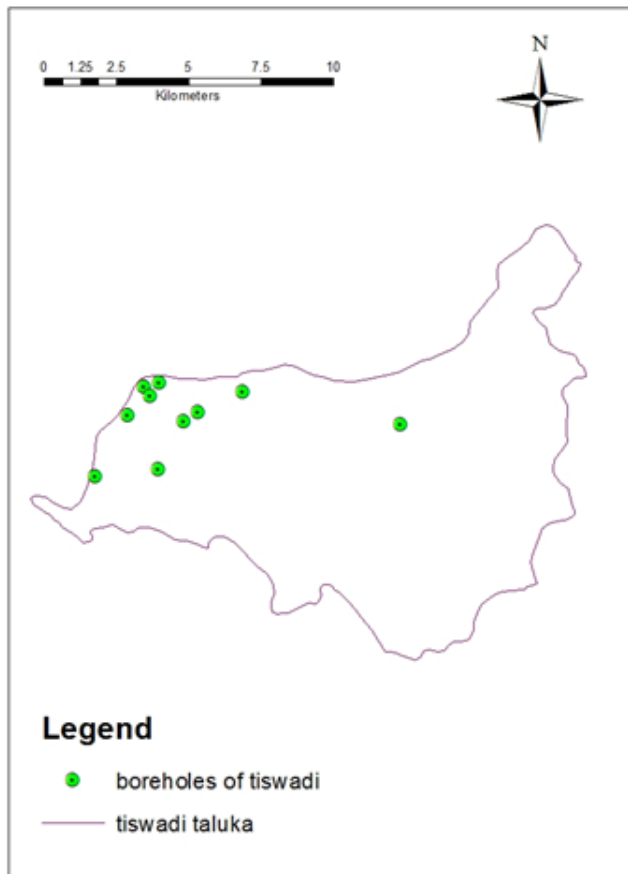
CONCLUSION

- ◆ The various properties of soil i.e. **moisture content, dry density, shear stress, Atterberg's limits, cohesion, angle of friction**, etc. obtained from soil reports which were collected from **GSIDC, Alcon, Descon, MILROC, CPWD Goa**.
- ◆ The properties of soil such as moisture content, dry density, sieve analysis, shear stress, Atterberg's limits at Baina beach, KMC Baina, KTC Vasco,

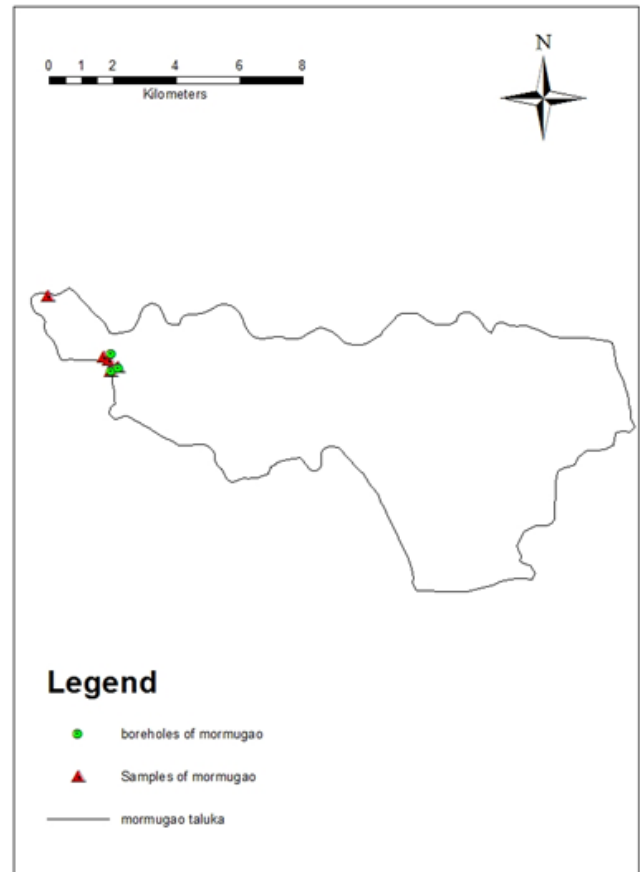
Harbour Vasco were determined manually in laboratory.

- ◆ Overlaying of spatial & non spatial data was done in GIS software in order to obtain the maps.
- ◆ Maps representing various boreholes & sample locations were created.
- ◆ Collected borehole data and soil testing reports from various sources.
- ◆ An effective database is created by extracting data from soil investigation reports.
- ◆ Overlaying of spatial and non-spatial data was done in GIS software in order to obtain the maps.
- ◆ Maps representing various borehole and sample locations were created.

*Final maps*



*Tiswadi taluka with borehole locations*



*Mormugao taluka with boreholes and sample locations*

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