International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 8 ǁ 2021 ǁ PP. 88-94

Application of GIS for Study of Geotechnical Properties of Baramati Area, India

Gunavant K.Kate[1], Anil S.Parlikar[1*], Chittaranjan B. Nayak[2]
[1]*Assistant Professor, Civil Engineering Department, SVPM's College of Engineering, Malegaon(Bk)*
[2]*Assistant Professor, Civil Engineering Department, VP's Kamalnayan Bajaj Institute of Engineering andTechnology, Baramati*

ABSTRACT
A study was undertaken in thirteen locations of Baramati Taluka in Pune District for the application of GIS to study the geotechnical properties. Standard proctor test (SPT), California Bearing Ratio test, liquid limit, plastic limit, plasticity index, activity number were studied for soil samples from different locations in the study area. Variations in SPT results, CBR values at these locations were found. The topography, geological formations were observed to have their effects on various geotechnical properties. Based on these properties different maps are prepared using Quantum GIS (QGIS) software.
KEYWORDS*: Geotechnical properties, QGIS, SPT, CBR, activity number*

Date of Submission: 28-07-2021 Date of acceptance: 12-08-2021

I. INTRODUCTION

Soil is a natural body consisting of layers (soil horizons) resulting from the interplay between climate, topography, organisms, parent material (underlying geologic bedrock), and time. Soil plays a very crucial role in supporting ecosystems and human civilization. Besides being a non-renewable and valuable resource, it has high variability in its properties and behavior all over the world. Soil survey is an important agricultural research and advisory program, which provides complete information about soils. It also gives the information needed for planning land use and soil management programs.

The diversity of soil properties in the study area is represented geographically by soil map. Also, an important information about the characteristics and condition of the land is obtained from it.Soil map is useful for land evaluation, agricultural purposes, civil engineering construction purposes, etc.It is also helpful for the correct implementation of sustainable land use management practices. In recent years, improvement in quality of the maps produced by different methods and data availability is observed. However, the local knowledge is a great source of information. Traditional soil survey techniques are time consuming and labour intensive. Accurate soil data are needed in order to develop reliable and high-resolution soil maps for hydrological analysis, environmental protection, agriculture, and forest management. Several items of information required for soil characterization, deriving from sources with different spatial resolution, can be easily stored and managed within a geographic information system (GIS).

A geographic information system (GIS) is a computer-based tool for mapping and analyzing spatial data. GISis a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. There are townships being built using GIS mapping. Most significant difference between traditional and digital soil maps is the quality and amount of data available to make the map. The raster data model is popular for digital maps because it is a very efficient model for storing and analyzing spatial information in a digital format.

Jacek (2004) represented overview of the methods for GIS-based land-use suitability modeling. Digital elevation model (DEM) and Landsat TM imagery for detailed soil survey work in a hilly terrain was applied as an alternative and improved method for mapping soil patterns (Erturul et.al, 2009). Eric et.al, (2011) produced a digital soil map and developed an interactive geodatabase with crop-land suitability analysis on the growth and production requirement of oil palm, cassava, and citrus in the study area. The use of GIS in processing and presenting geotechnical data into formats useful to engineers, planners and land development professionals were prepared (Wan and Abdul, 2011). Yin and He (2011) applied remote sensing (RS) and geographic information system (GIS) to analyze the changes of vegetation cover in watershed. Zhang et.al (2012) used ARCGIS and FRAGSTATS softwares to carry out visual interpretation on remote sensing images according to the classification system, and digitalized the image data. A Geographic Information System (GIS) framework was used to provide interactive maps of different soil and rock formations that show the spatial distribution of the variables and identify their characteristics (Mary and Amani, 2013). Mohamed et.al, (2014) studied productivity, security, protection, economic viability and social acceptability of the Sinai area of Egypt and classified the sustainability degree of agricultural utilization to prepare the thematic map showing the sustainability index. The soil quality is equally important as that of crop production (Dhayalan et.al, 2016). The variation maps of soil nutrients were prepared using GIS technology and other related maps were prepared from remote sensing data in ArcGIS 10.1. Different land quality parameters, viz. soil texture, depth, erosion, slope, etc. were integrated using a sequence of logical operations to generate land suitability and capability maps (Mohamed et.al, 2016). The spatial distribution and correlation between OC and other soil properties was shown by overlay of maps in GIS environment (Pravat Kumar et.al, 2016). Parveen Chander et.al (2018) analyzed geotechnical data in GIS format.

In the present study, GIS is applied to prepare soil maps in the study area of thirteen villages in Baramati Taluka of Pune District (Maharashtra, India).

II. STUDY AREA

The study area is situated in Maharashtra, India at N 74.5234-18.2043 to S 74.5022-18.0906 and E 74.5452- 18.11117 to W 74.4286-18.1247.It covers area of 74.352 sq.km for geotechnical test.Thirteen villages in Baramati Taluka of Pune District in Maharashtra state (India) (Figure 1) taken for study arePanadare, Sonkaswadi, Malegaon (bk), Malegaon (kh), Yelewasti, Pipradchi Aai, Jarad wasti, Taware City, Near Giriraj Hotel, Near K.V.K (Krishi Vignyan Kendra), Near Om Sai Lawns, Pahunewadi, and COE (College of Engineering) Malegaon(bk).

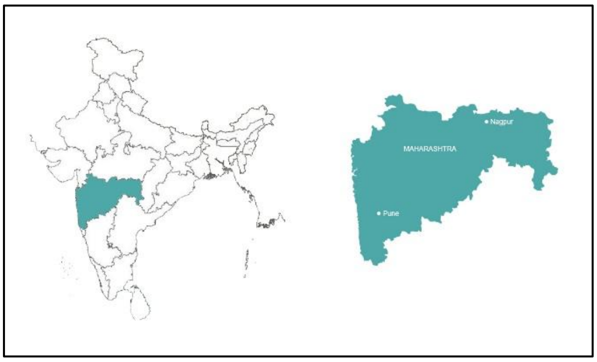

Figure 1: Study area

III. SAMPLE COLLECTION AND ANALYSIS

For the analysis purpose, the soil samples from study area are collected carefully. The tests performedon these samples are Standard Penetration Test (SPT), California Bearing Ratio Test, Liquid Limit, Plastic Limit, Plasticity Index and Activity Number.

The Standard Penetration Test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties. This test is the most frequently used subsurface exploration drilling test performed worldwide. The main purpose of the test is to provide an indication of the relative density of granular deposits, such as sands and gravels. The usefulness of SPT results depends on the soil type. The fine-grained sands give the most useful results, while coarser and silty sands give reasonably useful results, and clay and gravelly soils yield results which may be poorly representative of the true soil conditions. Table 1shows various properties such as relative density, percentage relative density, and internal angle of friction according to penetration resistance (N). These properties are the functions of penetration resistance.

Table 1: Standard characteristics according to SPT

Penetration Resistance (N)	Relative Density	% Relative Density	Approximate internal angle of friction
0-4	Very Loose	15	20°
4.1-10	Loose	35	30°
10.1-20	Moderately Dense	50	32°
20.1-30	Medium Dense	65	36°
30.1-50	Dense	85	42°
>50	Very Dense	100	45°

California Bearing Ratio (CBR) is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min to that required for the corresponding penetration of a standard material. The CBR test is penetration test meant for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. (Figure 2).

Figure 2: C.B.R Test Apparatus

Liquid limit is the water content in the soil at which soil changes from liquid to plastic state. Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit, the compression index may be estimated. The compression index value is helpful in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft;while the moisture content is lesser than liquid limit, the soil is brittle and stiffer.

Plastic limit is defined as water content at which soil sample changes from plastic state to semi-solid state. It is the moisture content at which soil can be deformed plastically.The plasticity index of a soil is the numerical difference between its liquid limit and plastic limit.

Activity of soil can be defined as ration of plasticity index to clay fraction as percentage. The amount of retained water in soil mass depends upon available clay mineral in soil. Activity of a soil assesses capacity of soil to hold water.

$$\mathrm{Ac} = \mathrm{Ip}/\mathrm{F}$$

Where,

Ac - Activity of Soil

Ip- Plasticity index of soil

F - Clay fraction expressed in percentage that are finer than two microns.

The main factors that are concerned in designing foundation on clayey soil are its swelling potential and shrinkage. The volume change that resultsin swelling and shrinkage depends on activity of clay soil (Ac).

IV. RESULTS AND DISCUSSION

Soil samples were collected from different locations of study area. They were tested by using Standard Penetration Test (SPT),California Bearing Ratio (CBR), liquid limit, plastic limit and plasticity index.Table 2 shows relative density, bulk density, approximate internal angle of friction, and foundation suitability with respect to SPT values in village.

Table 2: Foundation suitability for various location.

Sr.No.	Location	Relative density	Bulk density	Approximate internal angle of friction	Foundation suitability
1	Panadare	Very Dense	20.8-24.0	45°	Isolated Footing
2	Sonkaswadi	Very Dense	20.8-24.0	45°	Isolated Footing
3	Malegaon (bk)	Dense	17.6-22.4	42°	Isolated Footing,
4	Malegaon (kh)	Loose	14.4-18.4	30°	Mat Foundation
5	Yelewasti	Very Loose	11.2-11.6	20°	Pile Foundation
6	Pipradchi Aai	Medium Dense	17.6-20.8	36°	Isolated Footing
7	Jarad Wasti	Loose	14.4-18.4	30°	Mat Foundation

8	Taware City	Medium Dense	17.6-20.8	36°	Isolated Footing
9	Near Giriraj Hotel	Loose	14.4-18.4	30°	Mat Foundation
10	Near K.V. K	Moderately Dense	16.0-19.8	32°	Isolated Footing
11	Near Om Sai Lawns	Moderately Dense	16.0-19.8	32°	Isolated footing
12	Pahunewadi	Moderately Dense	16.0-19.8	32°	Isolated footing
13	COE Malegaon	Dense	17.6-22.4	42°	Isolated footing

Table 3:CBR value of respective location

Sr. No.	Location	C.B.R. Value (2.5mm)	C.B.R. Value (5mm)	Sub grade suitability
1	Panadare	28.89	25.16	Excellent
2	Sonkaswadi	18.87	16.87	Good
3	Malegaon (bk)	3.86	3.43	Very poor
4	Malegaon (kh)	4.78	4.57	Very poor
5	Yelewasti	3.48	3.14	Very poor
6	Pipradchi Aai	6.96	6.29	Poor
7	Jarad Wasti	3.04	2.86	Very poor
8	Taware City	7.83	7.43	Poor
9	Near Giriraj Hotel	5.22	5.14	Poor
10	Near K.V. K	6.96	6.86	Poor
11	Near Om Sai Lawns	7.40	7.15	Poor
12	Pahunewadi	7.40	6.86	Poor
13	COE Malegaon	27.41	25.73	Excellent

Table 3 shows mean CBR value which is calculated from CBR values of 5mm and 2.5mm. According to mean CBR value, the subgrade suitability is stated, which is useful for road construction purpose.

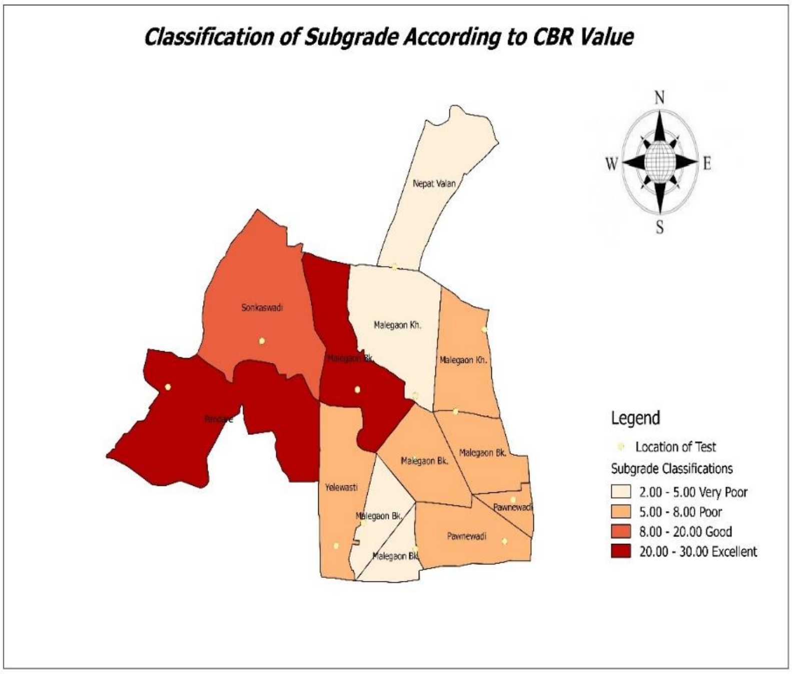

Figure 3: Soil classification according to CBR values of respective area.

Figure 3 shows soil classification according to California Bearing Ratio values. It is observed that there are two locations having excellent strata and one location having good strata for road construction. There are ten locations having availability of poor strata for road construction because of plain area and loose subgrade.

Liquid limit, plastic limit and plasticity index are shown in Table 4. Plasticity index is calculated from difference of liquid limit and plastic limit, which shows plasticity condition of soil. It mainly depends on type of soil available on site.

Table 4: Classification of soil according to plasticity index

Sr. No.	Location	Liquid Limit	Plastic Limit	Plasticity Index	Remark
1	Panadare	38	19	19	Medium Plasticity
2	Sonkaswadi	59	30	29	High Plasticity
3	Malegaon (bk)	42	23	19	Medium Plasticity
4	Malegaon (kh)	60	32	28	High Plasticity
5	Yelewasti	57	32	25	High Plasticity
6	Pipradchi Aai	41	21	20	Medium Plasticity
7	Jarad Wasti	57	35	22	High Plasticity
8	Taware City	40	20	20	Medium Plasticity
9	Near Giriraj Hotel	55	33	22	High Plasticity
10	Near K.V.K	54	39	15	Medium Plasticity
11	Near Om Sai Lawns	53	37	16	Medium Plasticity
12	Pahunewadi	54	38	16	Medium Plasticity
13	COE Malegaon	40	20	20	Medium Plasticity

Table 5 shows % of Clay Fraction and Plasticity Index for respective location. Activity numbers are found out from above parameters, which help to find out consistency of soil. From consistency of soil swelling condition of soil is known.

Table 5: Activity number (Ac) results

Sr. No.	Location	% of clay Fraction	Activity Number	Consistency of soil
1	Panadare	22.9	0.83	Normal
2	Sonkaswadi	24.7	1.17	Normal
3	Malegaon (bk)	20	0.95	Normal
4	Malegaon (kh)	6.2	4.5	Active
5	Yelewasti	4.8	5.2	Active
6	Pipradchi Aai	16.95	1.18	Normal
7	Jarad Wasti	4.25	5.17	Active
8	Taware City	19	1.05	Normal
9	Near Giriraj Hotel	4.45	4.95	Active
10	Near K.V.K	16.1	0.93	Normal
11	Near Om Sai Lawns	13.1	1.22	Normal
12	Pahunewadi	13.9	1.15	Normal
13	COE Malegaon	27.55	0.72	Inactive

Figure 4 shows a map for classification according to activity number showing diversity in study area. There are four locations Malegaon(kh), Yelewasti, Jarad wasti and Near Giriraj Hotel which have been classified as active, so the soil in these locations shows high swelling property as compared to other locations in the study area. The reason behind swelling is plasticity of soil and plasticity depends on the nature and the amount of clay minerals present. Most of locations in study area have black cotton soil which has high content of clay minerals. The remaining locations show normal and inactive soil distribution because they have low plasticity index.

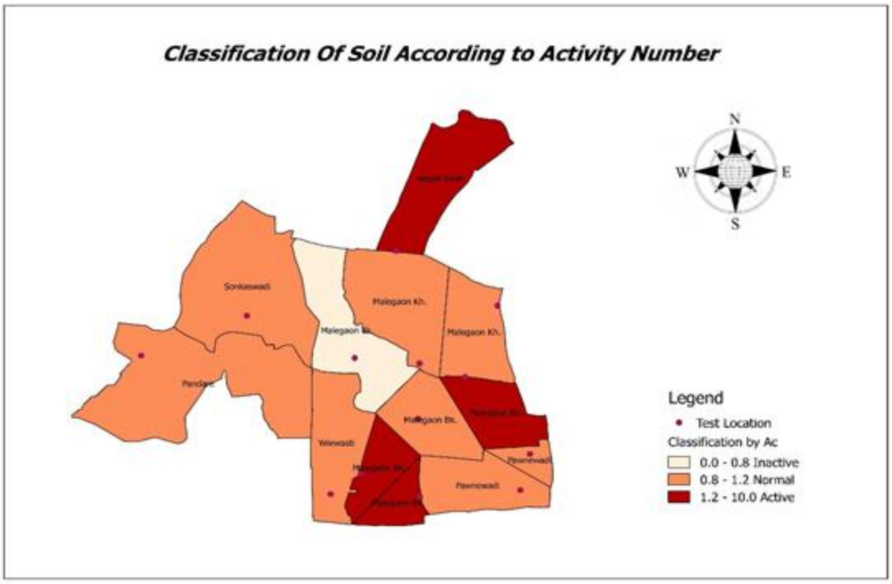

Figure 4: Soil classification according to activity number.

V. CONCLUSIONS

Thirteen villages of Baramati taluka in Pune district (Maharashtra, India)were studied to examine geotechnicalproperties of soil and representedthemin maps by using QGIS software. Geotechnical tests such as Standard Penetration Test (SPT), California Bearing Ratio (CBR), Liquid Limit, Plastic Limit and Activity Number were performed for testing the soil bearing capacity of subsurface for foundation design, swelling properties of soil and subgrade condition for road construction. It is observed that the surface and subsurface strata varied according to topography. In Panadare, Sonkaswadi regions, due to hilly area subsurface strata are suitable for foundation. In Malegaon (kh), Pahunewadi, and some part of Malegaon (bk) have black cotton soil, where mat foundation, pile foundationsare suggested. CBR values also varied with respect to topography. CBR values areaffected by temperature, rainfall, and land use pattern. Most of the land of Malegaon (bk), Malegaon (kh), and Pahunewadi is black cotton soil and it is useful for agricultural purpose as there CBR value is lesser. Sonkaswadi, Panadare have greater CBR value due to hard strata. In most of the parts of study area, the Activity Number is normal indicating low soil swelling there.

REFERENCES

[1]. Dhayalan V., Muthu Selvam M. and Ramaraj M., "Mapping and Analysis of Soil Fertility Using Remote Sensing and GIS", *International Journal of Engineering Research and General Science*, Volume 4, Issue 3, 2016, pp 218-230.

[2]. Eric K. Forkuo and Abrefa K. Nketia, "Digital Soil Mapping in GIS Environment for Crop-Land Suitability Analysis, *"International Journal of Geomantic and Geosciences,* Volume 2, Issue 1, 2011, pp 133-146.

[3]. Erturul Aksoy, Gokhan Ozsoy and M. Sabri Dirim, "Soil Mapping Approach in GIS Using Landsat Satellite Imagery and DEM Data", *African Journal of Agricultural Research,* Vol. 4 (11), November, 2009. pp 1295-1302.

[4]. E.S. Mohamed, A.M. Saleh and A.A. Belal, "Sustainability Indicators for Agricultural Land Use Based on GIS Spatial Modeling in North of Sinai-Egypt", *The Egyptian Journal of Remote Sensing and Space Sciences*, 2014, pp 1-15.

[5]. Jacek Malczewski, "GIS-based multicriteria decision analysis: a survey of the literature", *International Journal of Geographical Information Science*, Vol. 20, 2006, pp 703-726.

[6]. Mary Labib and Amani Nashed, "GIS and geotechnical mapping of expansive soil" *In Toshka region in Shams Engineering Journal,* 2013, pp 423-433.

[7]. Mohamed A.E. Abdel Rahman, A. Natarajan and Rajendra Hegde, "Assessment of land suitability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karnataka, India", *The Egyptian Journal of Remote Sensing and Space Sciences*, Volume 19, 2016, pp 125-141.

[8]. Parveen Chander, Rajiv Chauhan and Rajesh Kumar, "Geotechnical Data Analysis Using GIS: A Case Study", *International Journal of Interdisciplinary Research and Innovations* Vol. 6, Issue 2, 2018, pp 438-445.

[9]. Pravat Kumar Shit, Gouri Sankar Bhunia and Ramkrishna Maiti, "Spatial analysis of soil properties using GIS based geostatistics models", Modeling Earth Systems and Environment volume 2, 2016, pp 1-6.

[10]. W.N.S.Wan-Mohamada and A.N.Abdul-Ghanib, "The Use of Geographic Information System (GIS) for Geotechnical Data Processing and Presentation", *The 2nd International Building Control Conference Procedia Engineering,* 2011, pp 397-406.

[11]. Yin Jianzhong and He Fenqin, "Researching the Relationship between the Change of Vegetation Cover and Runoff Based on RS and GIS" *International Conference on Environmental Science and Engineering Procedia Environmental Sciences,* Vol. 12, 2012, pp 1077-1081.

[12]. Zhang Qingqing, Xu Hailiang, Fu Jingyi, Yu Pujia and Zhang Peng, "Spatial Analysis of Land Use and Land Cover Changes in Recent 30 Years in Manas River Basin", *International Conference on Environmental Science and Engineering, Procedia Environmental Sciences*, Vol. 12, 2012, pp 906-916.

[13]. Zhen Wang, Liming Wang, Ruina Xu, Haitao Huang, and Fang Wu, "GIS and RS based Assessment of Cultivated Land Quality of Shandong Province", International *Conference on Environmental Science and Engineering, Procedia Environmental Sciences*, 2012, pp 823-830.