INDEX PROPERTIES OF SOIL OF SABARMATI RIVER, GANDHINAGAR DISTRICT, GUJARAT

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ABSTRACT

The present work is mainly focused on the Geotechnical properties of the areas in Gandhinagar district. The recent growth which is associated with urbanization in Gandhinagar -Ahmedabad Township calls for appropriate geotechnical investigations of soils of the area. Representative soil samples were collected from the Sabarmati River bed near Gandhinagar area and were investigated as per Indian standard for their index properties with a view to classifying for their use in infrastructural development. Mainly all these locations are leading sites of sand mining from where the soils are supplied as construction material. The soil sample was collected from different locations of the mapped areas in Gandhinagar district. Samples from each site were collected at 3m depth and analyzed using standard geotechnical test e.g. Moisture content test (IS: 2720 (PART-2) -1973), Particle size distribution test (IS: 460-1962), Atterberg limit test (IS: 2720 (PART-5) 1985), Specific gravity test (IS: 2720 (PART-3) 1980). Based on the test results obtained from the study areas, the comparison was made with some standard specifications and it was revealed that samples from all the location are poorly sorted (uniform size) sand (SP soil) and it can be a good option as a construction material.

KEYWORDS: Geotechnical investigation; poorly sorted sand, Gujarat Alluvium, Sabarmati basin.

The incessant incidence of building failures is becoming alarming and has led to the loss of life and assets. These failures have been attributed to factors such as inadequate information about the subsurface geological material, poor foundation design, and poor building materials. (OyedeleKayode Festus et. al, 2014). The purpose of this paper is to identify appropriate methods of geotechnical soil assessment to establish engineering parameters for geotechnical design. Geotechnical soil parameters should be based on the results of a complete geotechnical investigation, which includes in-situ field-testing and/or a laboratory-testing program, used separately or in combination. Such investigation is carried out in order to avert structural failures, as these failures could lead to disasters which pose serious threats to public safety. The ultimate goal of site investigation is to have an appreciable understanding of the behavior of the soil which will bear load to be transmitted by the proposed structure. In the last decade, the involvement of geophysics and geotechnical methods in civil engineering has become a promising approach (Adepelumi et al., 2009; Al Omosh et al., 2008; Schoor, 2002; Adepelumi and Olorunfemi, 2000). Geotechnical measurements may greatly improve the quality of construction in civil engineering as it will focus on the behavior and performance of soils and rocks in the design and construction of civil engineering structures (Oyedele et al., 2009).

Study Area

Gandhinagar lies on 72°37'30'' E to 72°41'15'' E longitude and 23°09'45'' N to 23°15'00'' latitude and lies on banks of the Sabarmati River. It has an area of 649 km², and a population of 1,334,455 of which 35.02% were urban (2001 census). The district includes Gandhinagar with three Suburbs - Chandkheda, Motera, and Adalaj. The four tehsils are - Gandhinagar, Kalol INA, Dahegam and Mansa - and 216 villages. Gandhinagar district is bounded by the districts of Sabarkantha and Aravalli to the northeast, Kheda to the southeast, Ahmedabad to the southwest, and Mehsana to the northwest. (R.K.Verma, 2014).

Gandhinagar district forms a part of Gujarat plain and is sub-divided into two sub micro-regions namely Sabarmati plain and Khari plain on the basis of Physiography, climate, geology, soils and natural vegetation (Pancholi et al., 2017).Physiographically the Sabarmati plain is an alluvial plain claimed by the River Sabarmati which flows in this region from north to south direction and divided the district into two parts(Bhatt et al., 2017). The region has a maximum height of 75 meters above MSL. The geology of this region pertains to alluvium, blown sand, etc. The soils of this region are deep shallow black, brown and alluvial soils of the northern region. This region covers the major parts of the district. The terrain of the Khari plain region is flat alluvial plain with minor undulations. The geological structure of this region is formed of alluvium, blown sand, etc. This region covers Khari River's catchment area in the eastern parts of the district.

The River Sabarmati originates at the place near Vekaria in the Rajasthan state. Thereafter it touches the borders of three districts in the following order, viz. Banaskantha, Sabarkantha, and Mehsana. Subsequently, it enters Gandhinagar district. The River at present flow from the center of the district. The River has high banks particularly in its upper reaches, where they sometimes rise to a height of 60 meters. The River enters this district near the village Rajpur. Thereafter it traverses near the villages of Pindarada, Chekhalarni, Piplaj, Dolarana, Vasna, Pethapur, Lekavada, Indroda, Gandhinagar, Shahpur, Koba, Valad, Bhat, Motera, Koteshwar, and Chiloda in this district.

The River Khari is a tributary of the Sabarmati River. The Khari issues near village Kesarpura of Himmatnagartaluka of the Sabarkantha district. Out of its entire length of 160 km the Khari flows for only 18 km in the Gandhinagar district. It flows in the south-eastern direction of the Gandhinagar district.

The Vatrak River rises from the hills of Dungarpur in Rajasthan. Out of its entire length of 125 km Vatrak flows for only 20 km in the Gandhinagar district.



Figure 1 SEISMOTECTONIC AND GEOLOGICAL MAP OF STUDY AREA (after Bhatt et.al 2017)

GEOTECHNICAL INVESTIGATION

A Geotechnical survey is the first step in the construction or consolidation of a site. It includes information about soil consistency and structure, groundwater level and recommendations for the technical project. The tests required for determination of engineering properties are generally elaborate and time-consuming. The properties of soil which are not the primary interest of geotechnical engineer but which are indicative of the engineering properties are called index properties. (Bipulsen et al. 2014)

Physical and engineering properties of different soil reported that due to the increase of liquid limit, plasticity index of soil increases and frictional angle decreases. (Nath and Dalal 2004) Physical properties of soil may improve the understanding of soil susceptibility to compaction and load support capacity.

Grain size analysis is useful for characterizing a wide variety of physical properties and affect porosity and permeability, and they are also related to the geotechnical properties of sediment (Boggs 1995 and Fetter 2001). Grain size also affects Atterberg's limits, bulk density, shear strength, permeability, and pore pressure transients in response to cyclic loading (Hein 1991). Pal and Ghosh (2010) studied the influence of physical properties on Engineering Properties of Fly Ash and concluded that physical properties have the important effect of the variation of Optimum Moisture Content, Maximum Dry Density and hydraulic conductivity of the soil. Sridharan and Nagaraj (2000), Kaniraj and Havanagi (2001), Bera et al. (2007) have also estimated the physical and engineering behavior of different soils. Terzaghi and Peck (1967) determined the physical properties of all types of clay and also predicted the compression index by physical properties of clay. Nakase et al. (1988) performed large numbers of tests and estimated constitutive parameters of soil by using plasticity index. Giasi et al. (2003) studied the index properties, such as liquid limit and plasticity index of various soils and proposed numerous equations. Ring et al. (1962) estimated liquid limit, plastic limit and plasticity index of soil and they developed two correlations of compaction characteristics based on approximate average particle diameter, the content of particle size finer than 0.001 mm and fineness average. Seed et al. (1962) have studied the plasticity index of different soil which is used as a single factor for predicting swelling potential.

Geotechnical investigation is a tool used to communicate the site conditions, design and construction recommendations. Reliability of the information contained in the geotechnical report has a strong influence on design, construction, project cost, safety and resolution of contractual disputes. Foundation failures are heavily dependent on the quantity and quality of information obtained from geotechnical site investigation. (Goldsworthy et al. 2004). The seismic hazard analysis is concerned with getting an estimate of the strong-motion parameters at a site for the purpose of earthquake resistant design or seismic safety assessment. For generalized applications, seismic hazard analysis can also be used to prepare macro or micro-zoning maps of an area by estimating the strong-motion parameters for a closely spaced grid of sites. (I.D. Gupta 2002) Earthquake hazard is used to describe the severity of ground motion at a site (Anderson and Trifunac, 1977, 1978a), regardless of the consequences, while the risk refers to the consequences (Jordanovski et al., 1991, 1993).

The Geotechnical investigation was carried out to determine the engineering properties of soil material within the Alluvium deposits of Gandhinagar city of Gujarat State, India. Various index properties are investigated e.g. Grain size analysis, Consistency of soil (Atterberg's test), Specific gravity, Density, Moisture content



Figure 2 GRAIN SIZE DISTRIBUTION

This is done to determine the soil gradation. Course grade particles are separated in the sieve analysis portion, and fine grain particles are separated in hydrometer. Grain size analysis of soil samples is done with help of The following set of sieves are used for Coarse Analysis, **IS Sieve: 100, 63, 20, 10 and4.75 mm**, while for Fine Analysis, **IS Sieve: 2 mm, 1 mm, 600, 425, 300, 212, 150, 75 microns** are used .



Figure 3 Particle Size curve

Atterberg's Limit

The Atterberg limits define the boundaries of several states of consistency of plastic soils. The boundaries are defined by the amount of water a soil needs to be at one of those boundaries. The boundaries are called plastic limits and liquid limit, and the difference between them is called the plasticity index. The shrinkage limit is also a part of the Atterberg limits. The result of this test can be used to help predict other engineering properties.

Moisture Content (W_o)

The test provides the moisture content of soil, from this equation $W_0 = M_2 - M_3 / M_2 - M_1 * 100$ Where, M1 = Mass of container with lid, M2 = Mass of container with lid and wet soil, M3 = Mass of container with lid and dry soil

Specific Gravity (G)

The specific gravity of the soil is calculated with help of following formula. Where, W_1 = weight of empty bottle, W_2 = weight of bottle +soil, W_3 = weight of bottle +soil +water, W_4 = weight of bottle +water.

$$G = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

Density

The density (ρ) of soil is defined as the mass (M) of the soil pe**M** init volume (V).From the formula Where, M= mass **V** f the soil, V = volume of density bottle. It is expressed in terms of g/cm³ or kg/m³

Void ratio & Porosity

The porosity **n** of a given soil sample is the ratio of the volume of a void to the total volume of a given soil mass while void ratio \mathbf{e} of a given soil sample is the ratio of the volume of voids to the volume of soil solid in the given soil mass.

 $\mathbf{n} = \mathbf{V}_{\mathbf{v}} / \mathbf{V}$ where $\mathbf{V}\mathbf{v} =$ volume of void, $\mathbf{V} =$ Total volume of soil sample.

 $\mathbf{e} = \mathbf{V}_{\mathbf{v}} / \mathbf{V}_{\mathbf{s}}$ where $\mathbf{V}\mathbf{v} =$ volume of void, $\mathbf{V}\mathbf{s} =$ volume of soil.

RESULTS AND DISCUSSION

Index properties of soil can be traced by different engineering test which as below:

Table 1- Index properties of soil







A soil sample may be either well-graded soil or poorly graded (uniformly graded). A soil is said to be well graded when it has a good representation of particle of all sizes. On the other hand, a soil is said to be poorly graded if it has an excess of certain



particle and deficiency of other, or if it has most of the particles of about the same. From the particle-size distribution curve, we came to know that sample-06 and sample -08 are of dune sand while all other samples are of the poorly sorted soil sample.

All the soil samples are SP types which are poorly graded (uniform particle size) sand

All soil samples are ranging in Specific Gravity between 2.70 to 2.77 which suggest that these samples are mainly sandy soil, Dry Density ranging from 1.76 to 1.99g/cm³, Moisture content from 1.69 to 4.05, low Moisture content of soil suggest that samples are composed sandy soil, Grain size from 88 to 93 of course grain, due to soil is composed of mainly course grain Atterberg limits are NP (not possible), Void ratio ranging from 0.388 to 0.562 and Porosity ranging from 27 % to 35%. All these properties suggest that soils mainly type of sp soil, which is called poorly sorted sandy soil.

The calculation of Cc (co-efficient of the curvature), Cu (uniformity), and K (permeability)



From the calculation, it is noted that for uniformly graded soil, Cu is nearly unity. For a wellgraded soil, Cc must be in between 1 to 3 and in addition, Cu must be greater than 4 for gravel and 6 for sand (Dr.B.C.PUNMIA)

NO.	D10	D30	D60	Cc	Cu	к
SAMPLE 1	0.15	0.2	0.5	0.21	3.33	0.225
SAMPLE 2	0.195	0.7	1.05	1.172	5.38	0.38
SAMPLE 3	0.2	0.6	1.12	0.578	5.6	0.4
SAMPLE 4	0.1	0.4	1.05	0.244	10.5	0.1
SAMPLE 5	0.6	1.05	1.15	1.753	1.92	3.6
SAMPLE 6	0.13	0.5	0.6	0.801	4.62	0.169
SAMPLE 7	0.4	1	1.15	2.17	2.89	1.6
SAMPLE 8	0.15	0.22	0.45	0.034	3	2.25

Table 2 calculation of Cc, Cu and K

CONCLUSION

It is an initial approach to study the Index properties of soil in the central segment of Sabarmati River basin, Gujarat. The Central segment is enriched by sediments transported by a fluvial activity of Sabarmati River and its tributaries. The observations and Lab analysis suggest that the samples which collected from the different locations are having same properties. The soil of this area consists of the density ranges from 1.75(gm/cm²) to 1.90(gm/cm²), and grain size between 88 to 93 of course grain which shows the soil is favorable as a construction material.

From the study of the samples, it can be concluded that all the samples mainly consist of sandy material. Majority of all the samples are collected very nearer to River hence they are mainly having sandy material. Samples are **SP** (poorly **sorted sandy soil**), which make them favorable as a construction material.

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