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Electrical Resistivity Imaging for Characterizing the Shallow Landslide Hazard Site at Kutupalong Rohingya Refugee Camps of Ukhiya, Cox's Bazar, Bangladesh

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Abstract: Electrical imaging survey technique is especially suitable for shallow site investigations where understanding the complexities of the subsurface structure in detail is important. This study has been carried out to identify subsurface lithological variation by showing a connection between resistivity data and basic geotechnical parameters. The Wenner arrangement of approximately 25 m and 50 m image lines with electrode spacing of 1 m and 2 m respectively have been carried out to collect the resistivity data. The changes of shallow subsurface geo-electric layers are unfolded using RES2DINV software by creating the electrical images for a site located in the Kutupalong Rohingya Refugee Camps area in Ukhiya-Teknaf, Cox's Bazar, Bangladesh. Fundamental geotechnical parameters of the soils of the Kutupalong Site including moisture content, particle size distribution, liquid limit, plastic limit, plasticity index, and specific gravity values were evaluated. The importance of the electrical resistivity values was validated by comparing these geotechnical characteristics with the generated electrical images. As a result, the apparent resistivity pseudo sections give a very approximate but nevertheless useful picture that is illustrated on the image lines revealing subsurface geological changes and support to improve shallow landslide site characterization, in addition to the existing geotechnical site characterization method.

Keywords: Electrical Resistivity, Rohingya Refugee Camp, Wenner Configuration, Borehole, Geotechnical Properties, Subsurface Information, Shallow Landslide

1. Introduction

The electrical resistivity method is widely used for locating and identifying various subsurface objects and materials as well as for identifying subsurface lithology and aquifer locations and types. The recent development of practical electrical tomography field system and effective processing and inversion using RES2DINV software have resulted in the production of electrical images that more accurately mirror the subsurface [1] and hence make this geophysical technique particularly powerful. It is useful to study complex geology and in many other shallow subsurface investigations [2].

Due to the difficulty of conducting a geotechnical investigation and the scarcity of available data, the inexpensive surface geo-electric resistivity approach is frequently used to gather detailed information about the subsurface. Geo-electrical resistivity survey has long been used for groundwater survey and the method is found to be very successful. As a preliminary step for the development of groundwater, identifying subsurface lithological changes, engineering, environmental, and archaeological investigations geo-electrical resistivity survey has proven to be a very useful tool [3-10].

In the study area, millions of Rohingya refugees have constructed temporary shelters on the hill slope where numerous people are living densely and inhumanely in congested areas. According to UNHCR (2020), approximately 13 square kilometers of Kutupalong are the home to 8,60,356 people. Few studies have been carried out and suggested that the study area is seismically active and vulnerable for earthquake-induced liquefaction hazards as well as monsoonal rainfall-induced slope failures. Hossain, A. T. M. S. et.al (2023) studied and revealed that people living in these areas are at high risk of landslides and seismic hazards [11]. Therefore, it is full of peril for the people living in this area. On the other hand, groundwater has been used for drinking, households and many other daily purposes. Rapid urbanization requires the construction of roads and multistoried buildings in the Ukhiya hills and surrounding area. Very little sporadic information about the subsurface of the studied area is known by exploratory drilling, GIS-based analysis and some other techniques. Meanwhile, as the exploratory drillings are very costly, so it is highly needed to have knowledge on the subsurface ground state in a cost-effective method. Therefore, the electrical resistivity survey was carried out, and the obtained information was correlated with the information from the borehole.

However, the characterization subsurface imaging data and the basic geotechnical parameters are aided to evaluate the subsurface soil condition for the sustainable construction works in the study area and also to detect the suitable source of fresh water reservoir i.e. the structure of the subsurface aquifer and to assess the water condition in order to establish the groundwater development policy that will be helpful for the inhabitants of the Kutupalong refugee camp area.

In order to create a subsurface image, 2-D electrical resistivity survey technique has been carried out in the investigated area. Shallow subsurface geology has been delineated by analyzing various basic geotechnical parameters including moisture content, specific gravity, grain size distribution, and Atterberg limits of the collected samples from various depths of the boreholes and correlated with the constructed resistivity image.

2. Materials and Methods

2.1. Study Area

The Kutupalong Refugee Camp is located in south-eastern folded region of Bangladesh. It is situated at Ukhia Upazila under the Cox's Bazar division of Bangladesh with a latitude between 21°10′24″ & 21°13′23″ N and the longitude between 92°7′47″ & 92°10′15″ E (Figure 1). This area is characterized by the tropical monsoonal climate with average elevation ranging from 5-38 m. Ukhiya has an average annual temperature of 27.5°C and 143.38 mm of precipitation.

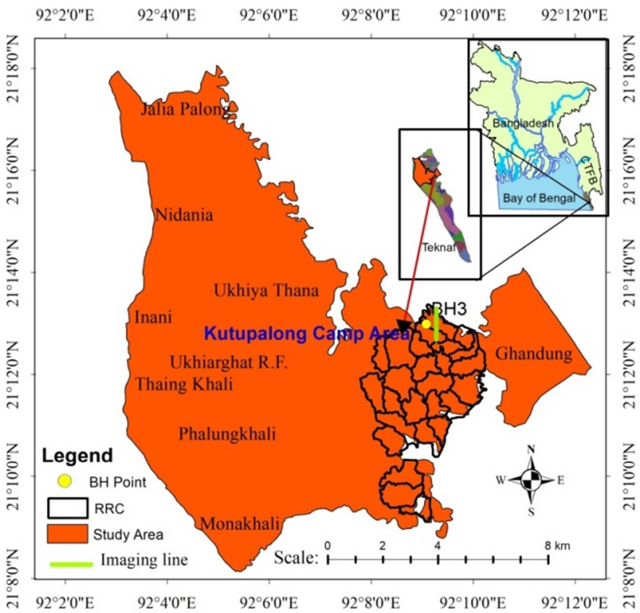

Figure 1. Map showing the location of the study area including the electrical imaging line.

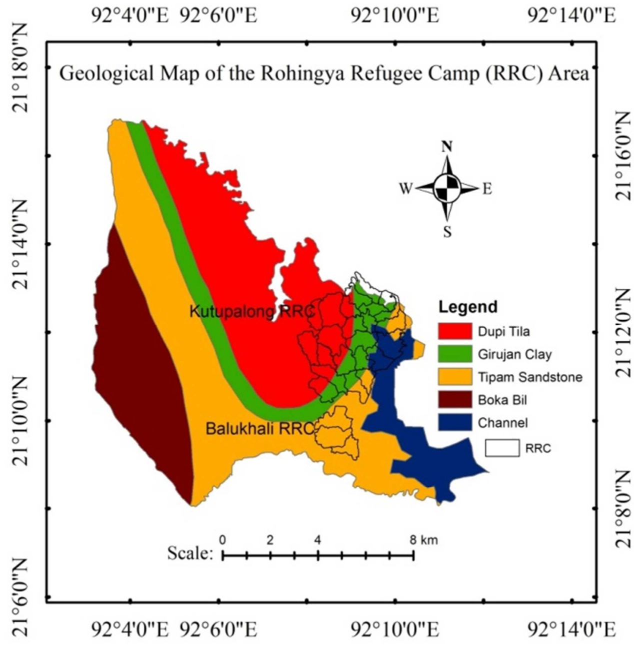

Figure 2. The geological map of the study area [11].

The investigated area is mainly composed of loose to very loose yellowish brown sand, medium to coarse-grained soils. On the other hand, Rohingya people are cutting trees from the hill slopes and digging the foothills to make their temporary shelters. In addition, the impact of climate change, particularly the continuous rainfall for a few days, may cause the hill slope failures. Therefore, the Ukhiya hills are at high risk.

The research area is located in the N-S trend Indo-Burma Orogeny of the Neogene period. The predominant east-west compression that has developed in this area is the result of the relative plate motion between the Indian and Burmese plates. The primary driving factor behind the compression of Tertiary sediments to form folds was the Burmese plate being overpowered by the Indian plate. Hossain A. T. M. S. et. al (2023) discussed the geology of the Rohingya refugee camp of Ukhiya area (Figure 2) [11].

Geologically, the area is composed of the Miocene to Recent aged clastic sedimentary strata including Pliocene Tipam Sandstone, Girujan Clay, and loose Pleistocene Dupi Tila Sandstone (Figure 2). These sedimentary strata are strongly affected by dominant weathering and erosion activities. As a result, the rocks developed faults, fractures, and joints, which caused the end products of alluvium to form unconsolidated to weakly consolidated, even loose sedimentary layers as well as susceptible to future landslide hazards.

2.2. 2-D Imaging and Data Collection

Electrical imaging is a survey technique that aims at building up a 2-D picture of the electrical properties of the subsurface by passing an electrical current along many different paths and measuring associated voltages [12, 13]. A series of earth connections is made by inserting metal stakes (electrodes) into the ground at equal intervals along a line. An excellent 2-D image of the subsurface is obtained by the electrical resistivity survey method with the operation of an IGIS DDR3 DC Resistivity Meter which has the voltage ranges of 50 to 200 mv. To accumulate good quality data, the Wenner electrode arrangement is employed along the lines of 25 m and 50 m with 1 m and 2 m unit electrode spacing respectively. The survey was executed during the month of June 2021.

There are two current electrodes; C1 and C2 as well as two potential electrodes; P1 and P2 have been used to carry out the measurement. The current, I, is injected into the ground through two electrodes, C1 and C2 while a voltage, V is monitored across the electrodes, P1 and P2 (Figure 3). An apparent ground resistivity can be derived using the formula of resistance, R (=V/I), and the inter-electrode distance [14, 8].

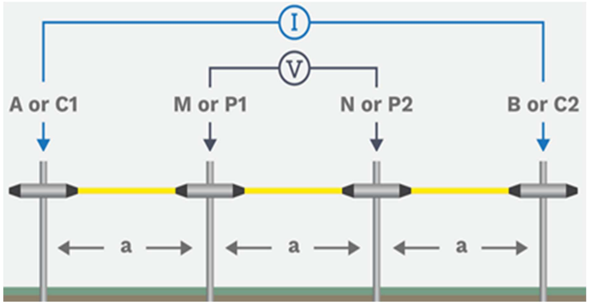

Figure 3. *A conventional four-electrode array (Wenner array) to measure the subsurface resistivity [14].*

For the field survey, a possible sequence of measurements for the Wenner electrode array is executed where the spacing between adjacent electrodes is "a" and is expanded about a fixed center. In the first step, all possible measurements with electrode number 1, 2, 3, 4 and an electrode spacing of "1a" is used. For the second measurement, electrodes number 2, 3, 4 and 5 are used with an electrode spacing of "2a". The same process is repeated by increasing the electrode spacing each time in multiples of N of the spacing a. With increasing the electrode spacing, the number of measurements decreases meanwhile increasing the depths as well as increasing greater volumes of ground.

2.3. Pseudo Section: Data Plotting Method

To plot the data from a 2-D imaging survey, the pseudo section contouring method is normally used (Figure 4). The pseudo section plot obtained by contouring the apparent resistivity values is a convenient means to display the data. To interpret the data from a 2-D imaging survey, a 2-D model for the subsurface which consists of a large number of rectangular blocks is usually used.

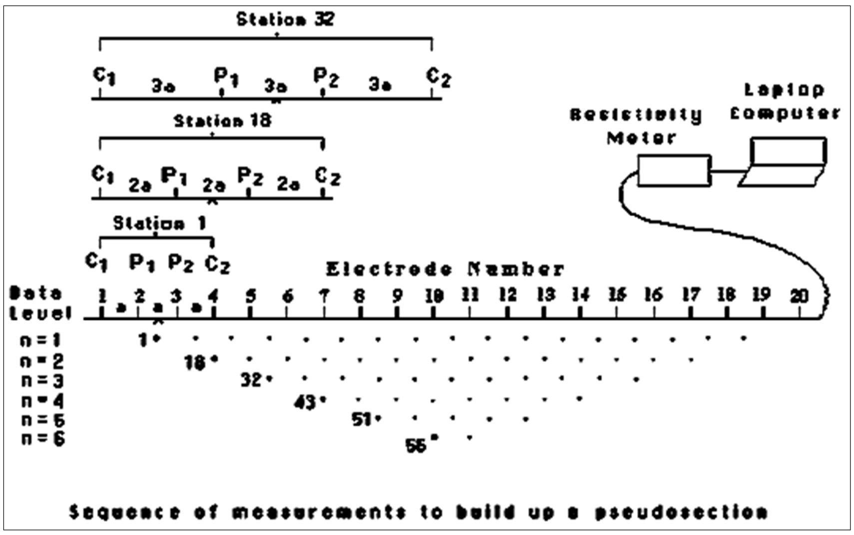

Figure 4. *The arrangement of electrodes for a 2-D electrical survey and the sequence of measurements used to build up a pseudo section [15].*

A computer program is then used to determine the resistivity of the blocks so that the calculated apparent resistivity values agree with the measured values from the field survey. The location of the electrodes and apparent resistivity values must be entered into a text file which can be read by the RES2DINV program. The recent technique developed by Loke, M. H. and Barker, R. D (1995, 1996) has proved to be markedly successful in eliminating electrode geometry effects so that the final processed image provides a good representation of the subsurface [16, 1]. Smoothness-constrained least-square method is used to produce a two-dimensional subsurface model directly from the apparent resistivity pseudo section while the inversion technique is completely automatic. According to Imam, M. H. et. al (2013, 2020, 2022), the technique quickly generates an image that geometrically and quantitatively resembles a genuine resistivity cross-section of the subsurface and offers useful information of the subsurface [8-10].

2.4. Methods for Geotechnical Properties Analyses

Figures 5 & 6 show the borehole locations of BH-2 & BH-03 respectively which have been selected based on the electrical resistivity images. Both disturbed and undisturbed soil samples have been collected from both boreholes in order to assess the subsurface geo-engineering parameters and correlate them with the resistivity data. The light cable percussion drilling technique was used to take samples from two boreholes at intervals of 1.52 m (5 ft). The collected samples were examined in the Engineering Geology Laboratory, Department of Geological Sciences, Jahangirnagar University to measure some fundamental geotechnical properties, such as moisture content (w%), liquid limit (LL), plastic limit (PL), plasticity index (IP), specific gravity (Gs), and grain size distribution using the Standard methods, such as American Society for Testing Materials and British Standards [17, 18].

3. Results and Discussion

The primary goal of this works is the shallow landslide site characterization by examining the shallow subsurface geological condition of the research area based on the relationship between electrical resistivity data and the fundamental geotechnical parameters. To assess the fundamental geotechnical parameters in the lab, samples were taken from the boreholes along the resistivity lines at various depths. Finally, to get a comprehensive image of the subsurface geology of the research area, the measured geotechnical parameters were compared and analyzed with the resistivity data.

3.1. Electrical Resistivity Interpretation

Two electrical images (IM-01 & IM-02) are constructed using RES2DINV software in the Kutupalong Rohingya Refugee Camps region. One image line is 25 m long with 1 m electrode spacing, and oriented from west to east while the another line is oriented from north to south with a length of 50 m and the measuring points are equally marked at every 2 m. Figures 5 and 6 display the generated 2-D electric images of the study location.

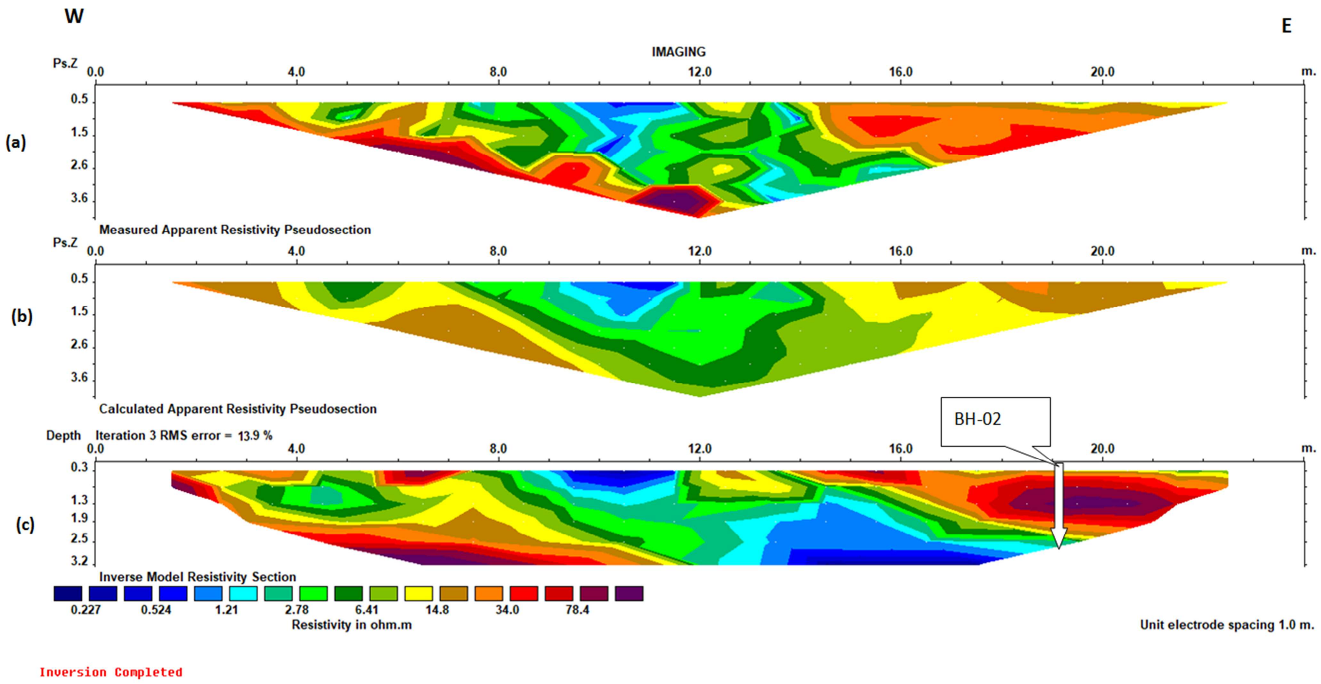

Figure 5. *The results of electrical imaging (IM-01) at the study site: (a) Pseudo section of measured apparent resistivity, (b) Pseudo section of calculated apparent resistivity, (c) Inverted model.*

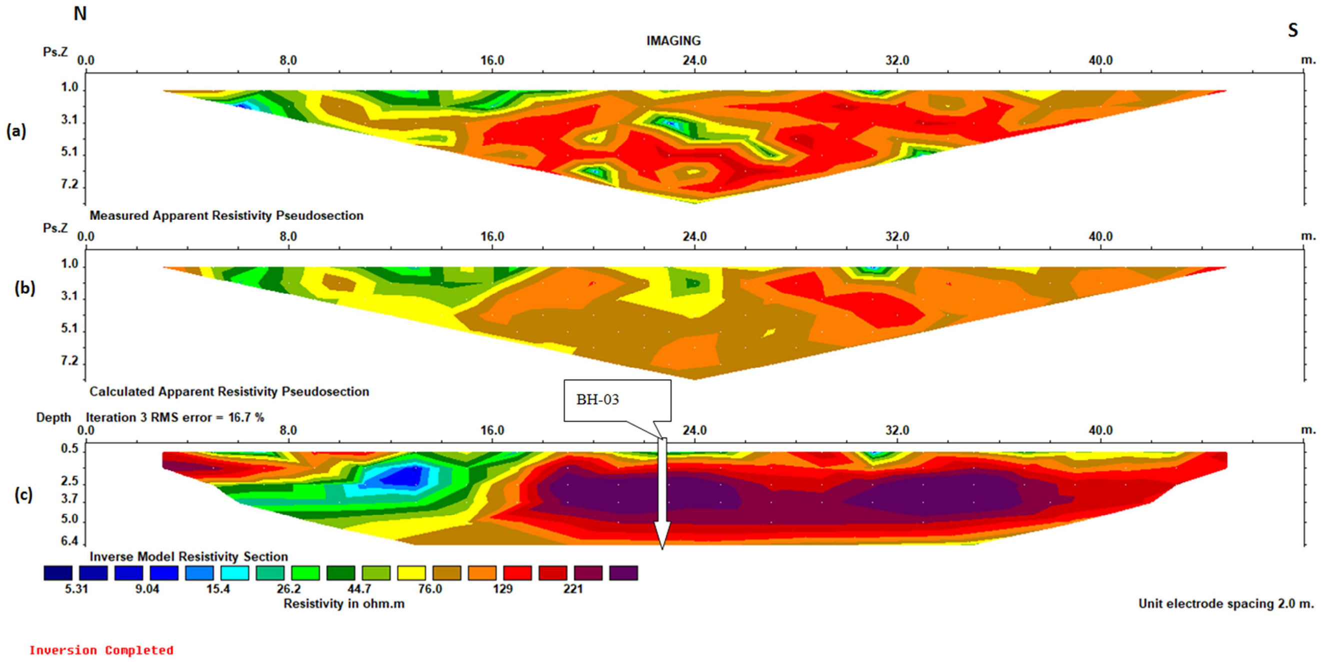

Figure 6. *The results of electrical imaging (IM-02) at the study site: (a) Pseudo section of measured apparent resistivity, (b) Pseudo section of calculated apparent resistivity, (c) Inverted model.*

Figures 5a and 6a show that the measured apparent resistivity pseudo-section changes in a complicated way with both lateral and vertical directions. Both the images show that there are general increases of resistivity values are up to a certain depth, after which it exhibits, moderate resistivity values. Additionally, these demonstrate the enormous variety of uneven topography. The layers are comparatively more distinct in the pseudo-section of computed apparent resistivity (Figures 5b & 6b), which also demonstrate stratification.

It is evident from the pseudo-section of the inverted model (Figures 5c & 6C). From the results of pseudo-section of inverted model (Figure 5c), it is clear that the apparent resistivity variation is more or less from 0.3 Ωm to more than 160 Ωm. The middle portion of the imaging line shows comparatively lower resistivity values which may indicate very fine sand, silty and clayey layers whereas the resistivity variations are prominent in western and eastern side of the imaging line. There are two high resistive zones such as in the western side below the depth of 2 m at about 4 m and 10 m spacing and another zone is in the eastern side below the depth of 0.40 m at about 17.5 m to 22.5m spacing where sand size particles are increasing which may indicate the fresh water pocket. On the other hand, figure 6c shows the apparent resistivity varies between 5 Ωm and more than 380 Ωm on an average. Comparatively higher resistivity values can be seen in the center of the imaging line, which may be fine to medium sand, indicating the locations of two distinct zones. One major zone is in the southern side below the depth of 1.7 m at approximately 31.5 m to 39 m electrode spacing and the other large zone is in the northern side below the depth of 0.8 m at approximately 17.5 m and 26 m electrode spacing where the fine to medium sand size particles are higher, which may imply as the probable aquifers with fresh water pockets. Below the high resistivity zone there are moderate resistivity layers below the depth of 5 m which may indicate the very fine sand along with stiff clay, silty sandy shale and clay layers.

3.2. Interpretation of Geotechnical Properties

3.2.1. Standard Penetration Test (SPT)

The standard penetration test has been conducted in the field using the [17]. This procedure is considered to be a standard insitu test to evaluate the strength of the soil. The test results are affected by many factors such as hammer configurations, hammering system, use of liner inside the split barrel sampler, overburden pressure and length of drill rod. For that reason, the SPT value is corrected in the present investigation. The field SPT data has been corrected using the standard procedure. The corrected SPT is presented corresponding to the depth of the boreholes in figure 7a which show the variations of SPT with depth. Usually, this kind of variations occur due to the variations of grain size, compactness, cementing material, relative density, effective overburden, lateral pressure, and fabric of the soil [19].

The field SPT varies from 5 to 56 and the corrected SPT varies from 10 to 35.5. The SPT values are increasing with increasing depth for both boreholes. However, Borehole-02 shows higher SPT values than Borehole-03 which indicates the soil samples of BH-02 are denser. According to Terzaghi, K. & Peck, R. B. (1967) and British Standard 5930 (1981), the SPT values of BH-02 suggest that the soils below 3.0 m depth may be medium dense and >8.0 m depth may be dense in nature which would be suitable for moderate load bearing structures [20, 21]. Whereas, the values of BH-03 suggest that the soils between 0.6 and 8.5 m in depth may be loose to medium dense (medium to stiff), and the soil is medium dense (or very stiff) below 8.5 m. The examined soil may therefore offer very good strength for light to moderate load bearing structures, according to the total SPT values however, the soils up to 8.5 m of BH-03 need to pay proper attention.

3.2.2. Basic Geotechnical Properties

Analyses have been done on a few chosen samples of the collected soils to identify their fundamental geotechnical properties, such as water content, specific gravity, particle size distribution, and liquid-plastic limit. These properties are summarized in Table 1 and their variations with depth are shown in figures 7 and 8. The moisture content and specific gravity range from 8.35 to 37.01% and 2.56 to 2.84, respectively (Figures 7b & 7c). The moisture content of the samples drops at the 5.18 to 7.77 m depth for borehole-02 and at 2.13 to 5.63 m, and 9.75 to 10.21 m depth for borehole-03 which might be due to the presence of less organic content than the others depth [22]. However, the moisture content values of borehole-03 are slightly lower than the moisture content values of borehole-02. It is identified that the moisture content values drop with depth for borehole-02, while slightly increasing for borehole-03, and the overall specific gravity values increase with depth. It can be seen from the study of the grain size distribution that there is a wide range of variation in the size of the particles and the percentages of sands are higher for the two boreholes. All the samples show well to nearly well grading according to the grain size distribution curves. The average percentage of sand in the soil is around 90.05%, whereas the fine particles (silt & clay) are 1.45% and gravel percentage is 7.5%. However, the samples from borehole-03 show much higher value of fine particles (silt & clay) relative to the samples from borehole-02. For both boreholes, the percentages of sand increased with depth while the percentages of gravel and fine particles dropped (Figure 7d, 7e & 7f).

The samples of borehole-02 is coarse grained and non-cohesive whereas some samples of borehole-03 show certain cohesive in nature. The liquid-plastic limit values for the cohesive soils of the investigated area range from low to intermediate values; the liquid limit values range from 32 to 40% and the plastic limit values range from 13.29 to 21.64%. The plasticity index has values between 17.81 and 24.71%. According to the Atterberg limit values of the tested soils it is evident that the soils of camp area belong to low to intermediate plasticity [23-27]. In Figure 8, the changing of the limit values with depth is depicted. The differences in soil composition and the degree of weathering may be used to explain the variations in physical qualities with regard to depth. According to Chen, F. H. (1975) and Snethen, D. R. (1979), the examined soil samples exhibit modest capacity for soil expansion and indicate medium to high swelling potentiality [28, 29].

Table 1. *Basic geotechnical properties of tested soils with respect to depth.*

BH No.	Depth (m)	Sample No	MC (%)	Gs	Grain size distribution (%)			Atterberg Limit (%)		
					Gravel	Sand	Silt+Clay	LL	PL	PI
BH-02	0.6-1.06	D-1	20.43	2.60	0.56	98.41	1.03	-	-	-
	2.13-2.59	D-2	33.76	2.56	10.03	88.95	1.02	-	-	-
	3.65-4.11	D-3	37.01	2.87	17.11	82.09	0.80	-	-	-
	5.18-5.63	D-4	18.52	2.89	4.69	94.7	0.61	-	-	-
	6.24-6.71	D-5	25.04	2.59	1.2	97.74	1.06	-	-	-
	7.32-7.77	D-6	8.35	2.58	-	-	-	-	-	-
	9.75-10.21	D-7	23.88	2.64	-	-	-	-	-	-
	11.73-12.19	D-8	26.19	2.71	-	-	-	-	-	-
	13.25-13.71	D-9	23.03	2.65	-	-	-	-	-	-
	14.78-15.24	D-10	20.45	2.64	-	-	-	-	-	-
BH-03	0.6-1.06	D-1	21.02	2.60	-	-	-	-	-	-
	2.13-2.59	D-2	15.68	2.76	12.81	84.18	3.01	-	-	-
	3.65-4.11	D-3	12.17	2.49	6.1	91.25	2.65	-	-	-
	5.18-5.63	D-4	17.55	2.73	-	-	-	-	-	-
	6.70-7.16	D-5	27.82	2.60	-	-	-	40.0	21.60	18.40
	8.22-8.68	D-6	27.78	2.66	-	-	-	32.0	14.19	17.81
	9.75-10.21	D-7	9.18	2.65	-	-	-	35.2	13.64	21.56
	10.21-10.66	D-8	24.59	2.84	-	-	-	38.0	13.29	24.71
	11.73-12.19	D-9	22.96	2.82	-	-	-	-	-	-
	13.25-13.71	D-10	22.91	2.84	-	-	-	39.7	18.63	21.07
	14.78-15.24	D-11	26.63	2.79				-	-	-

Based on the grading and plasticity of a disturbed sample of cohesive nature, the soil is classified into a small number of categories [21]. The Standard Plasticity Chart has been plotted (Figure 9) based on the obtained liquid limit and plasticity index results for a few selected samples. The plasticity ranges from low (L) to medium (M), and all of the samples are above the "A" line. As a result, the representative soil sample can be expressed as the low to intermediate plasticity soil (CL to CI).

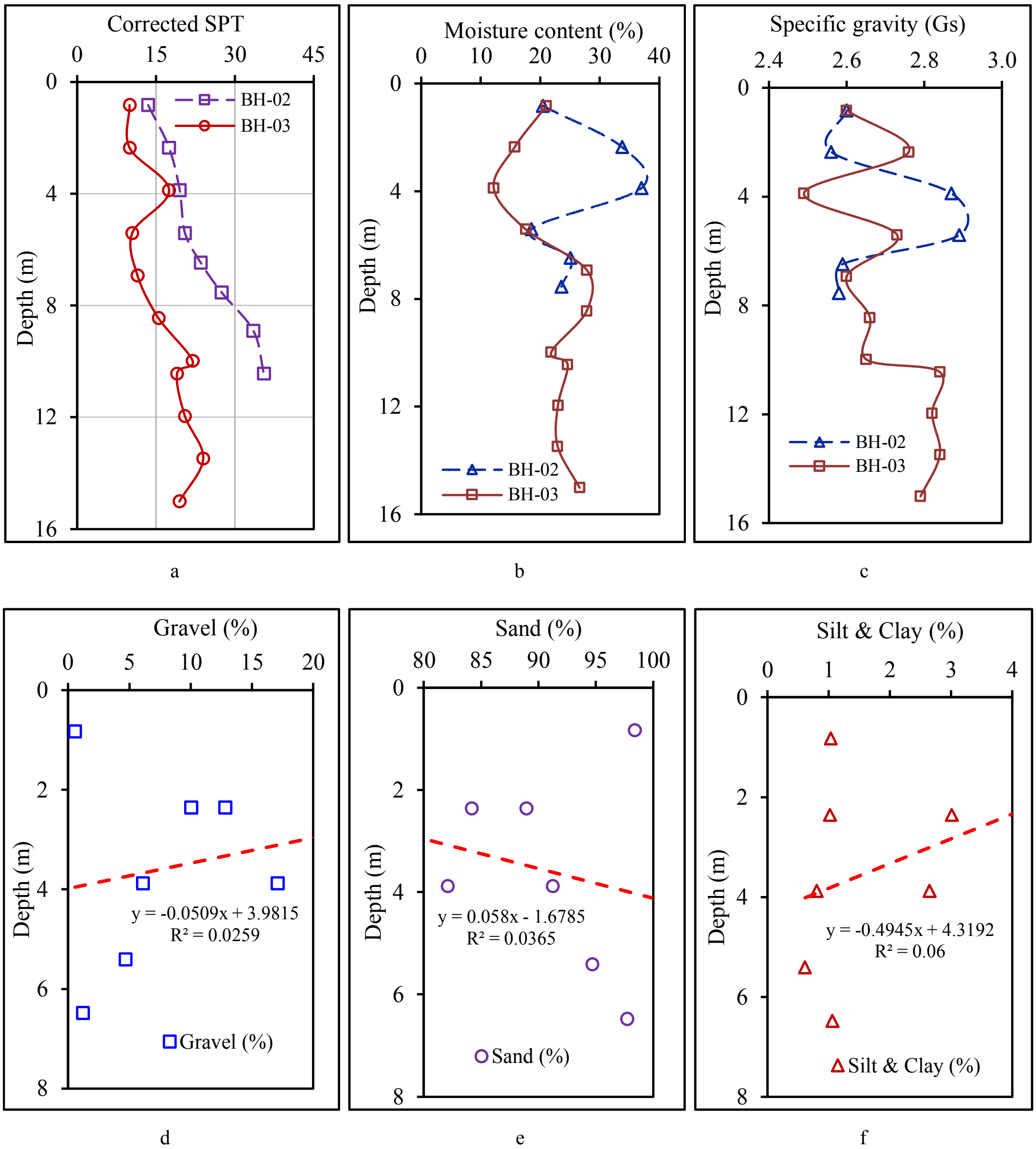

Figure 7. *Variations of basic geotechnical properties of tested soil with respect to depth (a-f).*

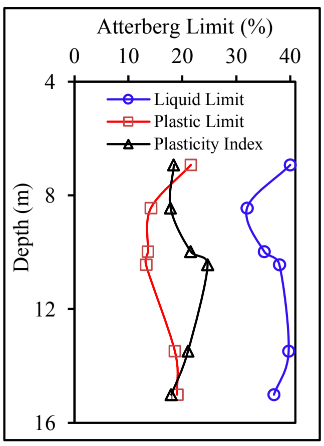

Figure 8. *Variation of limit values with respect to depth.*

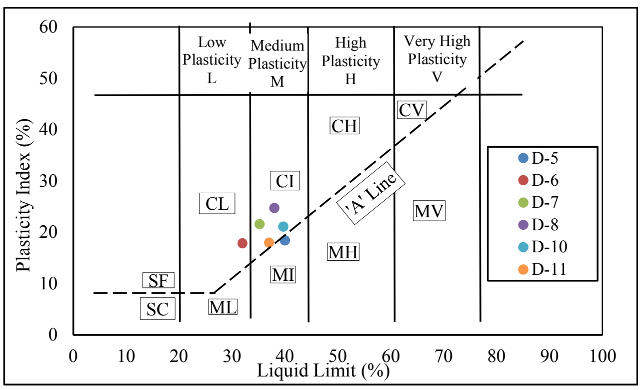

Figure 9. *Plasticity Chart of the studied soil samples [Modified after BS 5930 (1981)].*

4. Correlation Between Geophysical and Engineering Investigation

According to British Standard 5930 (1981), three distinct zones are identified in the study area based on the Standard Penetration Test (SPT), i.e., very loose to loose sand (SP) zone, medium dense sand with presence of silt and little clay (SM) and moderately dense clayey sand (SC) [21]. When resistivity data and drilling data (SPT value) are correlated, it can be seen that the underlying lithologies are related to one another (Table 2 and Figures 10, 11). According to Abu-Hassanein, Z. S. et. al (1996) and Jia, H. J. et. al (2014) the soil that has a higher proportion of smaller particles indicates a higher plasticity value and a lower resistivity value [30, 31]. Therefore, the resistivity of soils increases with increasing particle size or vice versa. The current study agrees with the aforementioned findings.

Table 2. *Correlation between SPT variations (BH-02 & BH-03) and electrical imagings (IM-01 & IM-02) at Kutupalong Rohingya Refugee Camp.*

BH No.	Drilling data	SPT Value (N)	Imaging No.	Resistivity imaging data	Lithology
BH-02	Very loose sand (0 – 0.6 m depth)	SPT: 2 to 5	IM-01	Low resistivity (<0.5 Ωm) material (0 – 0.8 m depth)	Weathered materials with very loose sands
	Fine to Medium sand with cobble and pebble (0.6 – 4.11 m depth)	SPT: 12 to 20		High resistivity (14 – >160 Ωm) material (0.8 – >3.5 m depth)	Medium Sandstone
	Very fine to fine sand with some clay (4.11 – 10.67+ m depth)	SPT: 21 to >24		Medium resistivity (01 – 10 Ωm) material (>4 m depth)	Fine sandstone with silty clay
BH-03	Very loose sand (0 – 0.6 m depth)	SPT: 2 to 5	IM-02	Low resistivity (<26 Ωm) material (0 – 0.5 m depth)	Weathered materials with very loose sands
	Fine to Medium sand with cobble and pebble (0.6 – 4.11 m depth)	SPT: 6 to 10		High resistivity (80 – >380 Ωm) material (0.8 – 5 m depth)	Medium Sandstone
	Very fine to fine sand with some clay (4.11 – 15.24+ m depth)	SPT: 11 to >30		Medium resistivity (<80 Ωm) material (>5 m depth)	Fine sandstone with silty clay

It is clear from the electric imaging results that resistivity values increase with grain size, particularly around the position of the boreholes. Differences in grain size and saturation level may contribute to resistivity differences. From the Figure 10 as well as the grain size analysis and visual observation, it is found that the finer particles (fine sand, silt & clay) are increasing below the depth of 4 in the middle portion of the image line where as the percentage of sand size particles are higher in western and eastern side of the image line which matched up both electric image and borehole data.

Meanwhile, Figure 11 shows that the percentage of sand size particles are higher in the middle portion of the image line where as the finer particles (fine sand, silt & clay) are increasing below the depth of 5 in the lower portion of the image line which also matched up both electric image and borehole data. However, the high resistive zones may indicate the sand layers of the top Dupi Tila Formation and this sand layers may serve as an outstanding fresh water aquifer.

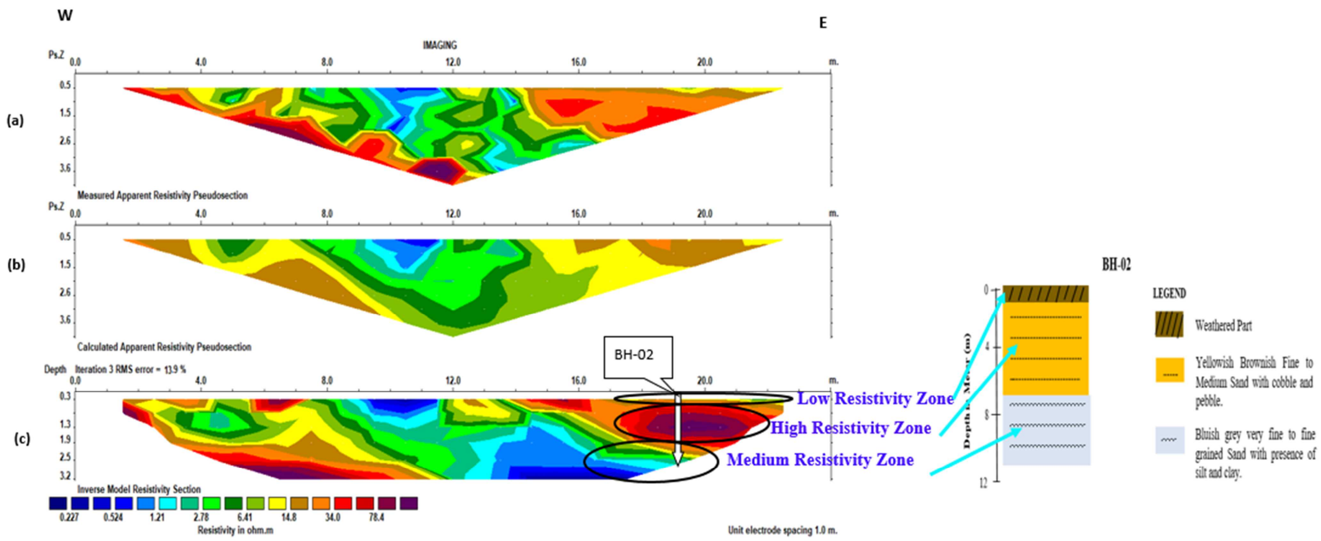

Figure 10. *Correlation between 2-D electrical image (IM-01) and BH-02 information.*

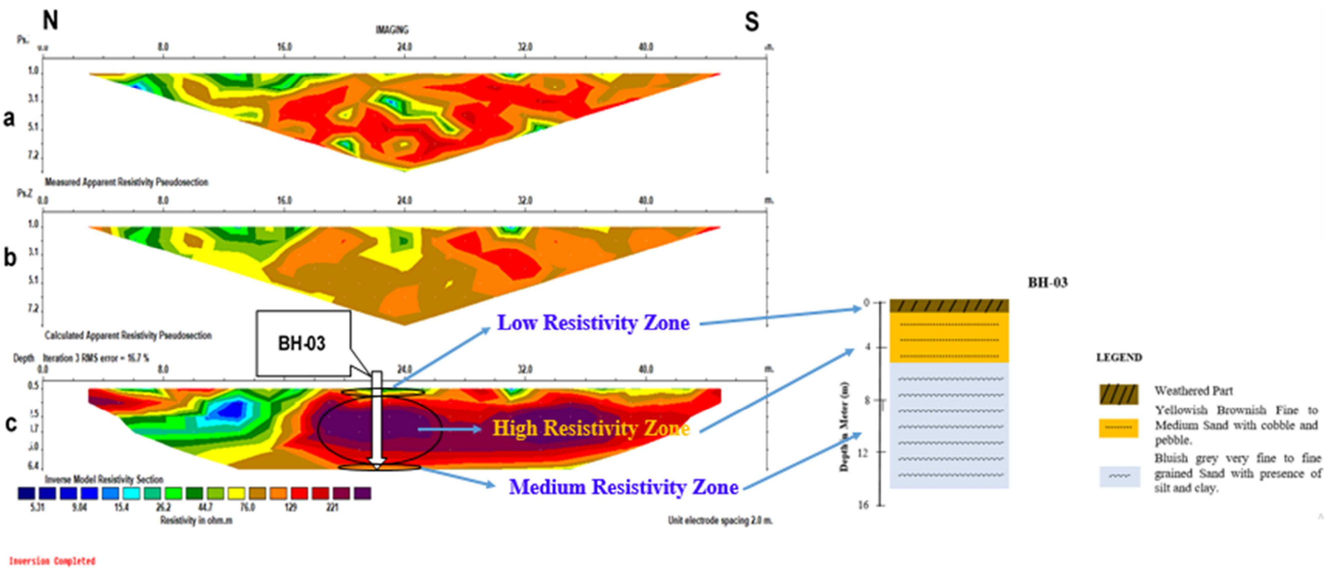

Figure 11. *Correlation between 2-D electrical image (IM-02) and BH-03 information.*

5. Conclusion

Geoelectrical resistivity survey has been carried out to collect good quality data as well as to characterize the subsurface geology and to compare the results with geotechnical site characterization. The present study reveals that the lithological succession is not consistent throughout the studied region; rather, it shows heterogeneous stratifications of clay, silt, and sand. There is an ambiguity to interpret the clayey layer and brackish water in the pore space because both show the very low resistivity values. Very low resistivity of this layer may be either due to the clayey composition of the layer or due to higher salinity of the pore space water. Therefore to overcome this ambiguity, resistivity values are correlated to borehole data.

According to the corrected SPT of the BH-02, the soils might be medium dense to dense and non-cohesive in nature which would be suitable for moderate load bearing structures. But for BH-03, the soils up to 8.5 m are loose/soft to stiff/medium dense which need to take proper attention for any constructions in the study area. The density of the soils below 8.5 m is very stiff /medium dense to dense state, making it suitable for constructions with moderate load bearing capacity.

The resistivity image shows higher values of two prominent zones in the middle portion of the imaging line indicating the increasing of grain size. From correlation of the image sections and geotechnical parameters at boreholes, it is clearly evident that the upper portion contains weathered materials and the percentages of sand size particles shows a gradual increasing in the middle portion of the image then further increasing the finer particles such as fine sand, silt and clay proportions with increasing depth. However, there are two prominent high resistive zones are located in almost the middle portion of the image where fine to medium sand size particles are present. These high resistive zones may indicate the potential aquifer of fresh water sources for drinking purpose.

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Author Contributions

Project proposal, and conception, research direction was initiated by Abu Taher Mohammad Shakhawat Hossain and edited the first draft. All authors were analyzed & discussed the results, and developed the manuscript concept at all stages. Mohammad Hasan Imam wrote the first draft of this manuscript. Abu Taher Mohammad Shakhawat Hossain, Mohammad Hasan Imam, Hossain Mohammad Sayem and Purba Anindita Khan helped to prepare the materials, revise this manuscript and provided feedback. Mahmuda Khatun, Mohammad Emdadul Haque, Sheikh Jafia Jafrin, Tonmoy Dutta, Hasan Mahmud were involved with field data collection and analysis. However, all authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The authors confirm that this article is original research works and has not been publish in any journal earlier. Consent to participate is not applicable.

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Conflicts of Interest

Authors declare that there is no conflict of interest.

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