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Determination of Landslide Characterization in the Bahramkosh Dam Reservoir using combination of Electrical Resistivity Tomography and Geotechnical Parameters

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Abstract

The main purpose of this research is consideration the landslide occurred at Bahramkush Dam Reservoir. To archive this aim geoelectrical soundings with Schlumberger and Dipole – Dipole arrays in this area did. 7 and 10 profile respectively by Schlumberger and dipole – dipole arrays were survived. 200 vertical electrical soundings by these arrays were carried out. The maximum current electrode spacing length AB/2 was 215 meter. This method revealed the significant electrical discontinuity which located between sound numbers 11 and 12. This research work showed the change in lithology from marl conglomerate to soft or tiny marls. The results of the performed analysis with vin32 software showed that the sliding mass has difference in resistance from 10 to 4000 Ohm.

Keywords: Geoelectrical soundings, landslide surface, sliding mass, Dipole – Dipole arras

1- Introduction

Landslides are the down slope movement of rock, soil, or both of them under the influence of gravity. Different landslide types are classified by rate of movement and the type of material. Velocity of landslide movement can also vary from slow to very rapid. Soil and rock material on slopes may have high moisture levels, increasing pore-water pressure, which destabilizes the slope and causes slides. It is important to be aware of storm-water drainage near homes, offices, and other buildings. Rapid lowering of groundwater against a slope can trigger landslides, especially along dams, coastlines, reservoirs, and rivers. The pore pressure in soil or rock material may not be able to adjust to a sudden drawdown of water, causing slope instability. Stream water erosion can destabilize slopes and cause failure. This is common at the toe (bottom) of a slope. Human activities–These include vegetation removal, excavation of toe slopes, loading on a slope, leakage from pipes, surface and underground mining. Ground shaking during earthquakes can cause landslides in many different topographic and geological settings. The best method for avoiding damages from landslides and having to mitigate the hazard is to avoid construction on steep slopes. As this is not an entirely possible, consulting soil and geologic maps in the early investigation for development of a property is important. Check for descriptions of soil and rock types that may be susceptible to landslides [1].

In this paper the first studies of Bahramkosh reservoir dam was carried out for purpose to supply agricultural lands water in Khoramabad city range with reservoir18368000m3 volumes and 78 meter elevation from foundation. Season River and BahramKosh River are water source for this dam. After the primary hydrological studies this research was binged and axis which located in downstream investigated with 5 geotechnical bore holes.

1. Geological Setting:

This project is located at $48^{\circ}\ 27'\ 30''$ longitude and $33^{\circ}\ 19'$ latitude which in the base of the Iran structural division's region this area located at the Zagros zone in the folded Zagorsk unit. In the base of Khoramabad1:100000 geological maps and Iran national oil company also Khoramabad 1:250000 geological maps that prepared by Iran geological organization and mineral exploration the Stratigraphy of units that occurrence in location from older to newer are :Ilam- surgah formations, Shali- Gurpi, Amiranclastic, Tale zang, Kashkanclastic, Asmari – Shahbazan, Ghachsaran and Bbakhtiari.(fig 1)

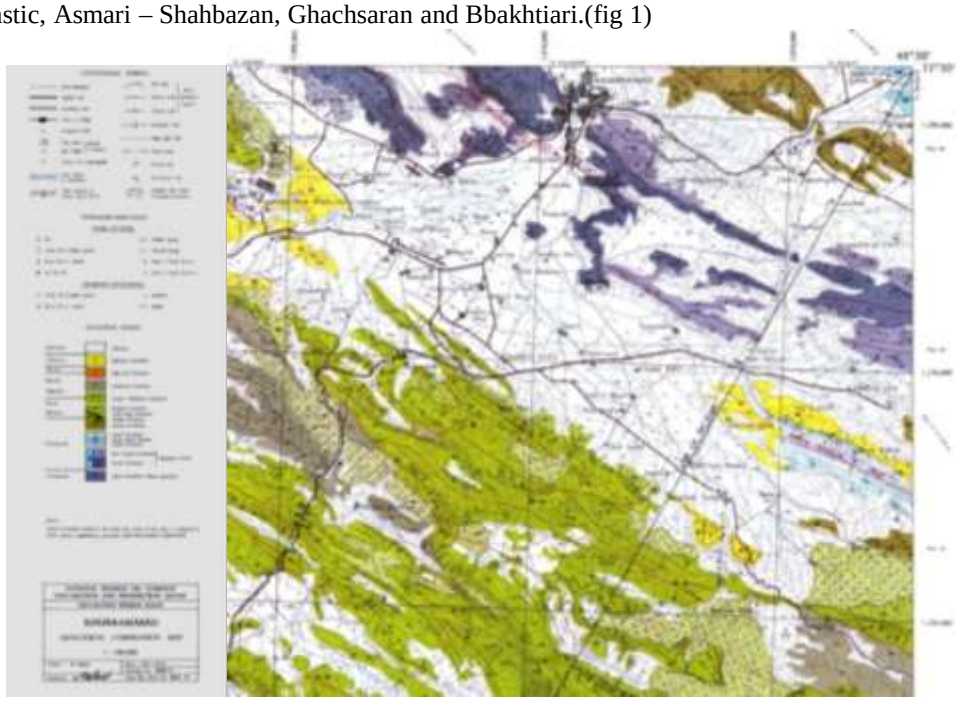


Fig.1 . Geological map of studied area retrieved from 1:100000 KhoramAbad general geology map of Iran national Oil Company

Bahramkosh Dam site is located in the rather open valley which constructed because of Conglomerate rack mass erosion. In site axis offered the river from south to north by Azimuth N10 degree in flow this direction is perpendicular to the river path. In the upstream of dam axis there are two streams that located in the right and the left of this axis. When these streams jointed together they cause to increase the reservoir volume.

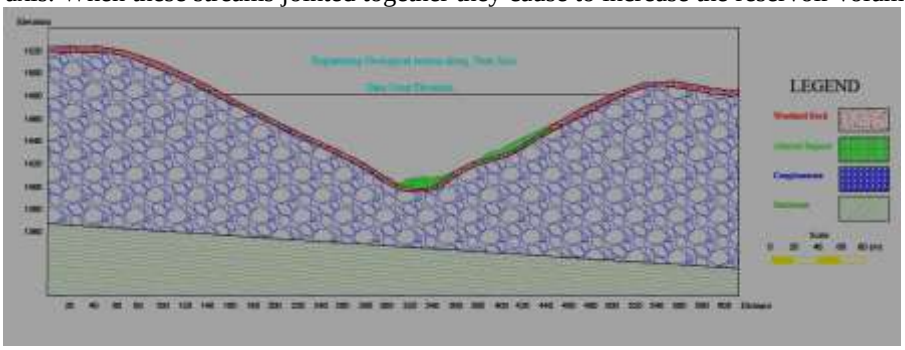


Fig. 2. Engineering geological section along dam axis

Geological layers outcrops in Bahramkosh Dam site consist of conglomerate sedimentary rocks, terrace deposits (old and new), river deposits and domain debris. Fulcrums, wings and reservoir include of sedimentary rocks(fig2). Bahramkosh dam site located in the northern domain of large anticline so both fulcrums in the trace of bedding are approximately similar together and formed to south east- North West. Bedding dip at fulcrum is approximately similar together and had changed about 35 to 45 degrees, bedding dip directions in dam fulcrums are to north east.

2. Joint study of area

All of the rock unit's separations are regard as discontinues. In this chapter layering, joint and faults are studied. It is tried to replace joints which are directly in contact with tectonic factors and joint with dam axis profile. That set of joints which influence by weight powers or oxidation are disregarded. Space locations of joint sets are determined with Dips software and are recorded in figure (Fig 4).
Investigations determined two joint sets which approximately perpendicular on beddings that has a limited spreading in the area.

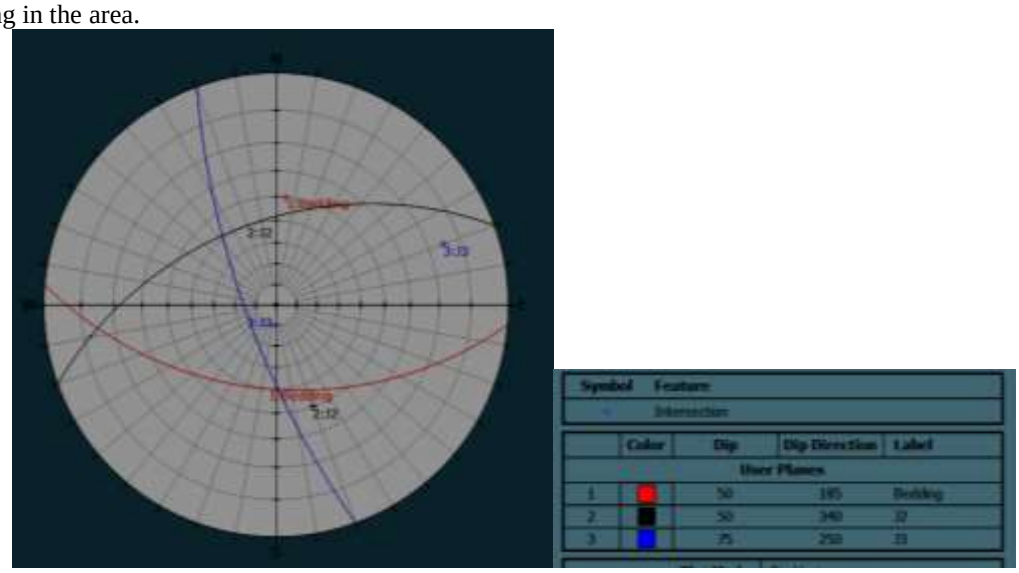


Fig. 3. Curve equal major joint set and bedding in studied area

3. Geoelectrical methods and Physical base

A geoelectrical measurement is carried out by recording the electrical potential arising from current input into the ground with the purpose of achieving information on the resistivity structure in the ground. In a homogeneous ground (half space) the current flow radically out from the current source and the arising equip potential surfaces run perpendicular to the current flow lines and form half spheres (Fig. 4.a). In the common situation with both a current source and a current sink the current flow lines and the equipotential surfaces become more complex (Fig. 4.b). In reality the current flow .Lines and the equip potential lines will form an even more complex pattern as the current flow lines will bend at boundaries, where the resistivity's change Geoelectrical data are commonly expressed as apparent resistivity's.

$$\rho_a = K\frac{\nabla V}{I} \qquad (1)$$

∇V is the measured potential, I the transmitted current and K the geometrical factor expressed in below formula

$$K = 2\pi\frac{1}{\left|r_A - r_B\right|} - \frac{1}{\left|r_A - r_N\right|} - \frac{1}{\left|r_B - r_M\right|} + \frac{1}{\left|r_B - r_N\right|} \qquad (2)$$

The apparent resistivity is defined so that it is equal to the true resistivity in a homogeneous half space. In Equation 2 r_A and r_B are positions of the current electrodes and r_M and r_N are positions of the potential electrodes (Fig. 4.)[2].

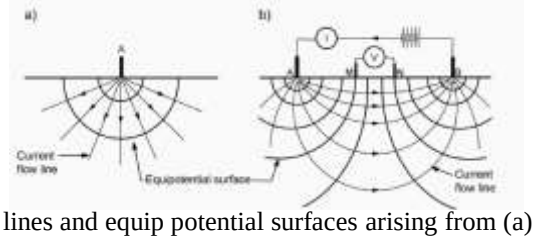


Fig. 4. Simplified current flow lines and equip potential surfaces arising from (a) a single current source and From (b) a set of current electrodes (a current source and sink).

4. 1. Dipole- dipole method:

The depth of investigation in this method is lower than Schlumberger method. Because this array is sensitive to lateral resistivity changes so in studies of vertical constructions such as dykes, undergrounds holes and landslides investigations has more uses. In this area that opens the wires simply was impossible the best method for definition the landslide morphology of underground layers is this array. But because of tiny clay sediments spreading and ragged topography in sliding masse so in addition of these method the Schlumberger array that have more penetration power was used.

Equipment which used in this field studies consist of DC electricity producer **with** 10 to 500 voltages and the intensity of current electricity1 Ampere , accuracy for 0.01 mA current intensity and potential difference (voltage) is 0.01 mV.

4. 2. VES and Schlumberger array

Vertical electrical sounding, VES, is used to determine the resistivity variation with depth. Single VES should only be applied in areas, where the ground is assumed to be horizontal layered with very little lateral variation, since the sounding curves only can be interpreted using a horizontally layered earth (1D) model. A short description of the field technique is given here. A VES is typically carried out in Schlumberger array, where the potential electrodes are placed in a fixed position with a short separation and the current electrodes are placed symmetrically on the outer sides of the potential electrodes. After each resistivity measurement the current electrodes are moved further away from the centre of the array. In this way the current is stepwise made to flow through deeper and deeper parts of the ground. The positions of the current electrodes are typically logarithmically distributed with at least 10 positions per decade. For large distances between the current electrodes, the distance of the potential electrodes is increased to ensure that the measured voltage is above the noise level and the detection level in the instrument. For a VES in Schlumberger array, the distance between the current electrodes should be about250 m to detect a resistivity layer boundary in the depth of 50 m.[3]

The depth of investigation set with change in electrodes spaces **whatever** this spaces is longer so the depth of investigation will be rather [fig5]. In general the purpose of specific resistivity survives is generalizing specific resistivity according to the depth or lateral changes. In this research Schlumberger and Dipole- Dipole arrays were used. In Schlumberger array electrical resistivity of underground layers simultaneously reviewed at vertical and lateral conditions. Maximum depth in isotropic environment almost is 250 meters.

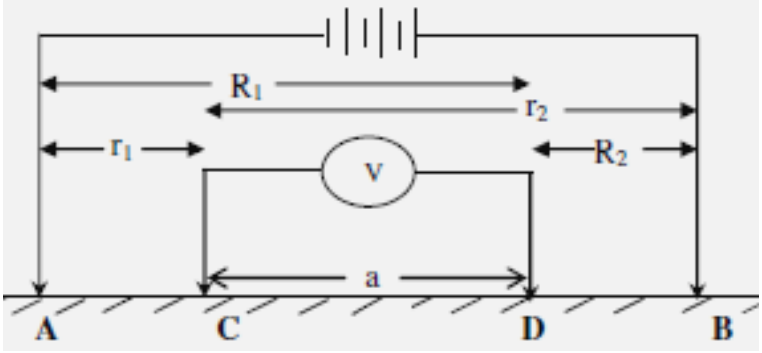


Fig. 5. Schlumberger electrode arrangement

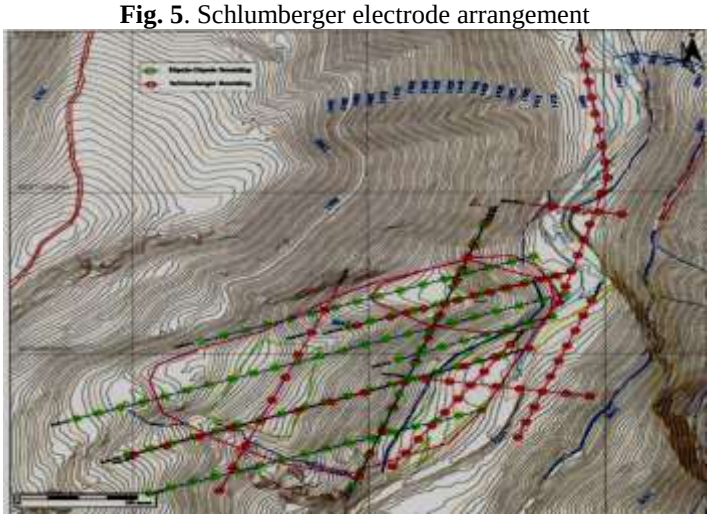


Fig. 6. Geoelectrical soundings location on topography map

4. The purpose of geoelecterical methods:

In this research in order to more accurate investigation on sliding mass so electrical resistivity tomography (ERT) in high density points was used. To achieve these goals so dipole- dipole and Schlumberger arrays were used.

Time schedule for this research consist of 93 electrical soundings with Schlumberger array and current electrode spacing length 500 meter (AB=500 m) and 113 survives with dipole – dipole array by electrode space 20 meter (a=20m were did. The purposes of these arrays survive in this article are below goals:

1- Detection the sliding surface and determine the massive morphology
2- Designation the saturated zone condition
3- Determine the Bedrock depth and condition, topography and material if it possible.
4- Probable faults at probed region
5- Detection the electrical anomaly sheets
6- Determination the electrical specifics of weathered layers and thickness

Geoelectrical soundings curves primary interoperated **in** one dimensional interoperation then electrical sounds connected together and sections of sub –surface conditions of apparent specific resistivity perpetrated. In this article at first by use of IP2win software data interoperated same as several layers and for reach a better image from undergrounds conditions geoelectrical model that have real distribution from layers resistivity used.

5.1 Electrical survives in the study area:

In general survives which were used in this landslide area consist of 7 profile with Dipole – Dipole array and 10 profile by Schlumberger array that shown respectively with D-A, D-B, D-C,D-E,D-F,D-J and SH-A,SH-B,SH-C,SH-D, SH-E, SH-F,SH-H, SH-I, SH-J.[Fig.6]

In the region of this case study 93 electrical sounding in 10 distinct profiles were used which researchable depth approximately had 100 meter also geo electrical current line length was 215 meter (AB/2= 215). Survives had been done at two direction; perpendicular and parallel on landslide movement in river trace and perpendicular of dam axes. SH-A, SH-B profiles had north east- south west motion in the bed of river and SH-C, SH-D, SH-E profiles had done in the left fulcrum and vertical to direction of sliding mass movement in addition of them SH-F, SH-G, SH-I are approximately in slide movement and SH-H in dam axis direction had been survived.

Results from Schlumberger survives analysis had been presented in sub section appearance specific resistivity, geoelectrical resistivity, contour interval maps of specific resistivity and then geological models.

Table1.Geoelectrical soundings coordination by Schlumberger array

Nu	X	Y	X	Nu	X	Y	Z
1	259981.08	3691175.97	1400	48	2598011	3690677	1423.5
2	259983.86	3691156.16	1401.5	49	259792	3690649	1426
3	259986.64	3691136.35	1403.5	50	259774	3690882	1451
4	259989.41	3691116.55	1404	51	259763	3690855	14449
5	259992.19	3691096.74	1404.2	52	259751	3690827	1456
6	259994.97	3691076.94	1403.7	53	259740	3690799	1460
7	259997.76	3691057.13	1402	54	259729	3690771	1458
8	260000.54	3691037.32	1400.2	55	259718	3690743	1457.5
9	260002.97	3691017.76	1403.5	56	259708	3690717	1457
10	259997.8	3690998.44	1406	57	259696	3690688	1454.5
11	259995.01	3690975.24	1407	58	259684	3690660	1454
12	259987.44	3690959.8	1406.8	59	259673	3690632	1452
13	259982.27	3690940.48	1406	60	259600	3690676	1476.5
14	259977.09	3690921.17	1405	61	259627..97	3690687	1471.5
15	259971.91	3690901.85	1407.2	62	259656	3690698	1464.5
16	259966.74	3690882.53	1408	63	259684	3690708	1458
17	259961.56	3690863.21	1408	64	259740	3690730	1451.5
18	259988.45	3690865.62	1407.5	65	259768	3690741	1445.5
19	259981.52	3690846.86	1408.8	66	259796	3690752	1437.5
20	259974.6	3690828.09	1410	67	259848	3690768	1419.5
21	259967.67	3690809.33	1411	68	259880	3690784	1414.5
22	259960.74	3690790.57	1413	69	259936	3690806	1409
23	259953.82	3690711.81	1414.5	70	259868	3690765	1415.5
24	259946.89	3690753.04	1415.5	71	259908	3690760	1412.5

25	259939.97	3690734.28	1417	72	259927	3690757	1410
26	259933.04	3690715.52	1418.5	73	259967	3690751	1420
27	259926.11	3690696.76	1419	74	259987	3690748	1426
28	259919.79	3690810.86	1413	75	259790	3690835	1451
29	259907.7	3690795.21	1412.7	76	259818	3690845	1446.5
30	259897.56	3690777.61	1413	77	259846	3690856	1440
31	259886.45	3690760.98	1413.7	78	259875	3690866	1436.5
32	259875.34	3690744.35	1414.5	79	259903	3690876	1427.5
33	259864.22	3690727.72	1416	80	259931	3690886	1416
34	259853.11	3690711.09	1416.8	81	259959	3690896	1407
35	259842	3690694.46	1417.5	82	259936	3690985	1415.5
36	259830.88	3690677.84	1418.5	83	259996	3690982	1404.5
37	259819.77	3690661.21	1419.5	84	259975	3690978	1403
38	259898.91	3690961.03	1429	85	260015	3690972	1413.5
39	259889.15	3690932.66	1425.5	86	259832	3690850	1443.5
40	259879.4	3690904.29	1431.5	87	259865	3690860	1437
41	259869.65	3690875.92	1436.5	88	259889	3690871	1433.5
42	259859.89	3690847.55	1438	89	259918	3690882	1421
43	259850.14	3690819.18	1429	90	259947	3690892	1410
44	259840.38	3690790.81	1425	91	259855	3690833	1432
45	259830.44	3690764.9	1426	92	259874	3690890	1435
46	259820.88	3690734.07	1426	93	259884	3690919	1426.5
47	259811.12	3690705.7	1423.5				

In this article equal specific resistivity maps drown from Schlumberger smoothed data, these maps designed for half current lengths 10, 21.5, 46.4, 68.1,100,147, 215 that each of them indicated the specific resistivity alternative in difference depths [tables 3, 7]. It is necessary notice to that these maps just shown the general overview from underground conditions because topography hadn't involved and real depth couldn't be determined. Statistics parameters which had shown in table 3 these calculated the electrical resistivity values in front of appearance and approximate depths at 5, 10, 23, 34, 50, 73, 107 meters. By attention the table 3 and compare specific resistivity data so can estimate when half current length increased then tiny clay alluvium had widely spread in depth of investigation (at 10, 23meter)after this condition with increase the dig depth change from marl to conglomerate and layer compaction resistance increase in these layers had occurred. (Table3)

Table2.Geoelectrical soundings coordination by Dipole- Dipole array

Nu	**X**	**Y**	**Z**	**Nu**	**X**	**Y**	**Z**
1	259658.39	3690815.62	1479	58	259955.1	3690846	1407
2	259677.13	3690822.59	1477	59	259595.6	3690676	1477.5
3	259695.88	3690829.56	1473.5	60	259614.3	3690683	1473.5
4	259714.63	3690836.52	1466	61	259632.9	3690691	1470.5
5	259733.37	3690843.49	1458	62	259651.6	3690698	1465.5
6	259752.12	3690850.46	1452.5	63	259670.2	3690705	1461
7	259770.87	3690857.42	1447	64	259688.9	3690712	1457.5
8	259789.62	3690864.39	1442.5	65	259707.6	3690719	1457
9	259808.36	3690871.36	1440.5	66	259726.2	3690727	1453.5
10	249827.11	3690878.32	1439	67	259744.9	3690734	1451.5
11	259845.86	3690885.29	1438	68	259763.5	3690741	1447
12	259864.61	3690892.26	1436.7	69	259782.2	3690748	1441
13	259883.35	3690899.23	1431	70	259800.8	3690755	1437
14	259902.1	3690906.19	1420	71	259819.5	3690763	1430
15	259920.85	3690913.16	1413.5	72	259838.1	3690770	1423.5
16	259939.6	3690920.13	1407.5	73	259856.8	3690777	1418.5
17	259782.98	3690833.62	1452	74	259875.5	3690784	1415.5
18	259801.79	3690840.39	1448.5	75	259894.1	3690791	1413
19	259820.61	3690847.16	1445.5	76	259912.8	3690799	1412.5
20	259839.43	3690853.94	1441.5	77	259931.4	3690806	1409.5
21	259858.25	3690860.71	1437.5	78	259632.2	3690636	1470.5
22	259877.07	3690867.48	1436.2	79	259613.6	3690628	1476.5

23	259895.89	3690874.25	1431	80	259651	3690642	1462
24	259914.71	3690881.03	1422	81	259669.8	3690649	1465.5
25	259933.52	3690887.8	1415	82	259688.6	3690656	1452
26	259952.34	3690894.57	1408.5	83	259707.5	3690663	1448
27	259971.16	3690901.35	1407.5	84	259726.3	3690670	1446
28	259552.23	3690720.79	1488.7	85	259745.1	3690676	1442.5
29	259570.98	3690727.72	1485.5	86	259736.9	3690683	1436
30	259589.74	3690734.66	1482.2	87	259782.7	3690690	1430
31	259608.5	3690741.6	1483	88	259801.5	3690697	1424.5
32	259627.26	3690748.54	1478.8	89	259820.3	3690704	1420.5
33	259646.02	3690755.48	1476.5	90	259839.2	3690710	1418.2
34	259664.77	3690762.41	1472.5	91	259858	3690717	1416.7
35	259683.53	3690769.35	1469	92	259876.8	3690724	1414.8
36	259702.29	3690776.29	1466	93	259895.6	3690731	1413.5
37	259721.05	3690783.23	1463	94	259914.4	3690737	1410
38	259739.81	3690790.17	1459	95	259780.2	3690618	1422
39	259758.57	3690797.1	1456	96	259786.8	3690637	1426
40	259777.32	3690804.04	1453.5	97	259793.3	3690666	1428
41	259796.08	3690810.98	1447.5	98	259799.8	3690675	1424
42	259814.84	3690817.92	1442.5	99	259806.3	3690640	1423
43	259833.6	3690824.86	1437.5	100	259812.8	3690713	1424
44	259852.36	3690831.79	1432.5	101	259819.4	3690732	1426
45	259871.11	3690838.73	1429	102	259825.9	3690750	1426
46	259889.87	3690845.67	1427.5	103	259832.4	3690769	1425.5
47	259908.63	3690852.61	1425	104	259838.9	3690788	1425
48	259927.42	3690859.45	1421.5	105	259845.5	3690807	1427.5
49	259946.22	3690866.29	1413.5	106	259852	3690826	1430.5
50	259965.01	3690873.13	1408.5	107	259858.5	3690845	1437
51	259825.55	3690793.23	1431.5	108	259865	3690864	1437.5
52	259844.06	3690800.81	1426	109	259871.6	3690883	1436
53	259862.57	3690808.39	1422.5	110	259878.1	3690902	1432.5
54	259881.08	3690815.97	1419.5	111	259884.6	3690921	1426.5
55	259899.59	3690823.54	1418	112	259891.1	3690939	1427
56	259918.1	3690831.12	1417.5	113	259897.7	3690958	1428
57	259936.61	3690838.7	1414				

Table 3. Statistic parameters of specific electrical resistance at half-length current

Parameters	**AB/2 (meter)**						
Rho (Ohm- m)	10	21.5	46.4	68.1	100	147	215
Minimum	21	20	7	8	7	7	10
Maximum	753	433	618	687	656	839	901
Average	238	132	55	46	42	48	55
Median	160	87	27	17	15	18	23
Range	733	413	611	680	649	832	891
25% -tile	111	50	17	13	12	15	19
75% - tile	362	204	42	35	27	34	41
Standard Deviation	175	107	82	83	79	96	102

One of the electrical methods which have a using in landslides detections and same studies is dipole – dipole array. One of the advantages of this array is that the changes in lateral and vertical electrical resistance are more detectable. In the table 4 specifications of dipole – dipole arrays exhebited.

Table 4. Specification of survived profiles

Profile name	**D-A,D-B,D-C,D-E,D-F,D-G**
Profile conditions	Parallel to landslide movement (north east- south west) and from lower level to upper level expect D-G that vertical to slid mass movement.
Current electrodes spaces from together	10 meter

Potential electrodes spaces	10 meter
N factor in measurements	From 1 to 8
Exploration depth	30 meter approximately
Electrical sounds spaces from each other	20 meter

In order to provide sub section calculated errors were minimums and difference between calculated and measured resistivity reduced to the lowest value. Also to have better understanding from profiles condition therefore locations of other profiles from this survived detected on them.

Table5.Example of Dipole – Dipole array field data as number 104

No	**a**	**na**	**k**	**∇V**	**I**	**Res**	**Remarks**
1	10	10	188	22	18	229	104
2	10	20	754	1.6	11	104	
3	10	30	1885	0.6	18	62	
4	10	40	3770	0.6	78	29	
5	10	50	6597	1.2	286	28	
6	10	60	10556	0.34	243	12.2	
7	10	70	15834	0.2	344	9	
8	10	80	55619	0.3	350	19	

SH-A is a Schlumberger section is in fig 7. In this section apparent electrical resistivity has changes from 30-500 Ohm also in sound NO.11 electrical discontinuity form these curves is well recognized.

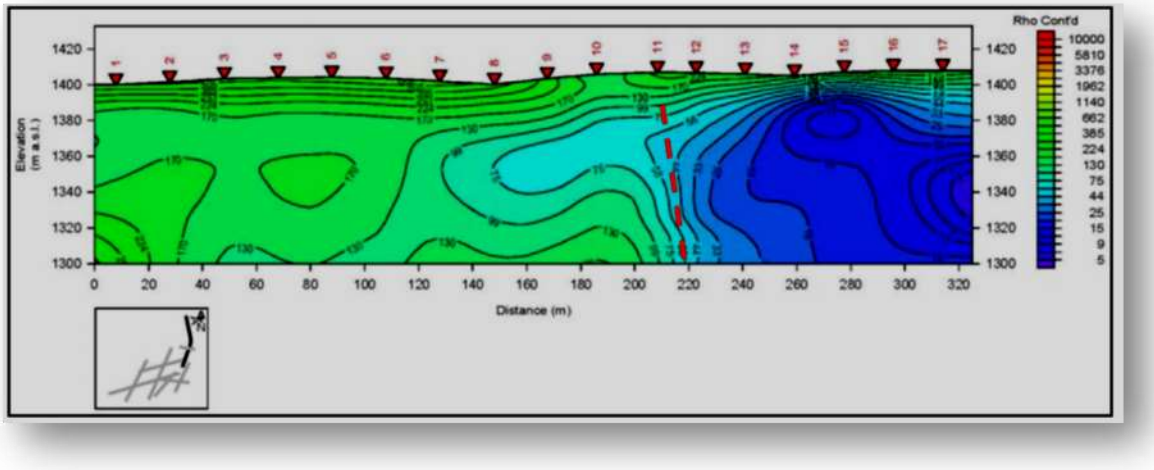


Fig. 7. Equal specific resistance section for SH-A profile

From this research four layers by below characterization detected.

Table 6. Real specific resistance classification in researched area

Layer material	**Real specific resistivity ranges (Oh meter)**
Alluvium deposits and alluvium debris	30-600
Sliding mass	10-4000
Marl and tiny clay	5-50
Conglomerate with marl interlayer	20-1000

Table 7. Example of Schlumberger field data

AB/2	**MN**	**Const**	**∇V**	**I**	**P (a)**	**Remarks**
1	0.3	10.24				39
1.47	0.3	22.39				

2.15	0.3	48.17				
3.16	0.3	104.3				
3.16	1	30.6	80	5.5	445	
4.64	0.3	225.2				
4.64	1	66.85	33	4.2	525	
6.81	1	144.9	13.5	3.5	559	
10	1	313.4	7.2	5	451	
10	3	102.4	2.3	5	471	
14.7	1	678	5.2	8.5	414	
14.7	3	223.9	17	8.5	447	
21.5	3	482	4.4	8	265	
31.6	3	1043	7.3	45	166	
31.6	10	306	26	45	176	
46.4	3	2252	1.9	30.5	140	
46.4	10	668.5	6.1	30.5	134	
68.1	10	1449	0.9	13.5	96	
68.1	30	462	3.4	13.5	116	
100	10	3134	1.4	52	84	
100	30	1024	0.5	52	98	
147	30	2239	1.8	34	118	
215	30	4817	1.9	75	122	
316	30	10433				
464	30	22522				
681	30	48521				

5. Geotechnical boreholes

In the site of region 2 geotechnical bore holes BH1-1, BH1-4 was drilled. In BH1-1 that located on dam axis drilling depth was 68 meter. In this borehole after about 9 meter fine alluvial clay, then rock conglomerate layers being that have almost big grain texture. This layer continued until the 62 meter and after this depth marl and clay deposits continued until to depth equal 68 meter. In BH1-4 that located at left fulcrum drilling depth approximately was 35 meter in this geotechnical borehole about 15 meter sliding derides observed then from depth 15 to 35 marl and clay observed

6. Discussions and conclusions:

The purpose of this research was the investigation of landslide layers electrical characterizations in Bahramkosh reservoir dam. For this purpose electrical tomography with dipole- dipole and Schlumberger arrays carry out and geotechnical drilling were used. The results of these article are mentioned:

1- Layer 1: consist of surface weathered soil and river alluvium deposits which more constructed elements are derbies particles on the extent of rubble, sand and gravel and youngterraces. This layer had electrical resistance rang about 30 to 600 ohm meter. Maximum thickness expected had about 10 meter also real electrical resistivity in saturated parts had decreased.

2- Layer 2: had spread electrical resistance rang and contained the sliding mass. Layer thickness in different stations was varied. Failing fragment rocks and weathered more form upper layers rocks containing the mixture foot of a mountain derbies, conglomerate fragments, lime or marl cement mixture. In this layer because of surface water penetrations in fractures or tiny clay sediments existence so electrical resistance significantly had reduces (less than 10 ohm meter) sometimes as result of big conglomerate fragments spread with lime cementation or empty holes therefore electrical resistance increased to 4000 ohm meter.

3- Layer 3: in this layer tiny grinds deposits contain of marl and clay generation. This layer in some profiles such a D-F, D-E, D-Chad outcrop. Real electrical resistance in this units less than 5 ohm meter and changed to 50. In bases of existence evidence these fine and impenetrable deposits spreads are one of the major factors for landslide occurrence in this area.

4- Layer 4; contain conglomerate layers that sometimes had interlayer consist of marl and clay lens. Electrical resistance in this layer changed from 20 to 1000 ohm meter but in more sounding electrical resistance about 50 to 100 ohm meter had been observed. The change in grading, cementation materials and compaction values were very effective in this layer resistance alter nativity.

5- Investigations showed significant geoelectrical discontinuity at SH-A profile (between 11, 12 soundings) that continued to researched depth; the down layer materials at location of this geo electrical discontinuity changed from marl conglomerate to soft and fine- grained marls with electrical resistance less than 10 ohm meter. In notice to nearness this location to dam axes more investigation for probable fractures existence offered.

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