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Characterization of Besak/Gandaf Quarries and Bada Clay Deposits Using in the Construction of Dams and Roads, District Swabi, Khyber Pakhtunkha, Pakistan

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ABSTRACT

The current study comprises of different tests conducted for soil and aggregates used in the construction of dams and roads. Among these tests gradation (sieve analysis), liquid limit, plastic limit, modified proctor, sand unit weight California bearing ratio (CBR) and hydrometer test were performed for soil mechanics. Gradation (sieve analysis) sand equivalent test, Loss Angles Abrasion (LA) test, soundness test, flakiness and elongation test, specific gravity and water absorption tests were performed for aggregate class. Based on observation regarding gradation test the collected sample is classified as A-6 type material. Data regarding plasticity index (PI) revealed that liquid limit is 38.1% while plastic limit is 24.7%. Proctor test exhibited that optimum moisture content (OMC) and maximum dry density (MDD) are 5.6 % and 2.293 g/cc respectively. Sand unit weight was noted as 1.547. The result for sand equivalent test is 83.3 %. LA and soundness test for coarse aggregate were analyzed as 24.0 % and 3.7% respectively. The result for flakiness and elongation test were 10% and 11% while the result for Specific Gravity and water Absorption test were analyzed as 2.647 and 1.6% respectively. The result obtained from all these tests are according to the American Association of state highways and transportation officials (AASHTO) standard. The materials with unsatisfactory result are strongly suggested to be avoided.

1. Introduction

It was enormously felt on need basis to put light on the specific qualities of materials utilized in construction of the dams. Dams are among the oldest structures built mainly for irrigation purposes and recently for the generation of the electricity. Dam is a barrier that is constructed across a river or stream so the water can be held back or impounded to supply water for drinking or irrigation, to control flooding, and to generate power. The main kinds of dams are earth fill dam, rock fill dam, concrete gravity dam, concrete arch dam and arch gravity (Ersayin, 2006).

For suitable strong and durable embankment dams the material used plays an important role in their construction. The material used to construct earth fill dam/embankment dam include earth material such as (gravel, sand, silt and clay).

Embankment dam is mainly classified into two main categories on the basis of types of soil mainly used as a construction material, such as earth fill dam and rock fill dam. The latter ones further can be classified into a few groups by configurations of dam sections, as one with a centrally located core, one with an inclined core and one with a facing core (Narita, 2000).

Homogenous earth fill dams are composed of only one kind of material, besides the slope protection material. The material utilized must be sufficiently impervious enough to provide an adequate water barrier and the slope must be relatively flat for stability. It is more usual today to build modified homogeneous segments in which pervious materials are set to control steeper slopes. The design and construction of an earth-fill dam is one of the key challenges in the field of geotechnical engineering (Athani, 2015). Zones within the dam, explorations of the dam foundation area, the reservoir where the water will be stored and surrounding areas are selected not only for design of the dam but to locate construction materials.

One of the biggest upstream impermeable blanket is executed in Tarbela Dam in Pakistan. The material used in the construction of Tarbela Dam is excavated from Besak and Gandaf Quarries' and from Bada clay deposits located in the North west of Tarbela Dam. Along within these areas a stream is present between Besak and Gandaf Quarries from where aggregate material is supplied to crush plant for crushing and then such crushed material (aggregate) is then used for construction purpose in buildings, roads, pavements and footpaths. The aggregate material is also used for sub base layer and sub grade layer of roads/highways.

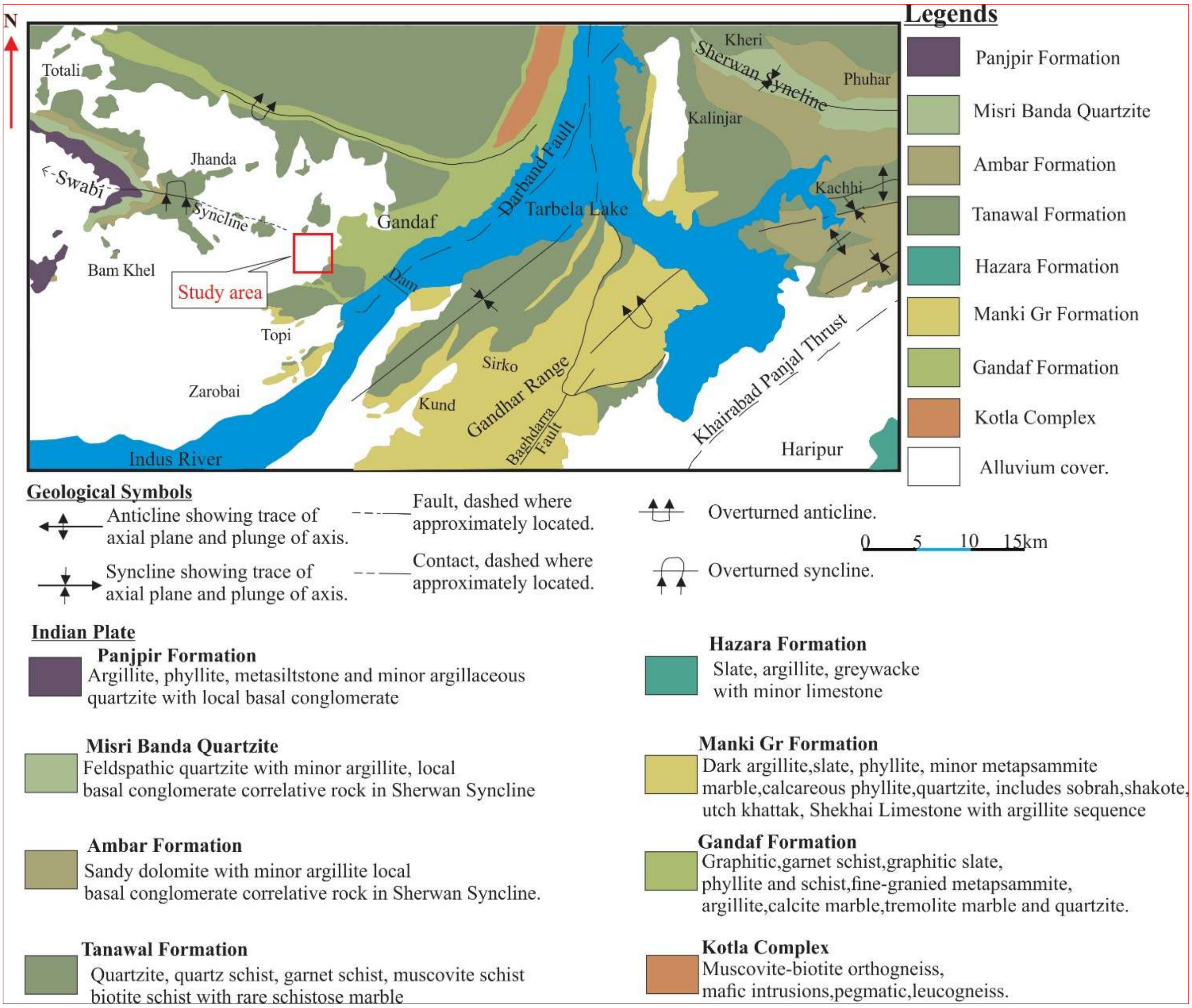

Fig. 1. Geological and accessibility map showing the exposed stratigraphy and macroscopic structures developed in north-west Himalayas, Pakistan. Rectangle shows study area (redrawn after Hussain et al., 2004)

The reason and scope of this study is to assess the engineering properties of the material and rocks being utilized for dams and roads on the premise of their engineering or geo-mechanical properties and to contrast them with the international standards, i.e. AASHTO in order to review its reasonableness for utilization of construction materials. In the current research the data acquired along with different tests were overall researched though computable study and represented in tabular form which was compared with that of international standards, AASHTO to find that either the current material is suitable or not for dam and road construction. The study area lies between latitude 34° 08′ 36.6″ and longitude 072° 40′ 48.7″ and at an elevation of 506 meters from sea level.

2. Regional Geology

The Peshawar intermountain basin lies at the southern margin of the Pakistan Himalaya. The basin came into existence in Plio–Pliestocene time when more than 300 meters of sediments were deposited in response to pounding of drainage by the rising Attock-Cherat range (Burbank and Tahirkheli 1985). It is bounded on the south by the Attock-

Cherat ranges and on the east and west by Gandghar ranges and Khyber ranges respectively. Both of which contain rock transitional between metasediments of the lesser Himalaya and unmetamorphosed foreland basin sediments of Kohat-Potwar plateau. To the north and northwest of the Peshawar basin the strata include metasediments intruded by the granitic rocks belonging to the marginal mass of the Indian plate (Burbank and Tahirkheli, 1985) (Fig. 1). The unlithified sediments of the Peshawar basin are predominantly lacustrine silts with fluvial sand and gravel.

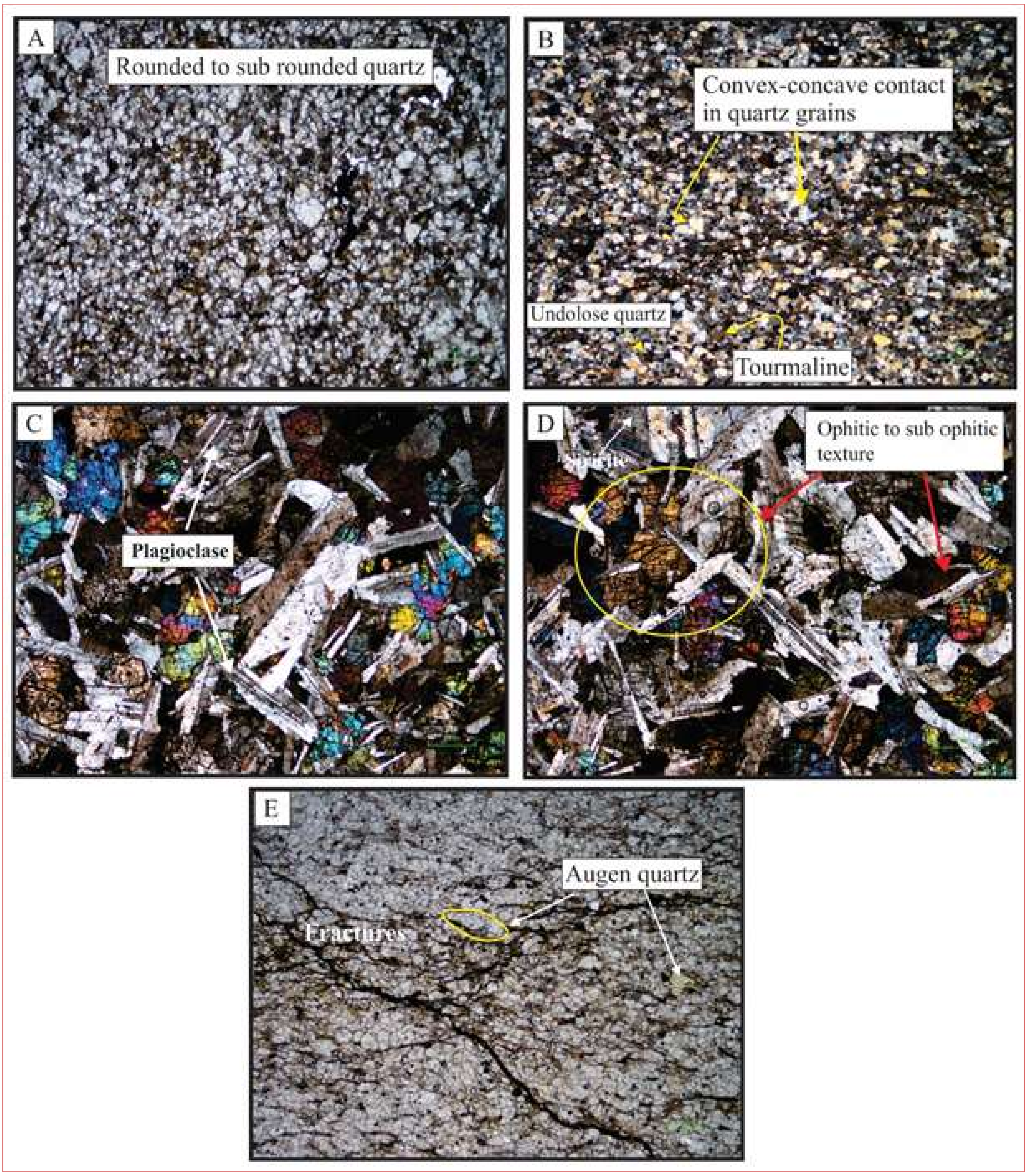

Fig. 2. Photomicrographs in XPL (A) showing rounded to sub-rounded quartz grains with well sorted nature, (B) Showing convex-concave contacts and undulose extinction quartz grains, (C and D) Laths of plagioclaserepresents ophitic to sub-ophitic texture with complete- partial enclosure in clinopyroxene and (E) Augen structure of quartz represents the granitic protolith

The Darband Fault runs northeast parallel to the Indus River and has formed an overhanging escarpment at the base of Indus River gravels with an escarpment at 140 to 210 m of vertical separation. This escarpment is presumed to represent a reverse–separation fault dipping 65° NW to vertical, based on the dip of the overhang as constrained by boreholes. The low rolling hills of the Tarbela Colony, mapped as quaternary terrace deposited by (Calkins and others 1975) are underlain by lacustrine, fluvial, and alluvial fan deposits having dips varying from 20 °N to 40 °N and strikes 20 °N to 70 °E. These are cut by faults having a few centimeters of displacement, striking 75 °NE to 70 °NW, dipping 50°N to vertical, most have reverse separation but some are normal. These sediments are cut by a more or less level erosion surface of moderate relief that may have originated as a high-level Indus River terrace, but if so, there are no Indus River gravels preserved on this surface.

The attitudes of bedding and minor faults strike more easterly than the Darband Fault and the straight course of the Indus River at Tarbela Dam. Further north, air photographs were taken prior to the filling of Tarbela Lake shows a fault cutting bedrock on the west side of the Indus Valley. This fault is characterized by aligned shutter ridges, scarps facing alternately uphill and downhill, and left- lateral stream offsets of 200 to 350 m. This fault may connect on the south with the Darband Fault at the dam.

3. Material and methods

A total of six samples were selected from aggregates of different quarries of the Besak and Gandaf (study area) for petrographic investigation to delineate the mineralogical composition of these aggregates used in construction. These aggregates represent the stream and river bank material transported Indus River water. A total of six thin sections were prepared and studied using the polarizing microscope housed at the petrography lab Department of Geology, Bacha Khan University Charsadda. The individual minerals were identified and their estimated modal compositions were determined on visual basis.

Table 1. Result and detail of gradation test for sandy soil

Sieve No. (Max size, mm)	Cumulative weight retained gr	Retained %	Passing %	Specification limits
3/8 (9.52 mm)	15	1.4	98.6	100
4 (4.76 mm)	45	4.2	95.8	95-100
8 (2.4 mm)	95	9.0	91.0	-----
16 (1.19 mm)	270	25.5	74.5	45-85
30 (0.69 mm)	465	43.9	56.1	------
50(0.30 mm)	675	63.7	36.3	10-30
100 (0.149 mm)	950	89.6	10.3	2-10
200 (0.074 mm)	985	92.9	7.1	0-3

Table 2. Result and detail of gradation test for clayey soil

Sieve No. (Max size, mm)	Cumulative weight retained gr	Retained %	Passing %
10 (2.00 mm)	-	-	100
40 (0.42 mm)	15	1.8	98.2
200 (0.074 mm)	20	2.3	97.7

Laboratory analyses were performed for the soil samples including gradation or sieve analysis (T-271 c 136), plastic index (T-89/96), proctor (AASHTO T-99 and T180) and CBR (AASHTO-193). Similarly, flakiness and elongation (Bs-812), sand unit weight (AASHTO T-19M/T-19-09), specific gravity and water absorption (AASHTO-T-85), LA (AASHTO T-96) and soundness (AASHTO T-104-99) were performed for aggregates.

4. Petrography

Quartz is the most dominant detrital component in the studied samples. Quartz grains constituent making 85 to 90 % composition in the bulk volume. Most of the quartz grains are rounded to sub-rounded in nature (Fig. 2A). These rounded and equidimensional quartz grains represent point and suture contacts (Figs. 2A-B). Furthermore, the intergrain boundaries are characterized by few contacts with convex-concave contacts as well (Fig. 2B). Most of the quartz grains are unaltered with undulose extinction (Fig. 2B). The recrystalized nature of quartz represents its metamorphic origin.

The laths of plagioclase are randomly oriented ranging from ~3 – ~4mm in size (Fig. 2C). These laths are well observed and identified by polysynthetic twinning. Plagioclase constitutes ~8% of the total rock volume represents ophitic to sub-ophitic texture with complete to partial enclosure in clinopyroxene (Fig. 2D). In some places plagioclase grains are altered to clay.

Blue and brown color tourmaline crystals constitute ~30% in the studied samples. The tourmaline crystals are embedded in fine grained quartz and siricite (groundmass). The modal composition of groundmass is <1%. In addition, clinopyroxene accompanied tourmaline in trace amount. Both are highly fractured (Figs. 2B-D). The studied samples also contain iron oxide and opaque minerals in trace amount randomly in groundmass.

Furthermore, minor amount of quartz grains has adopted the augen structure in between the interlocked flowing banded structures (Fig. 2E). The lithic fragments of igneous and metamorphic origin are present, constitute 1–2%. Moreover, the lithic fragments of metamorphic origin dominate over the igneous origin.

5. Characteristics of Materials

5.1. Gradation (Sieve analysis)

This test is used to determine the grading of materials used as a construction material in engineering purposes. This method provides compliance of the particle size distribution with the applicable specifications and necessary data for control of the production of various aggregate products and mixture containing aggregate. The gradation of collected sandy and clayey soil specimens were conducted in the laboratory following the internal standard T-271 c 136. The passing % on sieve No. 200 is 7.1% and 97.7% for sandy soil and clayey soil respectively (Tables 1 and 2).

Table 3. Calculation of plastic limit and liquid limit tests

Type of test	Liquid limit			Plastic limit	
Test No	1	2	3	1	2
Number of blows	17	26	31	-	-
Container No	A	B	C	D	E
Container + Wet sample	36.4	42.56	35.02	33.94	31.9
Container +Dry sample	32.4	37.8	30.1	32.2	29.5
Weight of water	4.0	4.76	4.92	1.74	2.4
Container	22.2	25.2	16.9	25.0	20.0
Weight of dry sample	10.2	12.6	13.2	7.2	9.5
Water content	39.2	37.8	37.3	24.2	25.3

Table 4. Showing the complete result of proctor test

Test No	Volume of mold (cm^3)	Mould + compacted sample (g)	Mould (g)	Container No	Container + wet sample (g)	Container + dry sample (g)	Weight of water (g)	Container weight (g)	Weight of dry soil (g)	Moisture content (%)	Wet density (g/cm^3)	Dry density (g/cm^3)
1	2141	11418	6920	A	253.0	250.6	2.4	50.5	200.1	1.2	2.101	2.060
2	2141	11669	6920	B	276.0	265.9	5.7	55.5	210.4	2.7	2.218	2.160
3	2141	11912	6920	C	280.5	271.8	8.7	60.2	211.6	4.1	2.332	2.240
4	2141	12104	6920	D	315.4	301.4	14.0	51.2	250.2	5.6	2.421	2.293
5	2141	11996	6920	E	279.1	264.5	14.6	50.0	214.5	6.8	2.371	2.220

Table 5. Showing calculations for CBR test

Dry density (g/cm^3)	Percentage compaction (%)	CBR (%)
2.060	90.4	43
2.160	95.1	53
2.240	100.2	67
2.293	95	52

5.2. Plastic index

After gradation or sieve analysis plastic index is performed to confirm the visual verification of the samples (Schroeder, 1984; Gillott, 1987). The same specimen used for sieve analyses was processed for plastic index analyses including both liquid limit determination and plastic limit determination. In this research, the international standard T-89/96 was followed for plastic index test and results are shown in Table 3.

5.3. Modified Proctor Test

OMC and MDD values are the basic requirements for field Density Test (FDT) and CBR. For these two values we conducted the modified proctor test. Proctor testis normally conducted for materials of all layers. The modified proctor test was conducted for collected specimens following the AASHTO standard AASHTO T-99 and T180. The values obtained are given in Table 4

5.4. Sand unit weight

The purpose of sand unit weight test is to prepare the sand for field density test through calibrating it by sand cone method. This test is used in field density test FDT on site and also used in mix design.

Following the standard procedure AASHTO T-19M/T-19-09, the sand was processed for calculation of sand unit weight. The detail calculations are given below.

A. Weight of mould + sand = 5535 grams
B. Weight of mould = 1460 grams
Volume of mould = 2624.8
$WS1$ = weight of sand (A – B) = 5535 – 1460 grams
$WS1$ = 4075 grams

For 2nd layer
Number of blows = 25
A. Weight of mould + sand = 5510 grams
B. Weight of mould = 1460 grams
Volume of mould = 2624.8
$WS2$ = weight of sand (A – B) = 5510 – 1460 grams
$WS2$ = 4050 grams

$$\text{Average weight} = \frac{WS1+WS2}{2}$$

Average weight = 4062.5

$$\text{Sand unit weight} = \frac{Averege\ Weight}{Volume\ of\ mould}$$

Putting the values in the formula,
Sand unit weight = 1.547.

5.5. California Bearing Ration (CBR)

The CBR is a measure of shearing resistance of the materials under controlled density and moisture condition. Considering limitation of CBR test, it is stated that the test procedure should be strictly adhered if high degree of accuracy is desired. To understand the soaked behavior of Bada Clay the collected specimen from the study area was processed for CBR following the international standard of AASHTO-193. The CBR test results are shown in the Tables 5-7.

Table 6. Showing calculations for CBR test

No. of blows	Dry density achieved
10	2.060
25	2.160
56	2.240

Table 7. Showing the calibration and strength of aggregate using CBR values

Penetration		Ring reading	Load (MPa)	Core load (MPa)	Ring reading	Load (MPa)	Core load (MPa)	Ring reading	Load (MPa)	Core load (MPa)
Inch	mm	A	A×RF 1935		A	A×RF 1935		A	A×RF 1935	
0.25	0.64	163	20		246	30		369	45	
0.050	1.27	197	24		279	34		393	48	
0.075	1.91	221	27		303	37		426	52	
0.100	2.54	246	30		328	40		451	55	
0.150	3.81	295	36		377	46		492	60	
0.200	5.08	328	40	43	410	50	53	525	64	67
0.300	7.62	377	46		459	56		574	70	

Table 8. Showing temperature correction for hydrometer analysis

Temperature (°C)	Ct	K (2.50)	K (2.55)	K (2.60)	K (2.65)	K (2.70)	K (2.80)	K (2.75)
16	-0.90	0.0151	0.0148	0.0146	0.0144	0.0141	0.0136	0.0140
17	-0.70	0.0149	0.0146	0.0144	0.0142	0.0140	0.0136	0.0138
18	-0.50	0.0148	0.0144	0.0142	0.0140	0.0138	0.0134	0.0136
19	-0.30	0.0145	0.0143	0.0140	0.0138	0.0136	0.0132	0.0134
20	0.00	0.0143	0.0141	0.0139	0.0137	0.0134	0.0131	0.0133
21	0.20	0.0141	0.0139	0.0137	0.0135	0.0133	0.0129	0.0131
22	0.40	0.0140	0.0137	0.0135	0.0133	0.0131	0.0128	0.0129
23	0.70	0.0138	0.0136	0.0134	0.0132	0.0130	0.0126	0.0128
24	1.00	0.0137	0.0134	0.0132	0.0130	0.0128	0.0125	0.0126
25	1.30	0.0135	0.0133	0.0131	0.0129	0.0127	0.0123	0.0125
26	1.65	0.0133	0.0131	0.0129	0.0127	0.0125	0.0122	0.0124
27	2.00	0.0132	0.0130	0.0128	0.0126	0.0124	0.0120	0.0122
28	2.50	0.0130	0.0128	0.0126	0.0124	0.0123	0.0119	0.0121
29	3.05	0.0129	0.0127	0.0125	0.0123	0.0121	0.0118	0.0120
30	3.80	0.0128	0.0126	0.0124	0.0122	0.0120	0.0117	0.0118

5.6. Hydrometer analysis

In geotechnical engineering, hydrometer analysis is primarily used to know the grain size distribution of a fine grained soil. Hydrometer is an instrument which is used to measure the relative density of a liquid. Hydrometer is made of glass and primarily consists of two parts;

A cylindrical stem with graduation marks
A bulb at bottom weighted with mercury

The hydrometer measures the specific gravity of the soil suspension at the centre of its bulb. The specific gravity depends upon the mass of solids present, which in turn depends upon the particle size. The detail calculation and data collected from hydrometer analyses of samples collected from Gandaf recent deposits are given in Tables 8-11. Furthermore, the mathematical calculations are given below.

Zero Correction = 7
Meniscus Correction = 1
Bitumen content b % Mb/Ms = 0
Amount of Calgen = 50 gm
CF a = .97
Percentage finer than 200 = 91.9
Specific Gravity Gs: 2.80
Dispersing Agent: Calgen

5.7. Sand equivalent analysis

The sand equivalent test was revised by Hveem (1953) as a quick test to determine the presence of undesirable quantities of adverse clay like materials, since an excess of clay is usually detrimental to the performance of any aggregates.

The purpose of sand equivalent test is to find out the presence (%) sand and clay in material. Regarding this, the AASHTO-176 standard was followed to determine the sand equivalent of specimen form the current project area. The value obtained (83.3%) qualify the international standard (i.e. minimum 75%) as given in Table 12.

Table 9. Showing sieve analysis for hydrometer test

Sieve#	Tare	Dry	Mass retained	Passing (Wt)	Passing (%)	Soil retained on each sieve
1in	0.00	0.00	0	430.00	100.00	0
3/4 in	0.00	0.00	0	430.00	100.00	0
3/8 in	0.00	0.00	0	430.00	100.00	0
4	0.00	0.00	0	430.00	100.00	0
10	0.00	0.00	0	430.00	100.00	0
40	0.00	0.00	15	415.00	96.51	15
200	0.00	0.00	20	395.00	91.86	20
pan	0.00	0.00	395			168.91
						2159
		Total	**430.00**			

Table 10. Showing sieve analysis for hydrometer test

Sieve	Mass	Passing (%)
1in	0.00	100.00
3/4 in	0.00	100.00
3/8 in	0.00	100.00
4.0	0.00	100.00
10.0	0.00	100.00
40.0	15.00	96.51
200.0	20.00	91.86
pan	395.00	

5.8. Soundness test for coarse aggregates

Soft and weak rocks breakdown easily during compaction. Therefore, it is necessary to use durable aggregates (Yipping et al., 1998). In order to determine the mass loss of coarse aggregate the aggregate sample is subjected to a number of cycles (usually 5 cycles) of submergence in a sulphate solution either sodium sulphate (Na_2SO_4) or magnesium sulfate ($MgSO_4$) followed by drying in air. This process causes salt crystals to form in the aggregate permeable pore spaces. The final reported loss value (reported as a percentage of total aggregates mass) is a weighted average of the mass loss of each size range.

Aggregates when subjected to wetting, freezing, drying and thawing, must be resistant to break down or failure. This test measures the resistance of aggregates to disintegration. Therefore, it is necessary to understand the behavior of aggregate used in the construction of mega structures. The sample was prepared according to the AASHTO T-104-99. Using the formulas given below the results were obtained in Table 13.

Loss in weight = Weight of aggregate before test − Weight of aggregate after test

$$\text{Percentage loss} = \frac{lossinweight}{weightofaggregatebeforete} \times 100$$

Actual loss % = retain % of original gradation×percentage loss
Maximum loss material using sodium sulphate = 12%
Maximum loss material using magnesium sulphate = 18%

5.9. Loss Angeles abrasion test

The LA test measure the maximum wearing and tearing of rock fragments and provide the accurate strength and hardness of aggregates. The fine grained rocks show less weight loss percent than coarse grained rocks (Cargill and Shakoor, 1990). In the current research the AASHTO T-96 standard was used for aggregates of different sizes collected from stream and queries in Besak and Gandaf areas. Table 14 represents the sample preparation techniques for LA test. Furthermore, by using formulas the results are given below.

$$\text{Los Angeles} = \frac{Tota\,lweight\ of\ sample\ before\ test-weight\ of\ sample\ aftertest}{Total\ weight\ of\ sample} \times 100$$

$$\text{Los Angles} = \frac{5000-3802}{5000} \times 100 = \frac{1198}{5000} \times 100$$

Los Angles = 24.0 %
Maximum required = 40%.

5.10. Specific gravity and water absorption

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. Using the AASHTO-T-85, aggregates were processed for specific gravity and water absorption. The detail calculation of specific gravity and water absorption of aggregates is given below.

Weight of saturated aggregate suspended in water with basket = W_1 g
Weight of basket suspended in water = W_2 g
Weight of saturated aggregate in water = $W_1 - W_2$ g
Weight of saturated surface dry aggregate in air = W_3 g
Weight of water equal to the volume of the aggregate = $W_3-(W_1-W_2)$ g

Weight of oven dry aggregate = W_4 g.
Specific gravity = W_3 / (W_3– (W_1– W_2))
Water Absorption = ((W_3– W_4) / W_4) X 100
Weight of aggregate in air = 2210 gram
Weight of aggregate in water = 1410 gram
Weight of aggregate in S.S.D = 2245 gram
Volume of water = 835

After putting the values in the given formula the specific gravity and water absorption value for aggregate sample is:

Bulk specific gravity (oven dry) = 2.647
Bulk specific gravity (S.S.D) = 2.689
Water Absorption = 1.6%
Required standard value is = 2.6 - 2.9%.

Table 11. Showing observation/calculation for hydrometer test

Elapsed Time (min)	Hydrometer reading	Temp (C)	Ft	Corr. hyd. reading	Hyd. corr. only for meniscus	Eff. depth (cm)	L/t	K	Finer (%)	Adjusted finer (%)	Diameter (mm)	Percentage of fine (%)
0.25	44	26	1.65	38.7	45.0	8.9	35.6620	0.0122	74.90	37.43	0.0729	100.00
0.5	42	26	1.65	36.7	43.0	9.2	18.4874	0.0122	71.10	35.50	0.0525	94.93
1	37	26	1.65	31.7	38.0	10.1	10.0642	0.0122	61.40	30.65	0.0387	81.98
2	32	26	1.65	26.7	33.0	10.9	5.4424	0.0122	51.70	25.81	0.0285	68.03
4	22	26	1.65	16.7	23.0	12.5	3.1314	0.0122	32.30	16.13	0.0216	43.08
8	15	26	1.65	9.7	16.0	13.7	1.7093	0.0122	18.72	9.35	0.0160	24.97
15	11	26	1.65	5.7	12.0	14.3	0.9554	0.0122	10.96	5.47	0.0119	14.62
30	8	26	1.65	2.7	9.0	14.8	0.4941	0.0122	5.14	2.57	0.0086	6.86
60	6	26	1.65	0.7	7.0	15.2	0.2525	0.0122	1.26	0.63	0.0061	1.68
120	5	26	1.65	-0.4	6.0	15.3	0.1276	0.0122	-0.67	-0.34	0.0044	-0.91
240	4	26	1.65	-1.4	5.0	15.5	0.0645	0.0122	-2.61	-0.31	0.0031	-3.49.
480	4	26	1.65	-1.4	5.0	15.5	0.0322	0.0122	-2.61	-0.31	0.0022	-3.49
1440	3	26	1.65	-2.4	4.0	15.6	0.0109	0.0122	-4.55	-2.28	0.0013	-6.08
2880	3	26	1.65	-2.4	4.0	15.6	0.0054	0.0122	-4.55	-2.28	0.0009	-6.08

Table 12. Sand equivalent test calculation for concrete sand

Clay reading (inches)	Sand reading (inches)	Sand equivalent (%)
4.8	4.0	83.3

Table 13. Result and detail of soundness test

Passing sieves (size mm)	Retained sieves	Retained % of original gradation	Weight of aggregate before test	Weight of aggregate after test	Loss in weight	Percentage loss	Actual loss percentage
$2\frac{1}{2}$ (63 mm)	$1\frac{1}{2}$	0	0	0	0	0	0
$1\frac{1}{2}$ (37.5 mm)	3/4	42%	1500	1480	20	1.3	0.6
¾ (9.5 mm)	3/8	43%	1000	962	38	3.8	1.6
3/8 (9.5 mm)	4	15%	300	270	30	10.0	1.5
				Total loss % of coarse aggregates: 3.7%			

Table 14. Gradation of sample for Los Angles Abrasion test

Sieve size (inches)		Weight of aggregates and class
Passing	Retained	Class B (11 Balls)
$1\frac{1}{2}$	1	-
1	$^3/_4$	-
$^3/_4$	$^1/_2$	2500 + 10
$^1/_2$	3/8	2500 + 10
3/8	$^1/_4$	-
$^1/_4$	4	-
4	8	-
Total		5000 +10
Number of spheres		11

6. Discussion

These entire tests are carried out according to the AASHTO standard. The soil tests have significant importance in the construction of dams, roads, highways, buildings, and bridges. The main purpose of these test is to determine the various parameters. In the soil analysis first of all the clay, sand and coarse percentages are determined which are of prime importance in the bearing capacity and stability of soil. The quarries on which we worked were already used for material in the construction of Tarbela Earth Fill Dam (Pakistan). But for the construction of any other dam in the future different tests were performed. The excavated sample material from these quarries was brought to the laboratory and various tests were carried out.

First of all, the suitability of the soil was checked and the soil was found to be suitable and can be used in the construction of dams as well as roads.

For further use as a shoulder material more tests were performed to check whether it qualifies international standards or not. These test included the gradation, plasticity index, proctor, CBR, sand unit weight test, soundness test and hydrometer analysis test.

Furthermore, tests were performed for aggregate material to find the nature of aggregate material. Sand equivalent test was carried out to find out the percentage of sand and clay in material. The soundness test was performed to find out the chemical loss in material while Los Angles Abrasion Test was performed to find mechanical loss. The gradation test was performed for finding the fine and coarse aggregates in the range of specifications. Beside these flakiness and elongation of aggregate material was found which follows international standards. Specific gravity and water absorption test was performed to measure strength and quality of material for being used in the construction of dam and road.

7. Conclusions

Several different types of tests including sieve analysis test, liquid limit determination, plastic limit determination, proctor, sand unit weight, CBR, hydrometer test, sand equivalent test, soundness test for coarse aggregates, Los Angles Abrasion test, gradation test for aggregate material, specific gravity and water absorption test for aggregate material indicate the following data.

In gradation (sieve analysis) test sieve No. 200 result was compared with AASHTO table which qualifies A-6 material which is normally suitable for filling of upstream clay blanket of earth fill dams, as well as in road embankments. Liquid limit determination value is 38.0% and plastic limit determination value is 24.7%. These values correspond to the standard values and can be used in any project. For proctor test the MDD value is 2.293 g/cc and OMC is 5.6%, these values are further used in CBR. Sand unit weight test value is 1.547. The CBR result is according to the laboratory test qualifies the international standard value. Hydrometer test result for clay percentage is 97.70%. Sand equivalent test clay percent and sand percent value is 83.3% against the required value which is 75%, this is according to the specification for any project. In soundness test total loss occurred in coarse aggregate is 3.7% which is suitable and specific for any project. The value for LA is 24% which is also specific respectively.

In specific gravity test the value recorded for bulk specific gravity (oven dry) is 2.647% and for bulk specific gravity surface saturated dry (S.S.D) is 2.689% against the required standard value which is 2.6- 2.9 % while the value for water absorption is 1.6%.

These entire tests were conducted in a sequence from soil to aggregate. The results are concluded mostly in tabular form and were compared with the standard values for each test so that these materials can be used in any project. The results for these entire different tests are satisfactory.

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