

Table of Contents

1.0	INTRODUCTION	2
1.1	Purpose of Work	2
1.2	Scope of Work	2
1.2.1	Core Drilling With Testing.....	2
1.2.2	Laboratory Tests.....	3
2.0	QUANTITY AND LOCATION OF THE WORK.....	3
3.0	PERIOD OF WORK	5
4.0	IMPLEMENTATION PLAN FOR APPROVAL.....	5
5.0	CORE DRILLING WITH TESTING.....	5
5.1	Equipment for the Work	5
5.2	Geodetic Measurement	6
5.3	Core Drilling	6
5.4	Photographs.....	7
5.5	Water Pressure Test in Bedrock (Lugeon test).....	9
5.6	Permeability Test in Unconsolidated Deposits.....	11
5.7	Measurement of Friction Energy Loss	12
5.8	Standard Penetration Test	13
5.9	Installation of Screen Pipes in Boreholes.....	13
6.0	LABORATORY TESTS OF ROCK CORE SAMPLES	13
7.0	REPORT	14
8.0	SAFETY MANAGEMENT	15
9.0	MEASUREMENT AND PAYMENT.....	15
9.1	Core drilling with Testing.....	15
9.2	Laboratory test.....	17
9.3	Mobilization and demobilization	17
9.4	Report.....	17
9.5	Hire of Security and Safety Management.....	18
10.0	SEISMIC SURVEY	18
11.0	FULLY FLEDGED CONSTRUCTION MATERIALS	18

1.0 INTRODUCTION

1.1 Purpose of Work

Detailed geological investigation works, composed of core drilling with testing and laboratory tests of rock core samples shall be performed for the purpose of obtaining geotechnical data about the sub-surface conditions of selected Radat Dam site (proposed Radat Dam Site 3) in Koibatek District of Kabarnet County. It is envisaged that during that period seismic survey will be carried out within the selected Radat Dam Site (at Kipting Bridge area). This in view of the fact that the general project area has been affected by grid-faulting and in particular the selected dam site close to a minor fault zone.

1.2 Scope of Work

The work shall be performed in accordance with the plan and the specifications prepared by the Consultant appointed by NIB (the Client) for the planning and design of Radat Dam. The scope of work for core drilling shall include, but not be limited, to the following:

1.2.1 Core Drilling With Testing

Core drilling shall be made for bedrock, soil and unconsolidated deposits that may contain boulders. The diameter of the boreholes shall be not less than 65 mm (usually 76mm). Every effort should be made for 100% core recovery. Three core drilling boreholes shall be drilled at Radat dam site (one at the riverbed to 85m, another on left abutment to 60m and the other on the right abutment to 50m depth). The drilling sites have been selected by the Consultant as indicated in Table 1.1.

Table 1.1: Selected Core Drilling Sites at Radat Dam Site

Borehole No.	VES No.	Coordinates		Elevation (m)	Depth (m)	Position
		X	Y			
Radat-1	RADAT3-1VES 4	0821827 (E)	0032980 (N)	1386	85	Riverbed
Radat-2	RADAT3-1VES 5	0821770 (E)	0029767 (N)	1426	50	Right Bank
Radat-3	RADAT3-1VES 2	0821874 (E)	0030024 (N)	1456	60	Left Bank

Standard Penetration Tests (SPT), in accordance with ASTM D1586, shall be carried out every 1.5 m of depth in the sections of the bore holes which are located within shales, unconsolidated deposits or intensively weathered rocks, in order to evaluate the mechanical strength of those materials.

Water Pressure Tests (Permeability Packer Test) shall be carried out, following the “Lugeon Test” procedure of the descending stage (down stage) method, for every five (5) metre section, in the parts of boreholes through bedrock in order to evaluate the seepage potential of the foundation rocks.

Permeability Tests shall be carried out by open-end constant head method for soil or unconsolidated deposits at three (3) meter intervals of depth.

1.2.2 Laboratory Tests

The laboratory tests of the core drilling samples shall be carried out in a laboratory approved by the Client before commencement of laboratory testing.

i) Laboratory Tests of Rock Core Samples

Typical specimens selected from the drilling core samples of cylindrical form shall be sent to an approved laboratory for the purpose of determining the basic physical and mechanical characteristics of the rocks in geotechnical aspects.

2.0 QUANTITY AND LOCATION OF THE WORK

The scheduled quantity of work is summarized in Table 2.1. The location map of geological investigations for the selected Radat dam site is provided by the Design Consultant. The exact locations of drill holes will be as instructed on site by the Design Consultant.

The quantities and the locations mentioned above may be subjected to revision in the course of the work depending on new findings.

Table 2.1: Scheduled Quantities for Geological Investigations

ITEM	DESCRIPTION	UNIT	QTY	RATE	AMOUNT (Kshs)
1	Mobilization of all Plant, Equipment and Personnel to site inclusive of camping facilities	LS	1		
2	Demobilization of all Plant, Equipment and Personnel from site	LS	1		
3	Provision of security personnel on site client to assist in facilitation	LS	1		-
4	Set up rig on each point including making platform;	No..	12		
5	Rotary augering / core drilling to depths 0 - 10 metres including provision of core boxes, sample bags, water and temporary casings	M	50		

Table 2.1: Scheduled Quantities for Geological Investigations (contd.)

ITEM	DESCRIPTION	UNIT	QTY	RATE	AMOUNT (Kshs)
6	Rotary core drilling to depths 10 - 20 metres	M	50		

	including provision of core boxes, sample bags, water and temporary casings				
7	Rotary core drilling to depths 20 - 30 metres including provision of core boxes, sample bags, water and temporary casings	M	50		
8	Rotary core drilling to depths 30 - 40 metres including provision of coreboxes, sample bags, water and temporary casings	M	50		
9	Rotary core drilling to depths 40 - 50 metres including provision of coreboxes, sample bags, water and temporary casings	M	30		
10	Rotary core drilling to depths 50 - 60 metres including provision of coreboxes, sample bags, water and temporary casings	M	10		
11	Rotary core drilling to depths 60 - 70 metres including provision of coreboxes, sample bags, water and temporary casings	M	10		
12	Rotary core drilling to depths 70 - 75 metres including provision of coreboxes, sample bags, water and temporary casings		5		
13	Standard Penetration Tests in soils	No.	25		-
14	Undisturbed u100 tests in soils	No.	25		-
15	Laboratory tests:				
15.1	Rockcore samples				-
	Pointload test	No.	36		
	UCS and E Modulus on rock cores	No.	36		-
15.2	Crushed core samples for aggregate tests		36		-
	Rock density and water absorption	No.	36		-
	Los Angeles Abrasion	No.	36		-
	Magnesium sulphate accelerated weathering test	No.	36		-
16	Performance of permeability tests in the soil falling/constant head method	No.	38		
17	Piezometer installation	No.	3		

Table 2.1: Scheduled Quantities for Geological Investigations (contd.)

ITEM	DESCRIPTION	UNIT	QTY	RATE	AMOUNT (Kshs)
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18	Geotechnical Engineering Report	L.S	1		
	SUB TOTAL				
	15% Contingencies on the sub-total to be utilized as directed by the Client				
	SUB-TOTAL				
				16% V.A.T.	
	GRAND TOTAL				

3.0 PERIOD OF WORK

The work period shall be 60 consecutive days calculated from the effective date of the contract. With the tentative commencement date of 1st August 2014, all site works such as core drillings with tests shall be completed by end of 30th September 2014. The final geological investigation report shall be submitted by 30th October 2014.

However, the Contractor is responsible to submit any data upon the request of the Client even before submission of the final report. The Contractor shall make an appropriate Work Program to ensure completion of the works by the scheduled date while taking into account the following key dates for draft design reporting.

Draft Reports

- Core drilling with testing: by 28th September 2014
- Laboratory test for rock core samples: by 25th October 2014

4.0 IMPLEMENTATION PLAN FOR APPROVAL

The Contractor shall submit an implementation plan of the geological investigation works to the Consultant for approval prior to the commencement of the field work. The implementation plan shall include but not be limited to the following items, and be in accordance with the Specifications:

- Detailed work schedule;
- Methods of core drilling with testing and laboratory test;
- Survey equipment used to carry out the survey works, including drilling machines, core barrels, bits, water pumps, water pressure gauges, and packers for water pressure tests;
- The forms for the daily report specified in Section 6.3(8);
- The forms for water pressure test and permeability test as specified in Sections 6.4 and 6.5 respectively; and
- Safety management plan specified in Section 10.

5.0 CORE DRILLING WITH TESTING

5.1 Equipment for the Work

The equipment to be used in the works shall satisfy the following requirements and shall be used under approval of the Client. The Client will hold the right to order replacement of any part of the equipment whenever it is judged to be incompetent.

- 1) The drilling machine shall be of hydraulic driven rotary type, with drilling capacity of not less than 100m of vertical depth at a minimum diameter of 65mm through hard rock. The drilling machine shall also be able to drive a casing pipe of 125mm in diameter to the depth of 40m through the gravel and sand deposits.
- 2) The core barrel shall be of double or triple tube type. The outer diameter of core barrel shall not be less than 60mm for rock and 116mm for soil. The use of a single tube core barrel will be allowed for soil when drilling without water circulation is necessary for good recovering of samples in unconsolidated deposits.
- 3) The bit for drilling rocks shall be diamond bit as a rule. Tungsten carbide metal bits can be used for drilling in unconsolidated deposits. The bit shall be selected deliberately to meet the geological conditions for the best core recovery and efficiency. The outer diameter of the drill bit shall be not less than 65mm, and the minimum core diameter not less than 45mm.
- 4) The water pump for water pressure test shall be of reciprocating-piston type with the maximum pumping capacity not less than 100 litres per minute under the pressure not less than 15kgf/cm² (1.5Mpa – It may be better to use bars instead).
- 5) The water pressure gauge shall have a measuring range not less than 15kgf/cm² (1.5MPa) and minimum reading of 1.0kgf/cm² (0.1MPa) or less. It shall be well calibrated prior to testing in the site.
- 6) The packer shall be of mechanically expanded rubber type or pneumatically expanded sleeve type with a diameter to fit the boreholes (both types will be used: mechanical packers are only appropriate at the top stage). Water pressure test shall be performed in principle by descending stage (down stage) method with a single packer. A set of double packer, however, should always be ready for use.

5.2 Geodetic Measurement

The locations of the holes to be drilled shall be shown at site by the Consultant to the contractor before starting the mobilization. The contractor shall determine the coordinates and levels of the site in relation with the available bench marks. The available bench marks will be availed by the Consultant.

5.3 Core Drilling

1) Core Drilling

Core drilling shall be performed at 1.2m intervals by use of hydraulic driven rotary machines, at the locations, in the directions and up to the depth as specified or directed by the Client. Any additional core drilling including re-drilling shall be done after the approval of the Client.

2) Core Recovery

The work shall aim at 100% core recovery in both rock and unconsolidated deposits (sections with wash outs at depth will indicate highly weathered layers should be properly documented). Taking drilling sludge in rock drilling will not be regarded as core recovery: however, it shall be kept in core boxes. The Client has a right to require re-drilling an entire borehole at the Contractor's expense in case that the core recovery in each ten metre section of drilled hole is less than 70% without acceptable reason as judged by the client.

3) Core Sampling

The recovered core samples shall be placed in order in core boxes as shown in photograph below and shall be submitted to the Client. Each core box shall have five grooves; each groove with adequate dimensions for containing one metre of core section. Accordingly, every core box will contain core samples of 5m section.

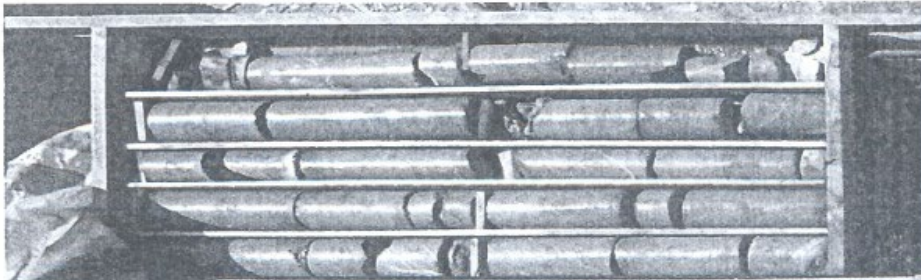


Plate 1: Core Samples in a Core Box

The core samples shall be placed in order, in the same length of grooves of the core box as the length which has been drilled. Parts of no core recovery (wash out) shall be left vacant in the grooves. Marks shall be put regularly to the grooves to indicate depths of sampling. Every core box shall be marked with the borehole number and depth of the section of which the core samples are put in it.

Core samples except rock sample shall be wrapped with polyethylene films in order that drilled samples keep their natural water (moisture: core drilling is done with water circulation; this requirement may not be appropriate?) contents. However, core photographs shall be taken on unwrapped condition.

5.4 Photographs

All cores shall, before the core boxes are stacked, be photographed from the zenith in colour so that details marked on the inside of the box are visible. A linear scale and colour scale shall be

included in the photograph and the final colour positives shall be provided showing core in clear focus at a scale of not less than 10% of the actual size of the core. All photographs shall be taken with the cores shaded from direct sunlight and using flash if necessary.

The cores shall be arranged to reveal the most interesting characteristics such as seams, strata and the like. Before photographing, the core shall be washed and they shall be photographed when still damp so as to bring out the nature and characteristics of the rock. Any wrapped core shall be unwrapped when photographed.

5) Submittal of Photographs of core boxes

The Contractor shall submit a set of colour photographs and a CD-ROM containing their digital images to the Client. Each core photograph cut along the box edge shall be connected to the one for the same hole, so as to be visible of core condition of same hole at a glance.

6) Storing of Core-boxes

All core boxes shall be stored at the designated place directed by the Client. The full core boxes shall be stored in a secure weather proof shed. The boxes shall be stacked not more than 10 boxes high or placed on racks in such a way to permit ready identification and removal of selected boxes.

7) Groundwater Level

Water level in boreholes shall be measured and recorded **every morning** before commencement of the day's drilling work. This measurement shall be continued during the period when the hole is being drilled.

If a location of outstanding loss of drilling water or spring-up of groundwater is encountered, its depth shall be recorded accurately and reported to the Client quickly. The spring water shall be recorded also with its discharge rate and the height at the top of the casing pipe, if any, where the spring discharge is measured. The back-pressure of the spring shall also be measured by attaching a water pressure gauge or a transparent stand pipe at the top of the casing.

8) Daily Report

Daily report of drilling shall be submitted to the Client by the time designated by the Client. The daily report shall contain but not limited to the following information:

- i. Borehole number and date
- ii. Work progress of the day
- iii. Model name of the drilling machine utilized;
- iv. Diameter of the drill bit and the casing;
- v. Water table in the borehole
- vi. Depths at which the core barrel was lifted up from the borehole
- vii. Core recovery length at each lift of the core barrel
- viii. Rate of drilling water circulation

- ix. Rock condition
- x. Depth and rate of water loss or spring, if any, and back pressure of spring water
- xi. Standard penetration test data
- xii. Water pressure test data (to be submitted in another form)
- xiii. Permeability test data (to be submitted in another form)
- xiv. Name of personnel in charge of the drilling and the tests.

The contractor shall propose the forms for the daily report for approval of the Client before commencement of the works.

9) Marking of drilling points after completion of drilling.

On completion of the drilling at each location, the drilling point shall be marked by putting an immovable post or a concrete block with description of the hole number and the elevation at the top of the hole (bore hole should be capped for future grouting during construction).

10) Cleaning of the land used for the works

After the completion of the drilling work, the Contractor shall remove all equipment/materials and garbage from the drilling points. The cleaning shall be satisfactory to Consultant.

5.5 Water Pressure Test in Bedrock (Lugeon test)

Water pressure test or lugeon test in the bedrock, shall be performed in the sections of borehole passing through bedrock, weathered or fresh, in 5 m stages in descending (down stage) order, by use of packers.

When a borehole has been drilled to the depth of bottom of a section to be tested in the bedrock, it shall be washed inside by flushing water through the drill rod inserted to the bottom of the hole. When the returning water becomes clean, a packer shall be installed at the top of the 5m long test section and water shall be pumped into the section through the injection pipe. Under a certain water pressure, regulated constant, the water injection rate shall be observed during 10 minutes. Through 10 minutes' observation time, the injected quantity of water shall be observed and every minute. This procedure shall be repeated under varied pressures directed by the Client, e. g, 1kgf/cm² (0.1Mpa?).

The pressure is varied through the following stages:

Depth (m)	Pressure (Mpa)
0 – 5	0.10 (0.10; 0.25; 0.35; 0.25; 0.1)
5 – 10	0.10 (0.10; 0.25; 0.35; 0.25; 0.1)
10 – 15	0.25 (0.25; 0.35; 0.50; 0.35; 0.25)
15 – 20	0.35 (0.35; 0.45; 0.60; 0.45; 0.35)
20 – 25	0.45 (0.45; 0.55; 0.70; 0.55; 0.45)
25 – 30	0.50 (0.50; 0.65; 0.80; 0.65; 0.50)
30 – 35	0.60 (0.60; 0.75; 0.90; 0.75; 0.60)
35 – 40	0.70 (0.70; 0.85; 1.00; 0.85; 0.70)
40 – 45	0.80 (0.80; 0.95; 1.10; 0.95; 0.80)

45 – 50	0.90 (0.90; 1.05; 1.20; 1.05; 1.05)
50 – 55	1.00 (1.00; 1.10; 1.30; 1.10; 1.00)
55 – 60	1.10 (1.10; 1.20; 1.45; 1.20; 1.10)
60 – 65	1.20 (1.20; 1.45; 1.60; 1.45; 1.20)
Etc.	

The water level in the borehole and the relative height of the pressure gauge from the neck of the hole shall be recorded in each test.

Once the above observation has been completed, the drilling shall be resumed for another 5 m. The new 5 m-section shall be tested again by the same procedure as above.

If the pressure cannot rise up to the designated maximum at an injection rate of 100 litres per minute because of high leakage potential in the test section, the test shall be made only for the attainable pressures. If the insufficient rise of the water pressure is due to deficiency shall be rectified immediately.

Water to be injected for the test shall be sufficiently clean.

The test record shall be submitted to the Client in the site within two days after the test. The results shall be presented in terms of coefficient of permeability and lugeon unit, as calculated by the following formulae:

$$k = \frac{q \times 10^3 \times \ln(L/r)}{2\pi LH \times 60} \quad \text{When } L > 10r$$

$$k = (q \times 10^3 \times \sin h^{-1}(L/2r)) / (2LH \times 60) \quad \text{When } 10r > L > r$$

$$Lu = \frac{q \times 10^6}{LH}$$

Where:

k: Coefficient of permeability (cm/sec)

Lu: Lugeon unit

L: Length of test section

H: Water pressure in head (cm)

r: Radius of the hole (cm)

H = A + B + C – Hf

A: Pumping pressure head (cm)

B: Static water head from the middle part of the test section up to the top of the hole. If the groundwater is higher than the middle part of the test section, this shall be the head from the water level to the top of the hole (cm)

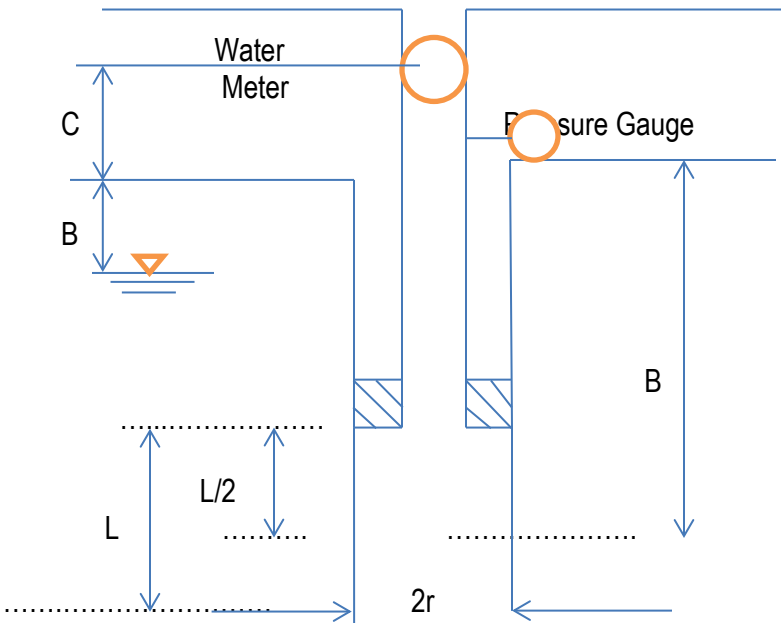
C: Height of the water pressure gauge from the top of the hole (cm)

Hf: Friction loss of energy in the injection pipe (cm)

q: Water injection rate (litre/min)

Return Valve





Schematic Layout of equipment and instruments

The test is conducted downstage unless otherwise directed by the Consultant.

5.6 Permeability Test in Unconsolidated Deposits

Permeability test by the open-end constant-head method shall be performed for soil, unconsolidated deposits, or intensively weathered rock to which a packer cannot be installed effectively. When a hole has been drilled to the depth where the test is intended, a casing shall be installed for the full length of the hole. For tight contact of the casing with the deposits in the surroundings, the casing shall be slightly large in diameter than the borehole.

To avoid disturbance of the deposits at the bottom of the hole, the casing shall not be driven by hammering. The inside of the casing shall be cleared to the bottom, of fallen loose materials, by taking them out with core barrel.

The casing shall be filled with clean water almost up to the top and the water shall be maintained constant by supplying clean water at the top of the casing. The quantity of the supplied water shall be measured and recorded every minute, until difference between two successive measurements fall within the limit of 5% during 20 minutes. The depth of groundwater level, if any, shall be recorded.

The test record shall be entered in a form and submitted to the client. The Contractor shall prepare the test result forms in advance of commencement of the work for the Client's approval. The results shall be presented in terms of coefficient of permeability, as calculated by the following formula.

$$K = \frac{Q}{60 \times 5.5 \times rH}$$

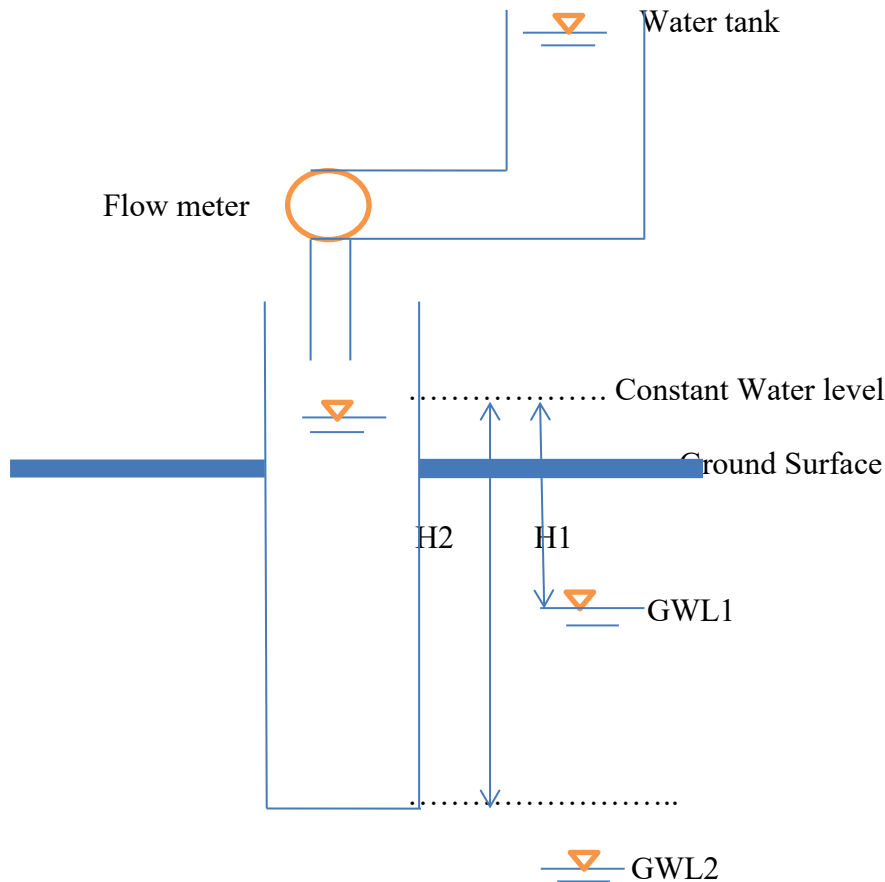
Where:

K: Coefficient of permeability (cm/s)

r: Radius of casing (cm)

H: Water head from the bottom of the hole up to the constant water level. If groundwater table is higher than the bottom of the hole, H is the height of the constant water level from the groundwater table (cm)

Q: Rate of water supply (cm³/min).



Schematic layout

5.7 Measurement of Friction Energy Loss

When a large quantity of water is injected through the injection pipe, energy of flow will be lost due to friction with the wall of the pipe. Thus the water pressure indicated by a pressure gauge at the neck of the hole will not represent the real pressure built in the test section, near the bottom of the hole. Correction of the water pressure test results will be necessary. To estimate the decreased head (H_f) due to the friction loss (see Clause 6.4), the following test shall be done, using injection pipes similar to those actually used for the water pressure test in site.

The injection pipes shall be connected to form a line of about 40m in length. One end of the line shall be left open and the other end, on which a pressure gauge will be fixed, shall be connected to

the hose coming from a pump. A water flow meter shall be attached between the pressure gauge and the pump. To control the pressure a diversion valve shall be attached between the flow meter and the pump.

5.8 Standard Penetration Test

Standard penetration test shall be performed in the sections of the hole that are drilled through unconsolidated deposits or intensively weathered rock. The tests shall be done **every 1.5 meter** intervals in depth till the borehole encounters bed rock which is hard enough to require more than 50 times' blow of the standard test hammer for 30 cm penetration of a split-tube sampler.

The standard penetration tests shall be done in accordance with ASTM D1586, or other equivalent method approved by the Consultant.

The results of the tests shall be recorded in the daily report of drilling in number of blows for every 10 cm in the 30 cm long test drive.

The soil samples collected in the split-tube during the penetration tests shall be put in plastic bags and into the core box at the corresponding depth.

5.9 Installation of Screen Pipes in Boreholes

A line of PVC screen pipes shall be installed in the designated boreholes for a long term monitoring of the groundwater table after drilling and in-situ testing are finished. The inside diameter of the pipe shall be not less than 40 mm and the perforation shall not be less than 10% of the peripheral area. For filtering effect, granule sand shall be filled in the space between the hole and the pipe, or the pipe shall be wrapped with pervious fabrics or thin jute cloth.

The top of the pipe shall protrude to the air and be higher than the ground surface at least by 30 cm. The pipe on the ground surface shall be fixed with concrete and locked in a cover for protection. The sign shall be attached to the concrete to show the borehole number and depth.

We need to consult with the Client concerning this since we are only drilling three boreholes.

6.0 LABORATORY TESTS OF ROCK CORE SAMPLES

Laboratory tests of rock core samples shall be performed to obtain the index and engineering properties of the dam foundation and construction materials. Samples shall be sent to the laboratory to examine the physical and mechanical characteristics to meet their utility.

Items and envisaged quantities of the laboratory tests are as listed below. The photographs of selected samples for the tests shall be submitted to the Consultant for approval prior to the testing:

- | | |
|--|------------|
| • Water absorption and bulk specific gravity (ASTM C 127) | 10 samples |
| • Unconfined compression test of rock core specimen (ASTM D2938) | 10 samples |
| • Soundness tests by sodium sulphate (ASTM C88) | 2 samples |

- Abrasion test of coarse aggregate by Los Angeles machine (ASTM C535) 2 samples
- Chemical (alkali) reactivity test (ASTM C289) 2 samples

Any other acceptable testing Standard can be used.

7.0 REPORT

Three (3) copies of the report and a CD-ROM containing all the data obtained shall be made and for submission to the Consultant for onward submission to the Client. The Report shall be submitted to the Client by the time designated by the Consultant.

In addition to the daily drilling reports, the Contractor shall prepare a geological investigation report at the end of all the investigation works. The report shall include but not limited to the following items:

- Description of regional and site geology with topography
- Location and coordinates of drill holes
- Drilling logs
- Records of water ground water measurements
- Cross sections connecting the logs in a designated scale;
- Results of water pressure test and comments;
- Results of permeability test and comments;
- Results of measurement of friction energy loss and comments;
- Geological pit logs with geological descriptions;
- Results of laboratory tests with technical interpretation and comments;
- Photographs of core samples; and
- Photographs of site condition at all points for the drilling works and laboratory tests.

Drilling Logs

The drill logs will present a continuous vertical record of the boreholes at the scale of 1/100 at least and contain the following information:

- Borehole number, location with coordinates and elevation at the neck of the hole;
- Inclination and depth of the hole;
- Model name of the drilling machine;
- Dates of drilling;
- Geological descriptions of the bore holes or the recovered cores, including the classification of rocks and soils, extent of weathering, spacing of joints, condition of joints (open or close, stained or fresh, roughness, filling material), color of rocks, solidity of rocks soft, moderately-hard or hard, massive, flaky or fractured), etc.;
- Core recovery length, core recovery ratio, length of fragmental core section and R.Q.D. (Rock Quality Designation: the proportion of cylindrical core samples longer than 10 cm) for every 1.2 metres section or for every raising of core barrel;
- Water level in the hole and location of sudden water loss or spring, if any, in the course of the drilling;
- Results of water pressure tests, permeability tests, and standard penetration tests; and

- Depth and size of casing.

8.0 SAFETY MANAGEMENT

The safety of all operations in the work shall at all times be responsibility of the Contractor and direction or approval of the Consultant shall not be taken to relieve the Contractor of any such responsibility.

Major causes of serious accidents in drilling work is due to loose clothes being caught in rotating parts and sudden drop of drilling rods smashing fingers or other parts of body. The Contractor shall make sure that all workers should wear (**protective gear**) proper clothes, helmet, and boots. The Contractor shall check equipment and tools, especially rod holders, being maintain and arranged properly.

During test pitting, the Contractor shall install wooden frame and plate for protecting to avoid collapses of the excavated pit wall as necessary. A ladder must also be installed from the bottom to the top of pit for inspection and sampling.

The Contractor shall submit the safety management plan of the geological investigation to the Client prior to the commencement of the work. The safety management methods shall include but not limited to the following items:

- List of survey party including the personal record and contact cell phone numbers of key survey engineers;
- Safety measures in core drilling; and
- Safety measures in test pitting.

9.0 MEASUREMENT AND PAYMENT

Measurement and payment for the works shall be made for all items shown in the Bill of Quantities and as specified hereunder.

9.1 Core drilling with Testing

(1) Core drilling

Measurement and payment for Core drilling, shall be made on the basis of linear meter in length of borehole which has actually been drilled at a designated angle and in designated sections of depth in accordance with the Specifications or as directed by the Client. Parts of the borehole, which had to be re-drilled because of the Contractor's deficiency or failure, shall not be subject to the measurement and payment. The length of drilling for emplacement of casing or for cleaning inside the borehole once drilled will be not be subject to the measurement and payment.

Unit price tendered for core drilling shall include all costs of man power, material and machinery depreciation that are required to perform the core drilling, the sampling, arranging core samples in core boxes, transportation of the samples to a laboratory and/or a store house, the daily reporting, preparation of drill logs and all other works concerned in accordance with the Specifications.

(2) Water pressure test

Measurement and payment for "Water pressure test", shall be made on the basis of the number of tests that have actually been performed in a designated section of depth in accordance with the Specifications or as directed by the Client. Each water pressure test in bedrock shall consist of observations of water injection rate under varied pressures for one test section. Preparatory and subordinate works for the water pressure tests, including installation and removal of the packer, shall not make separate items for the measurement and payment.

Unit tendered for water pressure test shall include all costs of man power, material and machinery depreciation that are required to perform the water pressure test in accordance with the Specifications. This rate shall also include installation and removal of the packer, setting and arranging pump, water tank, pipes, hoses, casing, etc., and all other preparatory works required, as well as the field reporting.

(3) Permeability test

Measurement and payment for Permeability test, shall be made on the basis of the number of tests that have actually been performed in a designated section of depth in accordance with the Specifications and/or as directed by the Consultant.

Unit prices tendered for the test shall include all costs of man power, material, and machinery depreciation that are required to perform the permeability test in accordance with the Specifications. The rate shall also include setting and arranging pump, water tank, hoses, casing, and all other preparatory works required, as well as the field reporting.

(4) Measurement of friction energy loss

Measurement and payment for Measurement of friction energy loss, shall be made on the basis of the number of the tests that have actually been performed in accordance with the Specifications and/or as directed by the Client.

Unit prices tendered for measurement of friction energy loss shall include all costs of man power, material, and machinery depreciation that are required to perform a set of the measurement of friction energy loss in accordance with the Specifications. This item shall also include setting and arranging pump, water tank, pipes, hoses, casing, and all other preparatory works required, as well as the field reporting.

(5) Standard penetration test

Measurement and payment for Standard penetration test, shall be made on the basis of the number of the tests that have actually been performed in a designated section of depth in accordance with the Specifications and/or as directed by the Consultant.

Unit prices tendered for this test shall include all costs of man power, material, and machinery depreciation that are required to perform the standard penetration test in accordance with the Specifications. This rate shall also include setting and arranging equipment and all other preparatory works required, as well as the field reporting.

(6) Installation of drilling machine

Measurement and payment for Installation of drilling machine, shall be made on the basis of the number of locations where drilling machines, accessories, and materials have been carried in and installed for the purpose of the drilling and the borehole tests in accordance with the Specifications and/or as directed by the Consultant.

Unit price tendered for Installation of drilling machine shall include all costs of man power, material, and machinery depreciation that are required for transportation of the machines, accessories, tools, materials and all other things necessary for the drilling and the borehole tests to each drilling locations from any other location within the project area and for installing and assembling them in their positions in order to perform the works in accordance with the Specifications, and then to evacuate them from the drilling location.

(7) Geodetic measurement

Measurement and payment for Geodetic measurement, shall be made on the basis of the number of drill holes which has been performed in accordance with the Specifications and/or as directed by the Consultant.

Unit price tendered for geodetic measurement shall include all costs of man power, material, and machinery depreciation that are required to perform the geodetic measurement of drill holes in accordance with the Specifications. The rate also shall include all preparatory and subordinate works required for geodetic measurement.

9.2 Laboratory test

Measurement and payment for Laboratory tests shall be made on the basis of the number of laboratory tests that have been completed with due reliability in accordance with the ASTM in Table 2.1, unless otherwise designated by the Consultant.

Unit price tendered for each test under this item shall include all costs of man power, material, and machinery depreciation that are required to perform the test in accordance with ASTM and/or the direction of the Consultant. This rate shall also include trimming of each core sample, capping and other preparatory work duty required.

9.3 Mobilization and demobilization

Measurement and payment for Mobilization and demobilization shall be made in lump-sum. Price tendered for this Item shall include all costs to gather to the project area man power, equipment, material and all other things required to perform all of the specified works and then to evacuate after completion of the works. This item shall also include all costs of site lodging.

9.4 Report

Measurement and payment for reporting shall be made in lump-sum. Price tendered for this Item shall include all costs of man power, material, and machinery depreciation that are required to

finalize all the data obtained and edit them into a report on geological investigation, and make three (3) copies of it and a CD-ROM containing all available data for submission.

9.5 Hire of Security and Safety Management

Measurement and payment for hire of Security and Safety Management shall be made in lump-sum. Price tendered for this item shall include all costs of man power, material, and machinery depreciation that are required to ensure the security of staff, safety for the works, and all other works concerned in accordance with the Specification.

10.0 SEISMIC SURVEY

As recommended in the reconnaissance geological survey and preliminary geophysical investigations report, it will be necessary for further investigations by seismic profiling to establish the structural conditions of the foundation to check presence of older faults. A qualified geophysical physical team with experience in seismic survey (seismic profiling) will be sourced to submit quotation for seismic profiling using Seismic Reflection and Refraction methods within selected Radat dam site area.

11.0 FULLY FLEDGED CONSTRUCTION MATERIALS

A fully fledged construction materials survey was also recommended in the reconnaissance geological survey and preliminary geophysical investigations report. Objective of the construction materials survey will be identification of borrow areas and establishment of the quantities. In particular identification suitable quarries for the rock fill materials and laboratory testing of the rocks; establishment of source areas with sufficient quantities for impervious core soils; and sources of aggregates and sands. The extent and quantity of the red clay soils observed near the selected during the initial survey will need to be evaluated using auger method.

Both the seismic survey and the construction materials survey will be carried out concurrently with the core drilling investigations.