Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
REGIONAL OFFICE I
City of San Fernando, La Union

TERMS OF REFERENCE

GEOTECHNICAL AND GEOLOGICAL SURVEY (SOIL BORING EXPLORATION) OF VARIOUS BRIDGES IN REGION 1 (PACKAGE 3)

I. PROJECT DESCRIPTION AND PURPOSE

PROJECT NAME	NUMBER OF HOLES
1.) Construction of By-Pass and Diversion Roads - Lingayen-Binmaley Bypass Road, Binmaley Side, Pangasinan	2 boreholes (2 abuts)
2.) Construction of By-Pass and Diversion Roads - Lingayen Bypass Road (Phase I), Package A, Pangasinan	2 boreholes (2 abuts)
3.) Sustainable Infrastructure Projects Alleviating Gaps (SIPAG), Construction of Bridge connecting Lacuben-Gabut Sur, Badoc, Ilocos Norte	14 boreholes (2 abuts, 12 piers)
Location : Pangasinan & Ilocos Norte	
Boreholes : 18 Boreholes; **60m** depth	
Duration : Fifty Five (**55**) Calendar Days	

II. SCOPE OF WORK

The Consultant shall provide all the labor, instrument/equipment materials and supplies, vehicles, bunkhouses, etc., necessary to perform satisfactorily the sub-surface exploration herein required, viz:

A. Field Works
B. Laboratory Testing
C. Soil Investigation and Preparation of Report
D. Geotechnical Evaluation Report

The Consultant shall be held solely responsible for the result of this boring/drilling exploration and other activities under this Terms of Reference (TOR).

III. DETAILED EXPLORATION REQUIREMENTS/SPECIFICATIONS

A. FIELD WORKS

1. Borehole Location

The geotechnical investigation shall include a geotechnical assessment of the site with at least one borehole at each abutment and pier of the proposed project location.

Additional boreholes shall be drilled when there is a significant difference between adjacent boreholes or in areas where subsurface condition is complex or variable. This shall be decided upon the instruction of the Geotechnical Engineer.

In case the proposed bridge site is realigned, confirmatory soil boring exploration shall be conducted at the new alignment. The locations and numbers of which shall be determined upon the instruction of the geotechnical engineer and subject for approval of the bridge designer/engineer of the office.

2. Borehole Depth

If foundation type has not been specified, boring shall be carried out to a depth of:

Minimum of 60 meters	Ordinary soil (Standard Penetration Test at interval of 1.5 meters and at every change in soil stratum)
Minimum of 6 meters	Continuous solid rock with >10% core recovery and rock unit and weathering must be identified

If the n-values in ordinary soil are inconsistently below 30 (<30), boring shall be extended until greater than 30 (>30) n-values are encountered for at least 3 consecutive SPTs or into 6 meters of penetration. In case bearing layer is not encountered beyond 30 m, it shall be continued until preferred layer is encountered subject upon the instruction of the geotechnical engineer and approval of the bridge designer/engineer of the office.

3. Procedure

a. The Consultant shall perform the in-situ soil boring exploration, analysis and laboratory testing. It shall be performed in accordance with AASHTO and ASTM standards.

b. The soil samples obtained from drilling shall be tested for the determination of the main characteristics:

- Soil classification
- Sieve Analysis
- Natural Moisture Content
- Atterberg Limits
- Specific gravity
- Consolidation Test (if soft soils are encountered)
- Direct shear test or triaxial test

c. Submit design recommendations, foundation condition scheme, bearing capacity and settlement, groundwater table, hydrological influences, excavation stability, seismic design consideration and liquefaction potential.

d. Geological structure, especially active faults which might traverse the area, have be delineated and potential mass movement areas are identified. Analysis for liquefaction potential during earthquake and consolidation due to soft ground must be included as well.

4. Handling and Core Samples

The consultant shall provide all the materials, equipment and labor necessary for preserving the samples for 5 years. Rock core samples need to be handled such that their properties are not altered in a way due to mechanical damage or changes in ambient conditions of moisture and temperature or other environmental factors.

All soil and rock samples must be clearly, accurately, and properly labelled to show all pertinent information necessary in identifying the samples.

B. LABORATORY TESTING

The preparation of samples and procedure of testing shall be made in accordance with the standards of American Association of Highway and Transportation Officials (AASHTO) and/or American Society for Testing and Materials (ASTM). The following tests shall be made on samples obtained from drilling.

Bearing Capacity Test

The maximum load per unit area which the soil or rock can carry without yielding or displacement is termed the bearing capacity of soils. Various methods of computing the bearing capacity can be by presumptive analysis, analytical method, plate bearing test, penetration test, or centrifuge test. The SPT is widely used to get the bearing capacity of soil directly at a certain depth. The consistency of clayey soils can often be estimated from this test.

Standard Penetration Test

The test shall be carried out through ordinary soil encountered to the depths specified above. Standard penetration test shall be performed by dropping a hammer weighing 140 lbs. (63.6 kg) onto the drill rods from a height of 76.00 cm (30 inch) at 1.50 meter interval or closer if necessary. First blow count shall be ignored as it represents materials from the previous layers and hole collapse materials hence the N-value is the sum of 2nd and 3rd blow counts. The procedure of SPT shall be conducted according to AASHTO T 99 or AASHTO T 180.

Soil Classification

The Unified Soil Classification System (USCS), adopted by ASTM D2487-98 and IS: 1498-1970 shall be followed for classification and identification of soils for general engineering purpose. This is to be used for identification of soils in the field, laboratory, or any other location where soil samples are inspected and described. There should be assigned group name and symbol(s) along with the descriptive information. Initial

. description can be made during on-site logging, and revised upon availability of laboratory tests.

Sieve Analysis

This is the determination of particle size distribution in soils by sieve, hydrometer, or combined analysis. The procedure covers sieve analysis in accordance with AASHTO T 27 and materials finer than No. 200 (75 µm) in accordance with AASHTO T 11. The procedure combines the two test methods.

Natural Moisture Content

This test determines the relationship between the moisture content and the density of soils compacted in a mold. It is the ratio of the weight/mass of water in the soil to the weight/mass of the dry soil after it has been dried to a constant weight/mass at a temperature of 110 ± 5° C. This shall be conducted according to ASTM D2216 or AASHTO T 265.

Atterberg Limits

The procedure for the determination of Atterberg limit shall be in accordance with ASTM D4318. The Liquid limit (AASHTO T 89) is the lowest moisture content at which the soil will flow upon the application of a very small shearing force whereas the Plastic limit (AASHTO T 90) is the minimum moisture content at which the soil can be readily molded without breaking or crumbling.

Specific Gravity

Specific gravity is a fundamental property of soils and other construction materials. This dimensionless unit is the ratio of material density to the density of water and is used to calculate soil density, void ratio, saturation, and other soil properties. The procedure for the determination of the specific gravity of soil shall be in accordance with ASTM D792 and ASTM D854 using a water pycnometer.

Consolidation Test

This test is performed to determine the magnitude and rate of volume decrease that a laterally confined soil specimen undergoes when subjected to different vertical pressures. The test for soil consolidation shall be in accordance with ASTM D2435.

Direct Shear Test or Triaxial Test

This test measures the shear characteristics under undrained conditions and is applicable to field conditions where soils that have been fully consolidated under one set of stresses are subjected to a change in stress without time for further consolidation to take place (undrained condition), and the filed stress conditions are similar to those in the test method. This test shall be in accordance with ASTM D4767.

C. KEY PERSONNEL'S DETAILED TASKS/RESPONSIBILITIES AND QUALIFICATION

Position	Qualification	No. of Person	Duration	Wt. per person (%)	Total Wt (%)
Team Leader (Project Manager)	▪ Must have at least **ten (10)** years experience related in Geotechnical/Soil Investigation, Test Borings, Sampling and Analysis of similar and/or related projects ▪ Must be a Registered Civil Engineer ▪ Doctorate degree is an advantage	1	55 man-days	30	30
Geotechnical Engineer	▪ Must have at least **five (5)** years experience in the related field for which geological investigations and assessment of geological condictions were undertaken ▪ Must be a Registered Civil Engineer with specialization in geotechnical engineering ▪ Doctorate degree is an advantage	1	55 man-days	20	20
Materials Engineer	▪ Must have at least **five (5)** years experience in the related field and is occupying the position of a Materials Engineer ▪ Must be a Registered Civil Engineer with specialization in materials engineering ▪ Doctorate degree is an advantage	1	55 man-days	15	15
Geodetic Engineer	▪ Must have at least **five (5)** years experience in the field of surveying and should be familiar with the latest technologies in surveying and research work ▪ Must be a Registered Geodetic Engineer ▪ Doctorate degree is an advantage	1	55 man-days	15	15
Senior Laboratory Technician	▪ Must have at least **five (5)** years experience in carrying out sampling and analysis for Geotechnical / Soil Investigation and or Surveys, Test Borings ▪ Degree in engineering / construction management is recommmended	2	27 man-days	10	20

Detailed Tasks and Responsibilities of Key Personnel

A. Team Leader

- overall guidance, direction and coordination of members of the Team.
- prepares operation plan and supervises all aspects of the project to ensure compliance with the objectives and maintain progress in accordance with the contract time schedule.

B. Geotechnical Engineer

- investigate risk of geological hazards and making sure any factors affecting engineering works are identified and managed
- study and determination of items and method of soil investigation and laboratory test
- responsible for supervising the conduct of geotechnical investigations; gathering information and reporting results of evaluations of areas of concern

C. Materials Engineer

- investigate and supervise the testing of Physical Properties of sample materials from areas of concern and prapare reports after performing calculations

D. Geodetic Engineer

- undertakes topographic survey and provides the necessary topographic maps.

E. Senior Laboratory Technician

- assists the Team Leader in the collection of necessary data and information in carrying out detailed soil test and investigations inlcuding Atterberg Limits, Consistency Test, Grading Analysis, and etc.
- responsible in maintaining and calibrating test equipment and other duties related to lab operations as assigned

D. REPORTS AND DELIVERABLES

The Consultant shall prepare the following reports and deliverables:

1. Progress Report

The Consultant is required to submit a progress report twenty seven (**27**) calendar days from the commencement of work briefly and concisely describing all activities and progress of the project. Problems encountered or problems anticipated shall be clearly stated, together with the steps taken or recommendations for their correction. It shall also indicate the works to be performed.

2. Final Report

The Consultant is required to submit the final report fifty five (**55**) calendar days from the commencement of work in four (4) bound copies and a soft copy saved in a CD to the DPWH Regional Office I, Aguila Rd., Sevilla, City of San Fernando, La Union. The final report shall not be limited to the following:

a. Introduction (Purpose and scope, Project Location, Project Description)
b. Climate Map covering the project site
c. Vicinity Maps in scale of 1:50,000
d. Borehole Location Plan in scale of 1:250
   - reflecting the coordinates of the boreholes
e. Methodology (Field and Laboratory)
f. Geology and Geohazards Aspect
g. Geotechnical Aspect
h. Field Investigation and Soil Boring Exploration
i. Final Boring Logs (BL)
j. Soil Profile (Cross section) showing boring/drilling logs and structures
k. Final Laboratory Tests Results (FLTR)
l. Appendices and References

3. Geology and Geohazards Aspect

a. Seismic Sources within the vicinity of the project site, it is necessary to determine the distance of an active fault/trench relative to the project site.
b. Earthquake magnitude that a fault/trench can generate (based on historical data provided by PHIVOLCS or USGS)
c. Geologic Map and Geomorphologic Map covering the project site
   - showing the geologic formations and structures present within the proposed location of the project (i.e. faults, fold)
d. Discussion on Regional Geology and Geomorphology
e. Brief Discussion about the Geohazard maps
   -degree of susceptability of each geohazard relative to the location of the project
f. Discussion on Problematic Soils

4. Geotechnical Aspect

a. Peak Ground Acceleration (PGA)
b. Spectral Acceleration Coefficient at 0.20 sec (S_{DS})
c. Spectral Acceleration Coefficient at 1.0 sec (S_{D1})
d. Soil Liquefaction Assessment
e. Soil Bearing Capacity
f. The computation of the Skin Friction (SFn) and End Bearing Capacity not using the German Standards for pile design
g. Recommendation such as type of proposed counter measures to address geological/geotechnical problems and foundation type.
h. Geotechnical Evaluation and recommendation

5. Other Data to be Submitted

A. Boring Logs

1. Job, boring, hole number, date, time, boring/drilling, foreman, supervisor
2. Weather condition
3. Depth of boring at start of day
4. Water level in casing at start of day
5. Method of penetration and flushing system
6. Description of soil strata encountered
7. Depth of soil boundaries
8. Size, type and depth of samples and sample number
9. Type and depth of in-situ tests
10. Standard Penetration Tests Resistance, "N" Value
11. Recovery ratios of samples
12. Detailed notes on boring/drilling procedure, casing sizes and resistance to driving, description of wash water or spoil from boring/drilling tools
13. Depth of boring at end of day
14. Other relevant information such RQD, percent core recovery, angle of friction etc.

B. Photographs

Photographs showing the borehole drilling and sampling at each proposed sites shall be taken by the Contractor and incorporated in the report. Photographs shall be taken at each borehole location depicting the following:

1. Equipment used
2. Core drilling operation
3. Water level measurements
4. Performance of SPT and Shelby tube sampling
5. All cores in the core boxes, SPT and Shelby tube samples
6. Date photographs was taken
7. Location or station

IV. PAYMENT

There should be no Advance Payment for Consultancy. The final payment shall be made only after the final report and a final statement, identified as such, shall have been submitted by the Consultant and approved as satisfactory by the Procuring Entity.

V. WORK SCHEDULE

The Consultant's contract period for undertaking the sub-surface exploration works including laboratory tests shall be Fifty Five (**55**) Calendar Days and the Consultant shall commence work after receipt of Notice to Proceed.

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