IV. TECHNICAL GUIDELINES FOR GEOTECHNICAL INVESTIGATIONS

A. Bridges

1. Deep Foundations (Piling)
    a. One Penetration hole per two bents. Example 4 bent bridge - 2 penetration holes
    b. Begin at the surface and run penetration tests every 5 feet until 30 continuous feet of 20 blow count or better of bearing strata is encountered. After bearing is achieved, continue penetration tests at 10 foot intervals until rock is encountered or boring is advanced to 100 feet. Core or rock bit 5 feet of rock or shale. (Should adequate bearing be at a deep depth, it may be cheaper to use point bearing piling placed on rock. This is why we need at least 1 boring to establish rock elevation).
    c. If shale is encountered and adequate bearing is not achieved in the overburden, run S.P.T on top of shale, core 5 feet, run S.P.T., core 5 feet and run S.P.T. (This method of shale penetration and core can be modified if the engineer/geologist retrieves an adequate shale sample to run a Qu test. If a good sample of shale is retrieved, eliminate the penetrations at the middle and end of the core runs.)
    d. If rock is encountered and adequate bearing is not achieved in the overburden, core 10 feet of rock.
    e. Augering
        i. Northern Missouri or Bootheel - Take boring at least to 100 feet if bedrock is not encountered. Other auger borings should be taken down to the depth where bearing is achieved as determined by the S.P.T. (Should adequate bearing be at a deep depth, it may be cheaper to use point bearing piling placed on rock. This is why we need at least 1 boring to establish rock elevation.)
        ii. Central Missouri -- Normally make borings to bedrock and make pattern holes if the top of rock is uneven (more than 5 feet difference in rock elevation within one bent), especially for spread footings.
        iii. Bootheel -- Auger some bents at least 20 feet below where bearing was achieved based on S.P.T. Check for any possible soft layers that may exist below bearing strata.
        iv. P.A.W.T. - Pushed Auger Without Turning - describes a soft condition and should be noted on any log where this is done.
    f. When eliminating bents due to bents falling within the waterway, make sure to penetrate until n values of greater than 20 are found for 25 or 30 consecutive feet below the elevation of the stream bed.
    g. Samples
        i. Atterberg samples of final grade surficial materials are required for geotextile recommendations on stream crossings. One sample on each side of the stream or river is adequate.
        ii. Bridges located in seismic zones require earthquake sampling (see Earthquake Sampling, Page 22).

2. Shallow Foundations
   a. Spread footings on some or all of the intermediate bents will normally be used if the top of rock is no more than 12 feet below finished grade. Therefore, at least 10 feet of good core (RQD 75 or higher) should be acquired on the intermediate bents. It is important to make borings on all bents where this condition exists. Piling is normally used on the end bents except where the bridge end is positioned on a rock bluff.
   b. When eliminating intermediate bents in waterways where rock is within 5 feet of stream bottom elevation, 15 feet of core below stream bottom elevation is needed. On major rivers, borings will normally be based on the type of footings that are planned (drilled shafts or spread footings). Always run S.P.T. in the overburden to aid contractor in driving coffer dams or drilling for shafts.
   c. Samples
      i. Atterberg samples of final grade surficial materials are required for geotextile recommendations on stream crossings. One sample on each side of the stream or river is adequate.
      ii. Bridges located in seismic zones require earthquake sampling (see Earthquake Sampling, Page 22).
3. Drilled Shafts (excluding major river and lake crossings)
   a. Minimum of one core hole per bent for small structures and for larger structures in uniform geology. One core hole per column for larger structures in non-uniform geology.
   b. Minimum of 25' of core in rock and 30' in shale.
      i. Ex: For end bearing on rock and a 6' shaft. The top 5' of rock is not counted. 5' rock socket. For end bearing you need to go 2 X diameter below the rock socket, 12'. 5+5+12=22' say 25'.
   c. Need Qu's for design of the rock socket.
4. Drilled Shafts/River Borings (major river and lake crossings)
   a. Minimum of one core hole per column except for drilled shaft groups where 5 core holes per bent will be required.
   b. Minimum of 40' of core in rock and 50' in shale.
   c. Need Qu's for design of the rock socket.

B. Walls

1. MSE (Mechanically Stabilized Earth)
   a. Sample about every 200' with shelby tubes. Two sample holes per wall minimum. Try to sample where the wall is the highest.
   b. Take undisturbed soil samples to at least 10 feet below footing elevation for Qu, Direct Shear, and Atterberg limits. Need to find internal angle of friction for retained and foundation material. If retained material is fill, get internal angle of friction from soil survey. If sand is encountered, take samples for gradations and atterberg limits as appropriate (seismic).
   c. If soil is too rocky to use shelby tube, penetrate every 2 1/2' at least 10 feet below footing elevation. Take Atterberg samples, moisture samples, and pocket penetrometer readings.
   d. If foundation material is too soft to use shelby tubes or osterberg sampler, run S.P.T. at 2.5 foot intervals for at least 10 feet below footing elevation. If still soft, go to 5 foot increment. May use cantilever wall on piling. Rock bit or core at least 5 feet of good rock or shale.
   e. If rock is encountered above footing elevation or before you sample 10' below bottom of wall, core a minimum of 5 feet below bottom of wall for MSE wall and 10' minimum below bottom of wall for cantilever wall.
   f. Auger holes are usually laid out about every 25'. If you are in uniform soil and rock is more than 5 feet below the footing elevation, you can skip every other hole. Auger about 10' below bottom of wall or a little deeper if you suspect rock is close.
2. Cantilever Walls or Spread Footings
   a. Do similar to MSE wall except if rock is near footing elevation and wall may be set on rock, take 10 feet of core (depending on wall height, 5' of good rock may be adequate) and if shale, run Qu's.
3. Sound Walls
   a. Use S.P.T. and 3" shelby tubes to sample a hole about every 200 feet of wall length.
   b. Push 3" shelby tube 2.5 feet followed by the split spoon sampler.
   c. Run S.P.T. and shelby tube on the first 5 feet interval below bottom of wall. Take Qus (for determination of allowable bearing), Atterberg samples, moisture samples, pocket penetrometer readings and torvane readings.
   d. Continue to run S.P.T. at 2.5 intervals for at least 20 feet below bottom of wall. Take Atterberg samples, moisture samples, and pocket penetrometer readings.
   e. Amount of Rock Core.
      i. If rock is encountered within 5 to 10' below bottom of wall, core 5'.
      ii. If rock is less than 5' from bottom of wall, core 10'.
   f. Augering
      i. Locations same as MSE walls.
      ii. Auger 25' below bottom of wall.

C. Box Culverts

1. Investigations for Using Rock as the Floor of the Culvert
   a. If rock is encountered deeper than 5' below flow line, drill enough holes to make sure rock does not come up to within 5 feet of flow line.
   b. If rock is encountered within 5 feet of the flow line, core a minimum of 2 holes per culvert. Usually one core hole on each side of the road. Core a minimum of 10'.
   c. If rock is encountered within 5 feet of the flow line, auger every 10' for each wall in the box culvert (i.e., double box: 3 walls; single box: 2 walls, etc.)
2. Culverts with Compressible Foundations
   a. Usually one boring on each side of the stream crossing is adequate. The boring locations should be close to the stream and under the highest part of the proposed fill.
   b. Sampling should be continuous shelby tubes unless material is too soft, then the Osterberg sampler should be used.
   c. Samples required are 3" for consolidation tests and unconfined compression. Either 3" or 5" for Direct Shear and soil samples for Atterberg test. moistures, pocket penetrometer, and Torvane should also be obtained.

D. Light Towers

1. Use S.P.T. and 3" shelby tubes to sample one hole per tower.
2. Push 3" shelby tube 2.5 feet followed by the split spoon.
3. Clean out to the next 5' interval and repeat the procedure.
4. Alternate S.P.T.s and 3" shelby tubes for at least 30' below finished ground line. Take Qus (undrained shear strength), Atterberg samples, moisture samples, pocket penetrometer readings, and torvane readings.
5. In either cohesive or cohesionless soil, perform SPT test at 35’ and 40’ to complete the boring. Take Atterberg samples, moisture samples, and pocket penetrometer readings.
6. If the soil is too rocky to use the Shelby tube, split spoon on 2.5 foot intervals to achieve a depth of 30' below finished ground line and then penetrate again at 35’ and 40’ to complete the boring.
7. Amount of Rock Core.
   a. If rock is encountered within 20' of finished ground line, core 10'.
   b. If rock is more than 20' from finished ground line, core 5'.
   b. If rock is more than 20' from finished ground line, core 5'.

Tower borings will need to be reported on a bridge log for spt’s and core log and a summary sheet for p-y parameters and electro-chemical parameters.

Cohesionless soil (Sand)

1. Friction Angle from Bowles 1977 using corrected Blow Count (N1)60
   (N1)60 = CnN60
   (N1)60 = N60 corrected for effective Overburden Pressure
   Cn = correction factor for Overburden Pressure
   (Peck et. al.1974)
2. Relative density from either DM 7.1-87 or FHWA/RD-86/102. DM 7.1 probably a better value because it accounts for effective overburden pressure.

Cohesive soils

1. Undrained Shear Strength- USS or C from Bowles 1977 using uncorrected blow count N60, preferably Qu/2.
2. Friction Angle from correlation of PI to angle of internal friction minus one standard deviation as published in Navdocks DM-7.

P-Y Curve Parameters

1. K(f) = slope (variation) of linear subgrade modulus. From Section 6.1 of the Bridge Manual or "Soil Properties (Lpile & Com624P)"
2. K(f)cyclic = for cyclic loading
3. E50 = strain at 50 % of the maximum difference in principal stresses, unitless, from Qu test and Section 6.1 of the Bridge Manual or "Soil Properties (Lpile & Com624P)"

Electro Chemical Parameters

Resistivity is a function of the chloride ion and sulfate ion content and most of the time we will not run this test. To run the test we need about half a materials sack and the sample is entered into site manager.

E. Horizontal Boring for Culverts

1. Use S.P.T. and 3" shelby tubes to sample one hole at each end of proposed pipe.
2. Push 3" shelby tube 2.5 feet followed by the split spoon.
3. Clean out to the next 5' interval and repeat the procedure.
4. Run S.P.T. and 3" shelby tubes for at least 10' below flow line. Take Qu's (for allowable bearing under pipe), Atterberg samples to determine soil type and angle of internal friction, moisture samples, pocket penetrometer readings, and torvane readings.
5. Pay particular attention to gravel content and presence of cobbles and boulders.