MARYLAND DEPARTMENT OF TRANSPORTATION STATE HIGHWAY ADMINISTRATION	Office of Structures ***Guidelines and Procedures Memorandum***	DESIGN Number: D-79-17(4) Date:
	Foundation Evaluation	Approval: DRAFT

The procedure for the establishment of the type and size of a structure's foundation shall be followed after the structure's Type, Size and Location (TS&L) has been approved.

FOUNDATION BORINGS

Foundation Borings shall be requested in accordance with the provisions outlined in this Guideline and Procedure Memorandum. For structures over water, the request for soil borings should be developed/reviewed jointly by a representative of the Structural Engineering /Structure Inspection and Remedial Engineering Division and the Structure Hydrology and Hydraulics Unit to assure that the boring request meets the needs of both units. This would include requests for preliminary soil borings (made prior to T.S. & L. approval) for purposes of evaluating alternative locations of foundation elements such as whether or not to locate a pier in a channel where there is potential for scour or determining the length of a bridge because of marsh areas adjacent to the bridge.

1. Borings will be required for all structures which include but are not limited to bridges, culverts, retaining walls, (includes proprietary walls), noise walls, headwalls, cut-off walls/bulkheads for slope protection, and pipes that are tunneled and/or jacked under roadways.

   Estimated bottom of footing elevations shall be indicated on all boring requests, so that borings and drive tests can be carried a sufficient distance below the estimated bottom of footing to clearly identify the materials upon which the foundations will be bearing.

   Plotting of borings shall be in accordance with GPM No. P-75-3(4).

2. Boring pattern

   a. Bridges - a minimum of two borings for each support shall be requested. If there are dual bridges involved or the equivalent length of a support would compare to dual bridges (i.e., excessive skew angles or narrow median - one structure) a minimum of three borings shall be requested at each support. The exception to this would be long bridges over water with multiple spans where the foundation material is found to be fairly constant. In such conditions the drillers may elect to eliminate borings where possible.

   b. Culverts - A minimum of two borings shall be requested for each culvert. They shall be at each end of the culvert and diagonally opposite from one another. If the center line length of the culvert exceeds 75 feet, additional borings should be requested so that the maximum spacing between borings is 75 feet.

c. Retaining Walls and Noise Walls - At least two borings shall be requested for each wall, one at each end. If the wall length exceeds 75 feet, additional borings should be requested so that the maximum spacing between borings is 75 feet.

d. Headwalls - At least one boring shall be requested for each headwall. If the headwall length exceeds 75 feet, additional borings should be requested so that the maximum spacing between borings is 75 feet.

e. Borings for slope protection cut-off walls will not be required if sufficient soil data is available from other foundation or roadway borings. Where borings are needed, one boring at the midpoint of each cut-off wall will generally be sufficient.

f. Borings for tunneling and/or jacking of pipes should be requested to give a complete knowledge of the type of soil to be encountered in the operation but should not exceed a 75 foot spacing.

EVALUATION OF FOUNDATION TYPES

The proposed minimum bottom of footing elevation shall be plotted on the borings to ascertain the type of material in which it will be placed.

An evaluation shall be made as to whether or not the material can support the intended structure. If it appears that a reasonable lowering of the footing (about 10 feet or less) will reach suitable foundation material then the footing shall be lowered. If it appears that a reasonable lowering of the footing will not reach suitable foundation material then piling shall be utilized. If the depth to good foundation material varies significantly within one footing unit from a pile to a spread footing condition, designers should consider the use of several different pile/ caisson designs to reach the good material from a constant bottom of footing elevation. The Contract should contain a Quantity of Subfoundation Drilling to be used to determine the proper depth of piles/ caissons. In the case of culvert barrels, when less than about 5 feet of poor material can be removed to reach good foundation material, that material shall be removed and replaced with select backfill. When the depth of poor material exceeds 5 feet, piling shall be utilized.

If a footing is to be placed on solid rock with high design bearing pressures, it shall be keyed into the rock at least 1 foot in depth.

All other structures previously constructed in the immediate area should be evaluated as to their selection of foundation type and the field results of the selection i.e. pile lengths, lowering of footings, etc.

HYDRAULIC CONSIDERATIONS

Regardless of type of support, where applicable, all bridges over water shall be evaluated for scour potential. After the preliminary screening, scour critical bridges shall receive a complete scour analysis per the OOS Manual for Hydrologic and Hydraulic Design. The foundation design shall take into account the results of this analysis.

STRUCTURE FOOTINGS

All footings (spread and pile supported) shall have the minimum bottom of footing at least 3 feet below the finished groundline. The bottom of all footings shall be level.

All footings (except abutment footings on piles where the slope protection meets the footing toe) shall have the top of footing at least 1 foot below the finished groundline.

All pile supported footings may be stepped in accordance with the OOS Structural Details whenever it is economical to do so. Each footing step must contain a row of piling at each end of the step.

SPREAD FOOTING FOUNDATIONS

The bottom of a spread footing, including leveling pads for a proprietary retaining wall, shall be placed so that the top of the footing is a minimum of 1 ft below the proposed ground line and the bottom of the footing is a minimum of 3 ft below the proposed ground line. If the footing is to be placed on rock as determined by the Engineer, it shall be keyed into the sound rock at least 1 ft.

Setting spread footings or leveling pads for proprietary retaining walls in embankment or fill material is prohibited. Any spread footing, including leveling pads for a proprietary retaining wall, shall be set into existing in-situ soil or sound rock.

PILE SUPPORTED FOUNDATIONS

If the foundation evaluation indicates that there is a lack of competent soils at an acceptable elevation or significant scour projections are identified, deep foundations shall be utilized. The following is a list of acceptable deep foundations (piles) that may be used on MDOT SHA structures:

1. Steel H Piles - In footings where a rock stratum lies beneath fair to poor material and is reachable with piling, or the material to be driven through consists of boulders or hard driving, steel H-piles shall be utilized.

   If the rock stratum appears to be on an incline then pile tips shall be attached to the piling before driving.

2. Pipe Piles (minimum 1/2" wall) - This type of piling shall generally be used in cases where a friction pile is appropriate and there are hard layers anticipated in driving piling. These piles shall be driven open ended except where the upper layer of soil is soft muddy or mucky material.

3. Micropiles - In footings where short piles (20 feet or less) are anticipated to reach a hard stratum beneath material which is susceptible to scour and/or the hard driving of piles would be detrimental to adjacent properties, pin piles fixed into the hard stratum shall be utilized.

4. Treated Timber Piles - This type of piling may be utilized on timber bridges, bulkheads and fenders.

5. Untreated timber piles - Where piling is required for box culverts and retaining walls and the piling will be totally encased or below ground line, untreated timber piling may be used. It may also be utilized in temporary structures, such as detour bridges.

6. Auger Cast Piles - In footings with small loads and the foundation material is borderline spread footing material, auger cast piles should be utilized.

7. Cylinder Piles - For large marine structures where extensive cofferdams would be required to construct a conventional footing the use of precast prestressed cylinder piles should be considered.

8. Cast-in-place Concrete Piles (thin walled, uniform diameter, helically welded shells and Monotubes) - This type of piling may be considered in cases where a friction pile is appropriate and there are no hard layers anticipated in driving piling.

Note to Designers: Precast Prestressed Piles are not permitted on MDOT SHA structures due to the erratic length of piling and the inability to economically splice these piles.

Driven Piles

Driven piles consist of Steel H-piles, steel pipe piles, or timber piles. Only one type of pile shall be used on each individual substructure unit. However, different substructure units of the same structure may have different foundation types.

Bottom of footings for the bridge abutments or wing walls may be in approach embankments provided they sit on pile-supported foundations with the pile tip elevation set in competent in-situ soil or sound rock. Pile tips shall be applied to driven piles where warranted. Piles shall extend below the elevation of the roadway that is being crossed.

The proposed pile spacing for design shall conform to the following:

1. Spacing in the front row of a pile group shall not exceed 8 ft.
2. Spacing for all other rows shall not exceed twice the spacing of the front row.
3. Pile patterns shall be designed so that no piles are in tension or uplift.

Battered piles shall be used to resist all horizontal loads. The use of plumb piles to resist horizontal loads may be considered on a case by case basis and approved by MDOT SHA prior to the Foundation Review submission. No substructure unit shall have all the piles battered in the same direction. (i.e. in most cases at an abutment, at least the back row of piling shall be vertical or battered in the opposite direction). The maximum pile batter rate permitted will be 4:12, with 3:12 the desirable rate.

Augered or Drilled Piles

Augered or drilled piles consist of micropiles, reinforced cast in place drilled shafts (caissons), and steel H-piles placed in augured holes with voids filled with concrete. Any augered or drilled pile foundation that encounters rock shall have its final tip elevation a minimum of 10 ft into competent rock or 5 ft into sound rock. Steel mini/pin piles shall have a 5’ deep grout bulb below the final tip elevation.

Structural capacity of auger cast piles with steel H-pile cores shall be determined solely on the capacity provided by the steel H-pile core without any contribution of the surrounding cast in place concrete. The augered or drilled pile spacing shall conform to the same criteria as driven piles, excluding mini/pin piles. Pile patterns shall be designed so that no piles are in tension or uplift. Design strength shall be maintained for the full length of the pile.

Test Piles and Load Tests

At least one pile in each footing shall be designated as a test pile on the Plans. The test pile shall be a plumb pile located near the centroid of the pile group it serves. The foundation report shall indicated the recommended pile testing method.

On structures with an overall length in excess of 250 feet over marshlands or waterways where friction piling is being used load tests shall be utilized to verify pile capacity and lengths. Piles should be load tested to at least twice their design load. Some larger piles may require more.

FOUNDATION REVIEW SUBMITTAL

A separate foundation report shall be prepared for each structure and submitted as part of the Foundation Review, and it shall contain, as a minimum, the information listed below.

Approved T.S & L. Plans including a General Plan and Elevation, Plan and Elevation of each footing and structural unit, and plotted boring and drive test logs.

In addition to the Plans a written report is to be made. It should contain an interpretation and analysis of the proposed structure and boring and drive test data as well as definite engineering recommendations for foundation design. The materials and conditions which may be encountered during construction should also be discussed. The Engineer responsible for the report preparation should have a broad enough background in engineering to have some knowledge of the type of structures which might be used in a certain location, including their foundation requirements and limitations. Problems of design and construction should be anticipated and recommendations made for their solution. The recommendations should be brief, concise, and, where possible, definite. Reasons for recommendations and their supporting data should always be included. Extraneous data which are of no use to the designer or Engineer in the field should be omitted. The written report should include the following items.

1. Type of Foundation: (i.e., pile or spread footing). Each substructure unit shall be addressed separately. If it appears that there is a choice of foundation such as spread vs. piling, then a cost analysis should be utilized for the final decision.

    a. Pile Foundation

        (1) Method of support - friction or end bearing, in rock or soil or both.

        (2) Suitable pile type - reasons for choice or exclusion of types.

        (3) Pile tip elevations.

            (a) Estimated - average values with range of variation if desirable.

(b) Minimum penetration elevation - explain reasons, such as driving through fill, negative skin friction, scour, underlying soft layers, piles uneconomically long, etc.

(4) Pile loadings (Design and Driving)

(5) Settlement consideration - requirements of structure vs. soil conditions.

(6) Cut-off elevations - water table, marine bore problems, etc.

(7) Test pile locations.

(8) Wave equation analysis and need for dynamic monitoring.

(9) Load tests or pile restrikes required.

(10) Effects on adjacent construction.

(11) Corrosion effects of various soils and waters, and possibility of galvanic reaction; need for pile encasement.

b. Spread Footing Foundation

(1) Elevation of footing.

(2) Material on which footing is to be placed.

(3) Nominal and Design (factored) Bearing Resistance (from soil) and Bearing Pressure (from structure).

(4) Settlement analysis. (settlement shall be less than 1")

(5) Slope stability analysis.

c. Scour Evaluation

Regardless of type of support, where applicable, all bridges over water shall be evaluated for scour potential. After the preliminary screening, scour critical bridges shall receive a complete scour analysis and address the following:

(1) Lowering the footings, spur dikes, stone blankets and revised pier alignment.

(2) Where pile foundations are used, piles must be driven deep enough to assure structure stability relative to potential scour depth. (i.e. if scour occurs will structure still be stable.) Consideration must also be given to the potential for pile buckling due to the increased unbraced length.

(3) Spread footings will only be used in rock or with subfoundation concrete where it is not feasible to use piles or lower the footing enough to protect against anticipated scour.

2. Approach Fill Consideration

Settlement of fill embankments should be considered when evaluating structure foundations. To account for any settlement of approach fills designers should consider removing the compressible material and replacing it with suitable backfill material, surcharging the existing embankment (this may include the use of wick drains) to maximize the effect of settlement prior to building the structure, drilling holes through the fill and placing sonotubes through which H-piles could be driven, coating the pile with bituminous material to minimize the effects of negative friction on piles or reducing the allowable loads on the piles to account for the draw down force.

3. Construction Considerations:

a. Water table - fluctuations, control in excavations, pumping, tremie seals, etc.

b. Adjacent structures - protection against damage from excavation, pile driving, drainage, etc.

c. Pile driving - difficulties or unusual conditions which may be encountered.

d. Excavation - control of earth slopes including shoring, sheeting, bracing, and special procedures, variation in type of material encountered, etc.

e. Stray currents - In areas where stray currents from electric facilities may cause rapid deterioration of the rebar, damage shall be minimized by bonding all the rebar together and grounding the rebar system.