1. design and construct Micropile (revised 2-1-2022)
	1. Description. Furnish all materials, labor, and equipment necessary to design and construction of micropiles in accordance with the specifications, plans, approved Contractor design and working drawings, as specified in the Contract. The Micropile Contractor is responsible for furnishing all designs, working drawings, materials, products, tools, equipment, labor, supervision, and manufacturing techniques required for installation, and testing of the micropile system.

Micropile Design Engineer and Contractor Experience Requirements.

Design Engineer. Designate a Montana licensed Professional Engineer to design the micropiles. The Design Engineer must have been the designer of record for a minimum of 3 successfully completed micropile projects within the past 5 years, with micropiles of similar capacity to those required in the plans and specifications.

Micropile Contractor. Use a Micropile Contractor with experience in the construction and load testing of micropiles that has constructed at least 5 projects in the last 5 years totaling a minimum of 50 total micropiles of similar capacity to those required in the plans and specifications.

Supervising Engineer. Designate a Supervising Engineer (Field Engineer) to supervise the work. The Supervising Engineer must have experience on a minimum 3 projects of similar scope to this project completed within the past 5 years.

Available Information. Available information developed by the Department includes the following items:

* Boring Logs (see Special Provisions)
* Bent Loadings (See Plans).

Construction Site Survey. Comply with the requirements of Subsection 102.06. The Prime Contractor is responsible for field locating and verifying the location of all utilities shown on the plans prior to starting the work. Maintain uninterrupted service for those utilities designated to remain in service throughout the project.

Micropile Design Requirements. Design the micropiles for the loading conditions specified on the plans. Design the micropiles and pile top to cap connections using the most current edition of the AASHTO LRFD Bridge Design Specifications, and FHWA Micropile Design and Construction (Report No. FHWA NHI-05-039). Determine soil/rock design shear strength parameters, unit weights, applied foundation loadings, slope and external surcharge loads, known utility locations, easements, right-of-ways and other applicable design criteria as shown in the plans or specified herein.

Steel reinforcement in the pile caps is laid out with no allowance for the piles. Rearrange reinforcement as needed to accommodate piling. Check cap reinforcement for structural adequacy in resisting any applied loads that include the cap in the load path.

Design micropile cap connections to meet punching shear requirements for the pile caps.

Experience Submittal. At the Preconstruction Conference submit an electronic copy (PDF format is preferred) of the completed project reference list and the micropile installation personnel list to the Project Manager. Include a brief project description with the owner's name and current phone number. Identify the Design Engineer, Supervising Engineer, drill rig operators, and on-site foremen to be assigned to the project. Provide a summary of each individual's experience with a brief description of each project completed. The submittal must contain the micropile lengths, drilling types, micropile type and size.

Design Submittal. Prior to the planned start of micropile installation, submit complete design calculations and working drawings to the Project Manager for review in accordance with Subsection 105.02. Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to install the micropiles. Verify the limits of the micropile structure and ground survey data before preparing the detailed working drawings. Provide drawings and calculations signed and sealed by the Design Engineer.

Design Calculations. Provide design calculations including, but not limited to, the following:

A written summary report describing the overall micropile design.

Applicable code requirement and design references.

Complete structural design of the micropiles. Include minimum size and strength requirements for permanent casing, reinforcing bar, pile cap plate, and attachments.

Micropile design cross-section(s) geometry including soil/rock strata and piezometric levels and locations.

Design criteria including, soil/rock shear strengths (friction angle and cohesion), unit weights, ground-grout bond values, grout strength requirements (3 day and 28 day) from a qualified independent laboratory, and micropile drillhole diameter for each soil/rock strata.

Design calculation sheets with the, date of preparation, initials of designer and checker, and page number at the top of each page. Provide an index page with MDT project name, MDT project number and contract number, micropile structure location, and designation.

Design notes including a listing of computer programs used in the design as well as an explanation of any symbols used in the calculations and drawings.

Working Drawings. Include all information required for the construction and quality control of the micropiles. Provide working drawings including, but not limited to, the following:

A Plan View of the micropile structure(s) identifying:

* A reference baseline and elevation datum.
* The offset from the construction centerline or baseline to the center of each micropile.
* Subsurface exploration locations showing a plan view of the proposed micropile alignment with appropriate reference base lines to fix the locations of the explorations relative to the micropile

An Elevation View of each micropile identifying:

* Micropile locations; top and bottom elevations; horizontal spacing; and batter.
* Elevations of top and bottom of permanent casing, top and bottom of reinforcing bar, and micropile connection location.

General notes for installing the micropiles including construction sequencing or other special construction requirements.

Horizontal and vertical curve data affecting the micropile control points.

Match lines or other details to relate micropile stationing to centerline stationing.

A listing of summary quantities on the elevation view drawing of each micropile showing estimated quantities of micropile components.

Verification Test and Proof Test Loading Schedule tables that are in conformance with FHWA Report No. FHWA NHI-05-039, Appendix C.

Micropile Typical Sections including:

Micropile spacing and inclination and minimum drillhole diameter

Details, dimensions, and schedules for all micropiles, casing, and reinforcing steel including reinforcing bar bending details, and casing plunge lengths (if used),.

Splice types and locations, centralizers and spacers; grout bond zone, concrete type, and grout strength requirements (3 day and 28 day).

Corrosion protection details; and connection details to the substructure footing, anchorage, plates, etc.

A Typical Detail showing the locations of verification and proof tests.

Submit electronic copies of the calculations and working drawings to the Project Manager. The project manager will submit the copies to MDT Bridge, MDT Geotechnical, and MDT Construction Services for review. Provide working drawings on an equivalent 11 x 17 inch drawing sheet size.

After review, the design submittal will be returned with any indicated corrections. When the drawings are approved, furnish a final copy of the approved drawings signed and sealed by the Design Engineer.

Do not begin micropile installation or incorporate materials into the work until the submittal requirements are satisfied and found acceptable to the Department. Changes or deviations from the approved submittals must be re-submitted to the Design Engineer and Project Manager for approval. No adjustments in contract time or delay or impact claims will be allowed due to incomplete submittals.

Construction Submittals. Submit electronic copies of the following for the micropile system or systems to be installed to the Project Manager for review in accordance with Subsection 105.02:

Micropile Construction Procedure. Provide a written step-by-step detailed description of the proposed micropile construction procedure, including personnel, testing protocol, and equipment to assure quality control.

Micropile Construction Outline. Provide an outline of the procedure on the working drawings in sufficient detail to enable the Supervising Engineer and Project Manager to monitor the construction and quality of the micropiles.

Micropile Construction Schedule and Procedure Information: Provide a proposed micropile installation schedule and procedure including the following information, at a minimum:

Micropile number, micropile design load, size of reinforcing steel, minimum bond length, size and length of permanent casing and total micropile length.

Micropile to cap attachment.

Proposed welding procedure(s), certified by a qualified welding specialist if welding of casing is proposed.

Space requirements for installation equipment that ensure the proposed equipment can perform at the site.

Plans/procedures for control and disposal of surface water, drill flush, and excess waste grout. Disposal must be in compliance with environmental permitting.

Certified mill test reports for the reinforcing steel. Include the ultimate strength, yield strength, elongation, and material properties composition.

Micropile Installation Log. Provide a copy of the proposed Micropile Installation Log that is in general conformance with the example provided in FHWA Report No. FHWA NHI-05-039.

Proposed Grouting Plan. Provide a Grouting Plan that includes complete descriptions, details, and supporting calculations for the following:

Grout mix design and type of materials to be used in the grout including

Certified test data and trial batch reports including grout density targets.

Methods and equipment for accurately monitoring and recording the grout depth, grout volume, and grout pressure during placement.

Grouting rate calculations. Provide the calculations based on the initial pump pressures or static head on the grout and losses throughout the placing system, including anticipated head of drilling fluid (if applicable) to be displaced.

Estimated curing time for grout to achieve specified strength. Grout strength test results for the proposed grout mix completed within one year prior to the start of grouting may be submitted for initial verification and acceptance prior to starting production micropiles. During production, test in accordance with these specifications.

Procedures and equipment for Contractor monitoring of grout quality.

Load Testing Plans. Provide detailed plans for the proposed micropile load testing method. Include all drawings, details, and structural design calculations necessary to describe the proposed test method, reaction load system capacity and equipment setup, types and precision level of apparatus to be used for applying and measuring the test loads and pile top movements in accordance with these specifications.

Load Testing Apparatus Data. Provide calibration reports and data for each test jack, pressure gauge(s), master pressure gauge, and electronic load cell to be used. The calibration tests must have been performed and certified by an independent testing laboratory within the preceding 90 calendar days. No Proof or Verification Testing is allowed until the Project Manager has reviewed the jack, pressure gauge, master pressure gauge and electronic load cell calibration data.

Do not install any micropiles until the Construction Submittals have been received, reviewed, and accepted in writing by the Project Manager and Design Engineer. Additional time required due to incomplete or unacceptable submittals will not be cause for delay or impact claims. All costs associated with incomplete or unacceptable Contractor submittals are the responsibility of the Contractor.

As-Built Submittals. Within 30 days after completion of the work, submit as-built drawings to the Project Manager. Provide any revised design calculations signed and sealed by the Design Engineer for all design changes made during the construction of the micropile.

Materials. Furnish materials that are new and without defects (dent, cracks, or tears). Remove defective materials from the jobsite at no additional cost to the Department. Provide materials for micropiles consisting of the following:

All steel or iron materials permanently incorporated into this work must meet the requirements of Subsection 106.09.

Grout Admixtures. Admixtures used in the proposed grout mix design must meet the requirements of Subsection 551.02.5

Cement. Provide Portland cement for grout meeting the requirements of Subsection 551.02.1 and the approved Working Drawings.

Centralizers and Spacers. Provide centralizers and spacers fabricated from schedule 40 PVC pipe or tube (minimum), steel, or other material non-detrimental to the reinforcing steel. Wood/wood-based material is not permitted.

Fine Aggregate. If sand-cement grout is used, the sand must conform to ASTM C144/AASHTO M45.

Galvanization. Galvanized materials must meet the requirements of ASTM A-153.

Grout. Provide a neat cement or sand/cement grout mixture with a minimum 3-day compressive strength as specified in the approved design submittals.

Permanent Casing Pipe. Provide permanent steel casing/pipe having the dimensional properties shown on the approved Working Drawings. The casing/pipe must conform to the following:

Casing/Pipe must meet the minimum Tensile Requirements of ASTM A252, Grade 3, except the yield strength must be the minimum used in the approved Design Submittals.

For permanent casing/pipe that will be welded for structural purposes, the following material conditions apply:

Develop at least the required compressive, tensile, and/or bending strength used in the design of the micropile within the threaded joints.

Plates and Shapes. Provide structural steel plates and shapes for pile top attachments conforming to ASTM A36/AASHTO M183, or ASTM A 572/AASHTO M223, Grade 350 or higher grade, if specified by the Design Engineer. If higher grade is used, provide AASHTO/ASTM testing designation.

Reinforcing Bars. Provide reinforcing steel (deformed bars) in accordance with ASTM A 615/AASHTO M31, Grade 420 or Grade 520 or ASTM A 722/AASHTO M275, Grade

1035.

When a bearing plate and nut are required to be threaded onto the top end of reinforcing bars for the pile top to footing anchorage, the threading may be continuous spiral deformed ribbing provided by the bar deformations or may be cut into a reinforcing bar. Provide bar/tendon couplers, if required, that will develop the ultimate tensile strength of the bars without evidence of any failure.

Sheathing. Provide smooth PVC sheathing that is watertight, including joints, conforming to ASTM D 1784, Class 13464-B.

Water. Provide water for the grout mix conforming to AASHTO T 26. The water must be potable, clean, and free from substances detrimental to cement and steel.

Construction.

Site Drainage Control. Control and properly dispose of drill flush and construction related waste, including excess grout, in accordance with the specifications, special provisions, and all applicable local, state, and Federal codes and regulations. Provide positive control and discharge of all surface water that will affect construction of the micropile installation. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water at no additional cost to the Department. Upon substantial completion of the work, remove surface water control pipes or conduits from the site.

Excavation. Coordinate the work and the excavation so the micropiles are safely constructed. Perform the micropile construction and related excavation in accordance with the plans, specifications, and construction submittals.

Micropile Allowable Construction Tolerances. The following are the allowable construction tolerances for the micropiles:

Place centerline of each micropile within 3 inches of the plan location.

Plumb each micropile within 2 % of total-length plan alignment.

Place top elevation of micropile +1 inch or -2 inches (maximum) from the vertical elevation indicated.

Place reinforcing steel within 3/4 inch of the center of plan location.

Micropile Installation. Provide the drilling method, grouting procedure, and grouting pressure approved for the installation of the micropiles. Use the approved micropile casing size, final drillhole diameter, bond length, and central reinforcement steel sizing shown on the approved design submittal(s) and working drawings. The Micropile Contractor is responsible for estimating the grout take. No extra payment will be made for grout overruns.

Drilling. Provide drilling equipment and methods suitable for drilling through the conditions to be encountered, without causing damage to any overlying or adjacent structures or services.

The drillhole must be open along its full length to at least the design minimum drillhole diameter prior to placing grout and reinforcement.

Temporary casing or other approved methods of micropile drillhole support will be required in caving or unstable ground to permit the micropile shaft to be formed to the minimum design drillhole diameter.

Ground Heave or Subsidence. During construction, observe the conditions in the vicinity of the micropile construction site on a daily basis for signs of ground heave or subsidence.

Immediately notify the Project Manager if signs of movement are observed. Immediately suspend or modify drilling or grouting operations if ground heave or subsidence is observed, if the micropile is adversely affected, or if adjacent structures are damaged from the drilling or grouting.

If the Project Manager determines that the movements require corrective action, take corrective actions as necessary to stop the movement or perform repairs.

Pipe Casing and Reinforcing Bars Placement and Splicing. Place reinforcement either prior to grouting or placed into the grout – filled drillhole before temporary casing (if used) is withdrawn.

Verify the reinforcement surface is free of deleterious substances such as soil, mud, grease or oil that can contaminate the grout or coat the reinforcement and impair bond. If pile cages and reinforcement groups are used, verify that they are sufficiently robust to withstand the installation and grouting process and the withdrawal of the drill casings without damage or disturbance.

Verify micropile top elevations and adjust all installed micropiles to the planned elevations.

Provide centralizers and spacers that permit the free flow of grout without misalignment of the reinforcing bar(s) and permanent casing. Place the centralizers on a 10 foot maximum spacing with the top-most and bottom-most centralizers a maximum of 5 feet from the top and bottom of the micropile. Place central reinforcement bars with centralizers into the stabilized drillhole and set.

Insert the reinforcing steel into the drill hole to the desired depth, unobstructed. Do not force any partially inserted reinforcing bars into the hole. Re-drill and reinsert reinforcing steel when necessary to facilitate insertion.

Properly align the casing and reinforcing bars in a manner that avoids eccentricity or angle between the axes of the two lengths to be spliced.

Provide splices and threaded joints that meet the requirements of these specifications. Locate any threaded pipe casing joints at least two casing diameters (OD) from a splice in any reinforcing bar. When multiple bars are used, stagger bar splices a minimum of 1 foot apart.

Grouting. Grout Micropiles the same day the load transfer bond length is drilled. Use a stable neat cement grout or a sand-cement grout as specified by Design Engineer. Use of admixtures must be done in accordance with manufacturer’s recommendations.

Use grouting equipment that produces a grout free of lumps and undispersed cement. Provide means and methods to measure the grout quantity and pumping pressure during the grouting operations.

Equip the grout pump with a pressure gauge to monitor grout pressures. Place a second pressure gauge at the point of injection into the pile top. Provide pressure gauges capable of measuring pressures of at least 145 psi or twice the actual grout pressures used, whichever is greater.

Keep the grout agitated prior to mixing. Place grout within 1 hour of mixing. Size the grouting equipment to enable each micropile to be grouted in one continuous operation.

Inject the grout from the lowest point of the drill hole and continue until uncontaminated grout flows from the top of the micropile. The grout may be pumped through grout tubes, casing, hollow-stem augers, or drill rods.

Extract temporary casing in stages ensuring that, after each length of casing is removed, the grout level is brought back up to the ground level before the next length is removed. Extend the tremie pipe or casing below the level of the existing grout in the drillhole.

Control the grout pressures and grout takes to prevent excessive heave or fracturing of rock or soil formations.

Upon completion of grouting, the grout tube may remain in the hole, but must be filled with grout.

Allow the grout within the micropiles to attain the required design strength prior to being loaded.

Grout Testing. Verify that the grout within the micropile verification test and proof test micropiles has attained the minimum required 3-day compressive strength. Previous results for the proposed grout mix completed within one year of the start of work may be submitted for initial verification of the required compressive strengths.

During production, the Department will test the micropile grout for compressive strength in accordance with AASHTO T106/ASTM C109 at a frequency of at least one set of 3 2- inch grout cubes from each grout plant each day of operation or per every 10 micropiles, whichever occurs more frequently. The average of the 3 cubes tested will be the recorded compressive strength.

Verify grout consistency as measured by grout density per ASTM C 188/AASHTO T 133 or API RP-13B-1 at a frequency of at least 1 test per micropile, conducted just prior to start of pile grouting. The Baroid Mud Balance used in accordance with API RP-13B-1 is an approved device for determining the grout density of neat cement grout.

Micropile Installation Records. Prepare and submit to the Project Manager a full-length installation record for each micropile installed. Submit the installation record within 1 work shift after that micropile installation is completed. Record the data on the micropile installation log. Provide a separate installation log for each micropile.

Micropile Load Tests. Perform verification and proof testing of micropiles at the locations specified. Perform compression load testing in accordance with ASTM D1143, tension load testing in accordance with ASTM D3689, and lateral load testing in accordance with ASTM D3966, except as modified herein. Complete testing as provided in the Construction Submittals and submit results to the Design Engineer for review and approval.

Verification Load Tests. Perform pre-production verification micropile load testing to verify the micropile system design and the proposed construction methods prior to installation of production micropiles.

Perform verification load tests to verify that the installed micropiles meet the required compression and tension load capacities, load test acceptance criteria, and adequacy of the micropile bond zone length. The Design Engineer will provide a written evaluation of the verification load test results to the Contractor and Project Manager within 5 working days of completion. The evaluation will either confirm the capacities and bond lengths specified in the Working Drawings or reject the micropiles based upon the verification test results.

The maximum verification and proof test loads applied to the micropile must not exceed 80 percent of the structural capacity of the micropile structural elements, including steel yield in tension, steel yield or buckling in compression, or grout crushing in compression.

Position the jack at the beginning of the test such that unloading and repositioning during the test will not be required. When both compression and tension load testing is to be performed on the same micropile, test under compression loads prior to testing under tension loads.

Testing Equipment and Data Recording. Include dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The load cell is required only for the creep test portion of the verification test.

Design the testing reaction frame(s) to be sufficiently rigid and of adequate dimensions so that excessive deformation of the testing equipment does not occur. Apply and measure the test load with a hydraulic jack and pressure gauge. Provide a pressure gauge that is graduated in 75 psi increments or less. Provide the jack and pressure gauge having a pressure range not exceeding twice the anticipated maximum test pressure. Provide a jack ram with enough travel to allow the test to be done without resetting the equipment.

Monitor the creep test during verification tests with both the pressure gauge and the electronic load cell. Use the load cell to accurately maintain a constant load hold during the creep test load hold increment of the verification test.

Measure the pile top movement with a dial gauge capable of measuring to 0.001 inch. Provide a dial gauge having sufficient travel to allow the test to be done without having to reset the gauge. Visually align the gauge to be parallel with the axis of the micropile and support the gauge independently from the jack, micropile or reaction frame.

Use a minimum of two dial gauges when the test setup requires reaction against the ground or single reaction piles on each side of the test micropile. The Field Engineer is required to record the load test data.

Verification Test Loading Schedule. Test verification micropiles designated for compression or tension load testing to a maximum test load of 2.0 times the micropile Design Load shown on the Plans or Working Drawings. Incrementally load the micropile in accordance with the verification load test schedule table, shown on the working drawings, for both compression and tension loading:

Pile top movement must be measured at each load increment. Start the load-hold period as soon as each test load increment is applied. Monitor the verification test micropile for creep at the 1.30 Design Load (DL).

Measure and record micropile movement during the creep test at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes.

The alignment load (AL) cannot exceed 5 percent of the DL. Set the dial gauges to zero after the initial AL is applied.

Verification Load Test Acceptance Criteria. The acceptance criteria for verification load tests are:

Place the micropile in compression or tension at 1.0 DL test load. Total vertical movement cannot exceed depth shown in working drawings. The total distance will be measured relative to the position of the top of the micropile prior to testing.

At the end of the 1.30 DL creep test load increment, the test micropiles creep rate cannot exceed 0.040 inch/log cycle time (1 to 10 minutes) or 0.080 inch/log cycle time (6 to 60 minutes or the last log cycle if held longer). The creep rate must be linear or decreasing throughout the creep load hold period.

Failure must not occur at the 2.0 DL maximum test load. Failure is defined as the load where the slope of the load versus head settlement curve first exceeds 0.025inch/kip

Verification Test Micropile Rejection. If a verification-tested micropile fails to meet the acceptance criteria, modify the design, the construction procedure, or both.

These modifications may include modifying the installation methods, increasing the bond length, or changing the micropile type.

Any modification necessitating changes to the Micropile structure design requires the Design Engineer’s prior review and acceptance.

Any modifications of design or construction procedures or cost of additional verification test micropiles and load testing will be at the Contractor’s expense.

Proof Load Tests. Perform proof load tests on the first set of production micropiles installed at each designated substructure unit prior to the installation of the remaining production micropiles in that unit. Conduct proof testing at locations shown in working drawings provided by the Design Engineer. Complete testing as provided in the Construction Submittals and submit results to the Design Engineer for review and approval.

Proof Test Loading Schedule. Test micropiles designated for compression or tension proof load testing to a maximum test load of 1.60 times the micropile Design Load shown on the Plans or Working Drawings. Incrementally load the micropile in accordance with the proof load test schedule table, shown on the working drawings, for both compression and tension loading:

Depending on performance, complete either a 10 minute or 60 minute creep test performed at the 1.30DL Test Load. Where the pile top movement between 1 and 10 minutes exceeds 0.04 inch, maintain Maximum Test Load an additional 50 minutes.

Record movements at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes.

Alignment Load (AL) cannot exceed 5 percent of DL. Reset the Dial gauges to zero after the initial AL is applied.

Proof Load Test Acceptance Criteria. The acceptance criteria for proof load tests are:

Place the micropile in compression or tension at 1.0 DL test load. Total vertical movement cannot exceed depth shown in working drawings.

At the end of the 1.30DL creep test load increment, creep rate on the test micropiles cannot exceed 0.04 inch/log cycle time (1 to 10 minutes) or 0.080 in/log cycle time (6 to 60 minutes). During the creep rate test, the rate must be linear or decreasing throughout the creep load hold period.

Failure must not occur at the 1.60DL maximum test load. Failure is defined as load where the slope of the load versus head settlement curve first exceeds 0.025 inch/kip.

The Design Engineer will provide a written evaluation of the proof load test results to the Contractor and Project Manager within 5 working days of completion. The evaluation will either confirm the capacities and bond lengths specified in the Working Drawings or reject the micropiles based upon the verification test results

Proof Test Micropile Rejection. If a proof-tested micropile fails to meet the acceptance criteria, immediately proof test another micropile within that footing. For failed micropiles and further construction of other micropiles, modify the design, the construction procedure, or both.

These modifications may include installing replacement micropiles, incorporating micropiles at not more than 50% of the maximum load attained, post-grouting, modifying installation methods, increasing the bond length, or changing the micropile type.

Any modification necessitating changes to the Micropile structure design requires the Design Engineer’s prior review and acceptance.

Modifications of design or construction procedures, or cost of additional verification test micropiles and verification and/or proof load testing, or replacement production micropiles, will be at the Contractor’s expense.

Method of Measurement. Measurement will be per linear foot of micropile installed and accepted.

Basis of Payment. Accepted quantities of Micropiles will be paid for at the contract unit price per linear foot. Payment is full compensation for all labor, equipment, material, testing, investigations, and incidentals necessary to design and construct micropiles.

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| --- | --- |
| Pay Item | Pay Unit |
| Micropiles | Linear Foot/Lump Sum/Each |