



**DEVELOPMENTAL SPECIFICATIONS  
FOR  
INTERMEDIATE FOUNDATION IMPROVEMENTS**

**Effective Date  
February 18, 2025**

**THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.**

**23073.01 GENERAL.**

**A. Description.**

1. This work includes furnishing the material for and installation of either stone columns or aggregate piers, hereafter collectively denoted as intermediate foundations. The design of the proposed intermediate foundations shall be the responsibility of the Contractor.
2. The primary purposes of the intermediate foundations on this project are to improve global slope stability, improve the underlying soils' bearing capacity, reduce post-construction settlement, and/or increase the time-rate of settlement of the underlying compressible layer(s).
3. The final location and extent of the intermediate foundations shall be determined by the Contractor but shall generally be located under the influence area of the new roadway embankment and MSE walls, as shown in the contract documents (Q sheets), to satisfy the design requirements listed in Article DS-23073.01, B.

**B. Design Requirements.**

1. The intermediate foundations shall extend through the compressible native soils, hereafter denoted as "soil to be improved". The soils to be improved include, but are not necessarily limited to, soft to medium stiff clays and loose sands.
2. The intermediate foundations shall extend into the underlying soils, hereafter denoted as "foundation soil", which includes stiff to very stiff clays or shale bedrock. Each individual intermediate foundation element shall penetrate a minimum of 2 feet into the foundation soil. Any other material encountered will be classified by the Engineer.
3. It should be noted that subsurface conditions can change abruptly across the site. The Contractor is required to obtain additional subsurface information, including soil borings and water table information, as part of their design of the intermediate foundations, as required to meet the requirements of this section. It is imperative that the surface of the foundation soil is delineated either before or during installation to ensure the intermediate foundations penetrates to the foundation soil layer.

4. After installation of the intermediate foundations, the minimum design criteria for MSE walls, bridge berms, and roadway embankments are:
  - a. Bearing capacity: a capacity to demand ratio greater than or equal to 1.0 (i.e., the ratio of strength limit state bearing resistance to the maximum factored load). The estimated minimum required strength limit state bearing resistance for MSE walls is provided in the contract documents (Q Sheets). Final determination of the required strength limit state bearing resistance should be developed in consultation with the MSE wall designer.
  - b. Settlement: Settlement criteria applies to areas within the intermediate foundation zones and to the transitions between improved areas and unimproved areas. In areas where more than one criterion applies, the more restrictive settlement tolerance shall control.
    - Settlement of up to 1 inch is tolerable adjacent to bridge structures
    - Settlement of up to 3.6 inches is tolerable below MSE walls
    - Settlement of up to 4.8 inches is tolerable below roadways
    - Differential settlement is limited to 1 inch over 120 feet (i.e., parallel to and perpendicular to the proposed roadway centerline)
  - c. Global slope stability: short-term minimum factor of safety of 1.3, long-term minimum factor of safety of 1.5.

**C. Method.**

1. The Contractor may elect to use either a stone column or aggregate pier intermediate foundation system, based on the soil information provided in the contract documents, additional borings conducted by the Contractor, the Contractor's expertise, and other factors. The Contractor shall be responsible for the design of the intermediate foundation system selected and meeting the performance requirements specified herein. The Contractor shall follow the Specified Construction Sequences listed in the contract documents (Q Sheets).
2. If the Contractor does not possess the capability or expertise to design and/or install the intermediate foundations or they select a system that is considered proprietary, they shall make arrangements to contract the services of a licensed Contractor or other qualified personnel to perform the necessary design and/or installation. All intermediate foundation design documents shall be signed and sealed by a Professional Engineer licensed in the State of Iowa. The procurement of any permits required for the installation of the intermediate foundations, including the disposal of any water or spoils, shall be the sole responsibility of the Contractor.

**D. Submittals.**

1. Submit the following documents to the Engineer a minimum of 30 days prior to the installation of the intermediate foundation system they have selected, pursuant to Article 1105.03, E of the Standard Specifications:
  - a. Evidence of successful installation of the selected intermediate foundation system in the United States on five or more projects under similar conditions using the same proposed installation technique within the last 3 years. The documentation to be submitted includes references for the specific projects. The references consist of the Contracting Authority and Engineer, including names, addresses, and telephone numbers.
  - b. Construction drawings showing intermediate foundation locations, depths, and identification numbers. The construction drawings shall follow the Specified Construction Sequences listed in the contract documents (Q Sheets). Construction drawings shall be signed and sealed by a Professional Engineer licensed in the State of Iowa.
  - c. A description of the equipment and construction procedures to be used, including a plan to dispose of any water or spoils if applicable.
  - d. A proposed verification program, including proposed independent testing agency to be used (see Article DS-23073.01, D, 2).
  - e. Certification that the project superintendent possesses a minimum of five years of method specific experience.
  - f. The source of the proposed intermediate foundation backfill material(s) and the gradation

and bandwidths the Contractor proposes to use. Upon approval of the backfill source and gradation, the Contractor shall maintain this gradation throughout the intermediate foundation installation.

- g. A proposed plan for quality control throughout the installation procedure. This shall address issues such as control and measurement of column or pier diameter, lift thickness, and any other pertinent information. The roles of the Contractor and Engineer shall be defined in the contract documents.
- h. Results of overall stability analysis, bearing capacity, anticipated settlements, and other calculations relating to performance of the intermediate foundations. Also include the results of any additional soil borings.

## 2. Verification Program.

A verification program designed, accomplished, and reported by the Contractor is required to measure the quality of the installed intermediate foundations. The proposed verification program is subject to approval by the Engineer. As a minimum, the verification program shall include the following:

- a. Proposed means and methods for verification that design and performance criteria as stated in Article DS-23073.01, B have been satisfied. This may include, but shall not be limited to, modulus or load tests on individual elements and/or groups, soil borings, and other methods as required by the intermediate foundation designer and approved by the Engineer.
- b. Quality control program to verify that intermediate foundation elements are installed in accordance with the designer's specifications and the requirements as outlined in this Special Provision. The quality control program shall include testing and/or observations by an independent testing laboratory.
- c. Program to monitor performance of the intermediate foundations during and after construction of the bridge berms and roadway embankment. This procedure may include installation of settlement plates, inclinometers, or other instrumentation. Instrumentation installed to monitor performance may also be used to aid in verification that design and performance criteria have been satisfied.

## 3. Daily Reports.

During construction, submit daily progress reports electronically to the Engineer detailing the following:

### a. Stone Columns.

- 1) Stone column identified by location number.
- 2) Date constructed.
- 3) Elevation of top and bottom of each stone column.
- 4) Average lift thickness.
- 5) Estimate of ground heave or subsidence.
- 6) Vibrator power consumption during penetration and compaction of each increment of stone column constructed.
- 7) Jetting pressure (air or water).
- 8) Description of soil and groundwater conditions.
- 9) Details of obstructions, delays, and any unusual ground conditions.
- 10) Quantity of aggregate placed in each stone column.
- 11) Amount of water used per column (if applicable).
- 12) Results of quality control testing.

### b. Aggregate Piers.

- 1) Aggregate pier identified by location number.
- 2) Date constructed.
- 3) Elevation of top and bottom of each aggregate pier.
- 4) Average lift thickness.
- 5) Description of soil and groundwater conditions.
- 6) Details of obstructions, delays, and any unusual ground conditions.
- 7) Quantity of aggregate placed in each aggregate pier.

8) Results of quality control testing.

**4. Final Report.**

At the completion of the installation of the intermediate foundations, submit a report to the Engineer detailing the equipment and methods used, production rates, the performance of the site during treatment, and that the site meets the criteria established for this project. This report shall include a summary of all verification testing performed.

**E. Pre-Construction Conference.**

1. A pre-construction conference shall be held at least 5 working days prior to beginning intermediate foundation installation work at the site to discuss construction procedures, personnel, verification program, quality control, and equipment to be used. Those attending shall include:
  - a. The superintendent, on-site supervisors, independent testing agency representative, and all foremen in charge of intermediate foundation installation operations.
  - b. The Engineer, key inspection personnel, and representatives of the Contracting Authority.
2. If the Contractor's key personnel change or if the Contractor proposes a significant revision of the approved intermediate foundation installation plan, an additional conference shall be held before any additional work is performed.

**F. Basis of Acceptance.**

The basis of acceptance for the intermediate foundations will include visual inspection by the Engineer, who will consider results of all verification tests as well as consistent use of procedures, methods, and construction performance rates.

**23073.02 MATERIALS.**

- A. Intermediate foundation system backfill material shall be furnished by the Contractor. Aggregate used for the construction of both stone columns and aggregate piers shall be relatively clean crushed stone, meeting the requirements of Section 4115 of the Standard Specifications for abrasion loss, freeze-thaw durability, and deleterious material content.
- B. Gradation for stone columns shall be in accordance with Section 4109, Gradation No. 4 of the Standard Specifications. Gradation for aggregate piers shall be in accordance with Section 4120 and with Section 4109, Gradation No. 11 of the Standard Specifications. However, in the case that the drilled cavity is partially filled with water, the Contractor may furnish a crushed granular material that meets the requirements of Section 4115 and Section 4109, Gradation No. 3 of the Standard Specifications. This Gradation No. 3 material shall be placed to a thickness of approximately two feet above the water level. Gradation for aggregate piers using a displacement or non-drilled system shall meet the requirements of Section 4115 and Section 4109, Gradation No. 3 or No. 5 of the Standard Specifications. Alternative gradations may be considered as part of the submittal process (Article DS-23073.01, D, 1, f).

**23073.03 CONSTRUCTION.**

**A. Procedures.**

**1. General.**

- a. The actual construction procedures shall be determined by the Contractor (Article DS-23073.01, D, 1, c). The following are minimum requirements and should be referenced when preparing submittals. The submittal shall include the manufacturer's specifications for the proposed equipment to ensure that it has sufficient capacity to perform the intended function.
- b. Grade and level the site as needed for proper installation of the intermediate foundation

system selected, which may include cutting benches into the existing roadway embankment slopes. This work shall be incidental to intermediate foundation installation.

## **2. Stone Columns.**

Construct the stone columns in accordance with the contract documents, the Contractor's design plans and the following requirements. Install the stone columns with a down-hole vibrator capable of densifying the aggregate by forcing it radially into the surrounding soil. The vibrator shall be of sufficient size and capacity appropriate to constructing stone columns to the Contractor's design plan diameters and lengths.

- a. The probe and follower tubes shall be of sufficient length to reach the elevations shown on the design plans and approved shop drawings. The probe, used in conjunction with the available pressure to the tip jet, shall be capable of penetrating to the required tip elevation. Pre-boring of silt lenses, layers, or strata, if encountered is permitted.
- b. The probe and follower tubes shall have visible markings at regular increments to enable measurement of penetration and re-penetration depths.
- c. Provide methods for supplying to the tip of the probe a sufficient quantity of air or water to widen the probe hole to allow adequate space for stone backfill placement around the probe. Maintain the flow of air or water from the bottom jet at all times during backfilling to prevent caving or collapse of the hole and to form a clean stone column.
- d. The probe shall penetrate into the foundation soil layer to the minimum depths required in the Contractor's design plans or 2 feet, whichever is deeper.
- e. Lift thickness shall not exceed 4 feet. After penetration to the treatment depth, slowly retrieve the vibrator in 1 foot to 1 1/2 foot increments to allow backfill placement.
- f. Compact the backfill in each lift by re-penetrating it at least twice with the horizontally vibrating probe so as to densify and force the stone radially into the surrounding soil. Re-penetrate the stone in each increment a sufficient number of times to develop an ammeter reading on the motor significantly higher than the freestanding (unloaded) ampere draw on the motor.
- g. Install stone columns so that each completed column is continuous throughout its length.
- h. Removal of subsurface obstructions, if directed by the Engineer, shall be incidental to the intermediate foundation system. Additional elements or replacement elements required due to obstructions shall also be incidental to the intermediate foundation system. Obstructions include but are not limited to boulders, timbers, concrete and utility lines which shall prevent placing the elements to the required depth or shall cause the element to drift from the required location.
- i. Rework and compact any ground heave that is observed prior to retaining wall foundation construction. The depth of soil to be reworked and the degree of compaction required will be determined by the Engineer. Rework and compaction of heaved ground shall be incidental to stone column installation.
- j. Provide a full-time quality control representative to verify all installation procedures.

## **3. Aggregate Piers, Drilled System.**

Construct the aggregate piers in accordance with the contract documents, the Contractor's design plans and the following requirements.

- a. The drilled cavity excavation shall be in reasonably close conformity to the limits and construction stages shown on the plans. If temporary casing is needed to limit the sloughing of subsurface soils, insert the casing to at least 2 feet beyond any sloughing strata. Casing of sufficient length should be available on-site during drilling operations. Upon extraction, maintain the bottom of the casing at not more than 1 foot to 2 feet above of level of the backfill.
- b. Removal of subsurface obstructions, if directed by the Engineer, shall be incidental to the intermediate foundation system. Additional elements or replacement elements required due to obstructions shall also be incidental to the intermediate foundation system. Obstructions include but are not limited to boulders, timbers, concrete and utility lines which shall prevent placing the elements to the required depth or shall cause the element to drift from the required location.

- c. Backfill placement shall closely follow the excavation of each cavity. Place the backfill in 2 feet thick lifts loose measure. Compact each lift with a high-energy impact tamper to the satisfaction of the Engineer and as recommended in the Contractor's design plans.
- d. Provide a full-time quality control representative to verify all installation procedures.

**4. Aggregate Piers, Displacement or Non-Drilled System.**

Construct the aggregate piers in accordance with the contract documents, the Contractor's design plans and the following requirements.

- a. The installed aggregate pier shall be in reasonably close conformity to the limits and construction stages shown on the plans.
- b. Removal of subsurface obstructions, if directed by the Engineer, shall be incidental to the intermediate foundation system. Additional elements or replacement elements required due to obstructions shall also be incidental to the intermediate foundation system. Obstructions include but are not limited to boulders, timbers, concrete and utility lines which shall prevent placing the elements to the required depth or shall cause the element to drift from the required location.
- c. Place the aggregate pier in 1 foot or 2 foot thick lifts compacted measure, or lift thickness as designed and scheduled in Contractor's design plans. Compact each lift with a high-energy impact tamper to the satisfaction of the Engineer and as recommended in the Contractor's design plans.
- d. Provide a full-time quality control representative to verify all installation procedures.

**B. Tolerances.**

- 1. Horizontal Control: The center of the completed pier or column shall be within 4 inches of the plan location.
- 2. Vertical Control: The completed pier or column shall not deviate from the vertical by more than 2 inches in 10 feet.
- 3. Diameter: The completed pier or column diameter shall not be more than 10% below the plan diameter.
  - a. If any pier or column falls outside these tolerances, an additional pier or column may be required to be installed at the Contractor's expense.
  - b. The Engineer may require additional aggregate piers or stone columns at the Contractor's expense if the average effective diameter of any group of 50 consecutively installed piers or columns is less than the plan diameter.
- 4. Finish top of stone column or aggregate pier to within 3 inches of the proposed foundation subgrade elevation.

**23073.04 METHOD OF MEASUREMENT.**

- A. Intermediate Foundation Improvements will be the lump sum for completed and accepted aggregate piers or stone columns in locations as shown in the contract documents. Backfill and temporary casing will not be measured.
- B. Intermediate Foundation Improvements Verification Testing will be the lump sum.
- C. For the purpose of subcontracting, Intermediate Foundation Improvements and Intermediate Foundation Improvements Verification Testing will be considered specialty items.

**23073.05 BASIS OF PAYMENT.**

- A. The Contractor will be paid the contract lump sum price for Intermediate Foundation Improvements. This payment shall be full compensation for design, field staking for the location of elements;

drilling, furnishing, transporting, placing and compacting intermediate foundation system backfill and associated work; and full-time quality control. Backfill and temporary casing will not be paid for directly but shall be considered incidental to the intermediate foundation improvements, as per plan.

- B.** The Contractor will be paid the contract lump sum price for Intermediate Foundation Improvements Verification Testing. This payment shall be full compensation for furnishing all of the labor and equipment and installing additional intermediate foundation members to comply with the procedures as outlined in Article DS-23073.01, D, 2.