

IMPACT DISPLACEMENT PIER

**\*\*From Cornwall BRS 0172(6)**

- xx. DESCRIPTION. This work shall consist of designing, furnishing, and installing Impact Displacement Pier(s) (IDP) to the lines and grades indicated in the Plans and as directed by the Engineer.
- xx. GENERAL REQUIREMENTS. IDP elements shall be constructed by driving a displacement mandrel to the design depth and using an enlarged rammer head to ram thin lifts of aggregate into the cavity created by the mandrel.
- xx. SUBMITTALS.
- (a) Design Calculations and Construction Drawings. Detailed design calculations and Construction Drawings shall be submitted by the IDP Soil Improvement Contractor in accordance with Section 105 to the Engineer for approval at least 2 weeks prior to the start of construction. The Construction Drawings shall indicate the spacing, location, and depth of the IDP installation points to achieve the performance criteria specified in these provisions. A detailed explanation of the design parameters for settlement calculations shall be included in the submittal. All computer-generated calculations and drawings shall be prepared and sealed by a Professional Engineer licensed in the State of Vermont.
  - (b) Quality Control Test Program. The quality control test program for the IDP system, meeting the design requirements, shall be submitted to the Engineer for approval at least two weeks prior to the start of construction.
  - (c) Area-fill Load Test. The IDP Soil Improvement Contractor shall furnish details and setup of the area-fill load test to the Engineer at least 1 week prior to the start of the test.
  - (d) Daily Progress Reports. The IDP Soil Improvement Contractor shall furnish to the Contractor and the Engineer a complete and accurate record of IDP installation. The record shall indicate the pier location, length, volume of aggregate used, densification forces during installation, and final elevations or depths of the base and top of piers. The record shall also indicate the type and size of the installation equipment and aggregate used. The IDP Soil Improvement Contractor shall immediately report to the Contractor and the Engineer any unusual conditions encountered during installation.
  - (e) IDP Modulus Load Test. IDP modulus load test details and setup shall be furnished to the Contractor and the Engineer at least one week prior to the start of the test.
  - (f) IDP Contractor Qualifications. A minimum of six weeks prior to the installation of IDPs, the specialty IDP Contractor shall submit a project reference list containing at least five similar projects completed in the past five years and personnel resumes.

For each project submitted in the reference list, the specialty IDP Contractor shall include: the name of the client contact, address, and telephone number; location of project; contract value; and scheduled and actual completion date of the project.

Resumes of the specialty IDP Contractor's staff shall be submitted to the Agency for review. Only those individuals designated as meeting the qualification requirements shall be used for the project. The specialty IDP Contractor cannot substitute for any of these individuals without written approval of the Engineer.

The Engineer shall approve or reject the Contractor's qualifications and staff within fifteen working days after receipt of the submission. Work shall be started on any IDP installation until the specialty IDP Contractor's qualifications have been approved by the Engineer. The Engineer may suspend the work if the specialty IDP Contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the specialty IDP Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in the contract time resulting from the suspension of work will be allowed.

xx. SOIL IMPROVEMENT PERFORMANCE CRITERIA. Perform appropriate soil improvement beneath areas of embankments as shown in the Plans to satisfy the following criteria:

(a) Global Stability.

(1) Short-term (Undrained) Conditions. A global stability factor of safety of at least 1.1 for short-term (undrained) conditions shall be achieved with soil improvement for embankment and abutment slopes.

(2) Long-termed (Drained) Conditions. A global stability factor of safety of at least 1.3 for long-term (drained) conditions shall be achieved with soil improvement for embankment slopes. A global stability factor of safety of at least 1.5 for long-term (drained) conditions shall be achieved with soil improvement for abutment slopes.

(b) Settlement. Total post-construction settlement from the placement of the embankment shall be limited to 76 mm (3 inches) for the subsurface soils following soil improvement.

(c) Time Rate of Settlement. At least 90% of consolidation settlement must be achieved within 30 days following the installation of the soil improvement and completion of the fill placement for the embankment.

xx. DESIGN PROCEDURES.

(a) IDP System Design. The design of the IDP system shall be performed in accordance with the procedures set forth in the

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Geopier Foundations and Soil Reinforcement Manual (Fox and Cowell, 1998) or as described herein.

- (b) Design Calculations. The IDP Soil Improvement Contractor shall produce design calculations that shall be completed by a Professional Engineer licensed in the State of Vermont. The design calculations shall be approved by the Engineer prior to construction.
  - (c) Construction Drawings. The IDP Soil Improvement Contractor shall produce project-specific Construction Drawings in accordance with Section 105 that shall be stamped and sealed by a Professional Engineer licensed in State of Vermont. The Construction Drawings shall be approved by the Engineer prior to construction.
  - (d) IDP Stiffness. The stiffness of the IDP shall be confirmed by conducting a field modulus load test on an individual IDP as described in INSPECTION AND TESTING of this Section.
- xx. EQUIPMENT AND PROCEDURES. Specific equipment and procedural specifications are left to the IDP Soil Improvement Contractor performing the soil improvement work to achieve the specified performance criteria. However, the following minimum guidelines shall be implemented:
- (a) The IDP Soil Improvement Contractor shall install a minimum of three initial "demonstration piers" to provide project-specific construction procedures prior to installing the modulus test pier or production piers. The demonstration pier installation shall be used to determine driving depths, the rate of mandrel withdrawal during the compaction process, and the appropriate flow of selected aggregate out of the mandrel.
  - (b) A sacrificial tip shall be installed at the bottom of the mandrel prior to penetrating the mandrel into the ground.
  - (c) The mandrel (and sacrificial tip) shall be driven to the design depth using crowd force and impact energy.
  - (d) The mandrel and hopper shall be filled with aggregate.
  - (e) The impact hammer shall begin operation and remain in operation during the raising of the mandrel. The impact hammer may remain in operation during the lowering of the mandrel depending on the specific installation procedures established at the site.
  - (f) The pier shall be constructed by raising the mandrel 0.91 meters (3 feet) and then driving the mandrel 0.61 meters (2 feet) using vertical impact energy and crowd pressure to construct an approximate 0.3 meter (1 foot) thick compacted lift. The mandrel shall be raised at a rate determined from the demonstration pier testing or no faster than 0.3 meters (1 foot) in 5 seconds. The crowd pressure shall be recorded to provide a measure of the vertical densification force as the mandrel is driven on its compaction stroke. Additional impact ramming and/or alternative lift heights and lowering depths may be used as appropriate for the project site upon approval by the Designer.

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- (g) Subsequent lifts shall be constructed following the same procedure described above until the pier is constructed to the top of pier elevation.
- (h) At IDP element locations, water or compressed air shall be used if necessary, as determined from the flow test, to enhance free flow of aggregate through the mandrel as determined during the performance of a flow test. Water or air flow shall be discontinued when the mandrel reaches the 0.91 meter (3 foot) raise height.
- (i) At the completion of the pier installation, the hammer shall be turned off and the mandrel pushed downward applying full crowd pressure on the top of the pier to provide pre-loading.
- (j) At completion of the pier installation, the remaining stone in the mandrel may be emptied outside the pier location to allow for a measure of the remaining volume of aggregate.
- (k) Special high-energy impact densification apparatus shall be employed to densify the IDP elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate. Densification shall be performed using a beveled tamper. Downward crowd pressure shall be constantly applied to the tamper shaft during tamping.
- (l) Drilling equipment used to construct the IDPs shall be capable of drilling through the soils anticipated for this project.
- (m) Should any obstruction be encountered during installation of the IDP, the Contractor shall be responsible for removing such obstruction, or the pier shall be relocated or abandoned. Obstructions include but are not limited to boulders, timbers, concrete, bricks, utility lines, etc., that prevent installing the IDPs to the required depth, or cause the IDP to drift from the required locations. Dense natural rock or weathered rock shall not be deemed obstructions, and piers may be terminated short of design lengths on such materials. If the Contractor cannot or does not remove such obstructions within one hour from the time the IDP Soil Improvement Contractor reports the obstruction to the Contractor, the IDP Soil Improvement Contractor may remove such obstructions by their own means and be compensated as obstruction removal.
- (n) The Contractor shall provide layout (construction staking) of the IDP locations. The Contractor shall provide ground elevations in sufficient detail to estimate drilling depth elevations to within 51 mm (2 inches).
- (o) The Contractor shall locate and protect underground and aboveground utilities and other structures from damage during installation of the IDP elements. The Contractor will provide site access to the IDP Soil Improvement Contractor, after earthwork in the area has been completed. Site subgrade shall be established by the Contractor within 152 mm (6 inches) of final design subgrade, as approved by the Engineer. A working surface

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shall be established and maintained by the Contractor to provide wet weather protection of the subgrade and to provide access for efficient operation of the IDP installation.

- (p) Prior to placing embankment fill on the IDP reinforced subgrade, the subgrade soils and tops of IDP elements shall be exposed and then thoroughly compacted with a standard, hand-operated impact compactor or twin drum vibratory roller. Compaction shall be performed on the same day that embankment fill is to be placed and shall extend over the entire subgrade to compact any loose surface soil and loose surface pier aggregate.

xx. INSPECTION AND TESTING.

- (a) A modulus test shall be performed to verify the design stiffness of the IDPs. The test shall be performed at a location approved by the Engineer.
- (b) The IDP Soil Improvement Contractor shall furnish the Contractor and the Engineer a description of the installation equipment, installation records, complete test data, analysis of the test data and recommended design parameter values for IDPs based on the modulus test results. The report shall be prepared under supervision of a Professional Engineer registered in Vermont.
- (c) Prior to or after the installation of the modulus test pier, a 0.6 meter (2 foot) diameter hole shall be drilled to a depth equal to the depth of embedment on the project, typically 0.6 meter (2 feet) to 0.9 meter (3 feet). The drilled hole will provide a location for the concrete cap.
- (d) The test pier shall be installed in the center of the drilled hole in the same manner as the production piers.
- (e) ASTM D-1143 general test procedures shall be used as a guide in establishing load increments, load increment duration, and load decrements.
- (f) With the exception of the load increment representing approximately 150% of the design maximum top of IDP stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.25 mm (0.01 inch) per hour, or less.
- (g) The load increment that represents approximately 150% of the design maximum stress on the IDP shall be held for a minimum of 15 minutes, a maximum of 4 hours, and until the rate of deflection reduces to 0.25 mm (0.01 inch) per hour or less.
- (h) A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
- (i) The modulus test IDP shall be installed in a manner that will be consistently used throughout the project for production IDPs.

(j) Modulus testing shall be performed in accordance with the requirements outlined in the design submittal and herein. The results of the modulus test shall show that the modulus at the test location exceeds the minimum modulus required for the design criteria. If actual modulus value measured does not meet these criteria, additional IDPs shall be added and/or lengthened to meet the criteria at the IDP Soil Improvement Contractor's expense. Additional modulus tests shall be performed at the IDP Soil Improvement Contractor's expense until the requirements of SOIL IMPROVEMENT PERFORMANCE CRITERIA of this Section have been met.

(k) The IDP Soil Improvement Contractor shall immediately report to the Contractor and the Engineer any unusual conditions encountered during installation. Any change in the predetermined Soil Improvement program necessitated by a change in the subsurface conditions shall be immediately reported and submitted to the Engineer for approval.

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (Impact Displacement Pier Modulus Load Test) to be measured for payment will be each modulus load test performed in the complete and accepted work.

The quantity of Special Provision (Impact Displacement Pier) to be measured for payment will be the number of meters (linear feet) installed in the complete and accepted work.

The quantity of Special Provision (Impact Displacement Pier Obstruction Removal) to be measured for payment will be the number of meters (linear feet) over the depth range in which obstructions are encountered and removed in the complete and accepted work, measured to the nearest 100 mm (4 inches) as determined by the Engineer.

The quantities of Special Provision (Impact Displacement Pier Design) and Special Provision (Impact Displacement Pier Mobilization) to be measured for payment will be on a lump sum basis in the complete and accepted work.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (Impact Displacement Pier Modulus Load Test) will be paid for at the Contract unit price per each. Payment will be full compensation for performing the test, providing data and reports as specified, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Special Provision (Impact Displacement Pier) will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for installing a complete IDP and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Special Provision (Impact Displacement Pier Obstruction Removal) will be paid for at the Contract unit price per meter (linear foot). Payment will be full compensation for performing the work of overcoming encountered obstructions and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

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The accepted quantity of Special Provision (Impact Displacement Pier Design) will be paid for at the Contract lump sum price. Payment will be full compensation for performing the IDP design, for providing design calculations, Construction Drawings, and reports as specified, including pier layout and installation depth, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

The accepted quantity of Special Provision (Impact Displacement Pier Mobilization) will be paid for at the Contract lump sum price. Payment will be full compensation for mobilizing, remobilizing, and demobilizing IDP equipment to and from the project, including erecting and dismantling, and for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete the work.

Partial payments will be made as follows:

- (a) When drilling equipment has been set up and drilling operations begin, a payment of 75 percent of the lump sum price will be allowed.
- (b) The remaining 25 percent of the lump sum price will be paid when the drilling operations are complete and the equipment has been removed from the site to the satisfaction of the Engineer.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
900.620 Special Provision (Impact Displacement Pier Modulus Load Test)	Each
900.640 Special Provision (Impact Displacement Pier)	Meter (Linear Foot)
900.640 Special Provision (Impact Displacement Pier Obstruction Removal)	Meter (Linear Foot)
900.645 Special Provision (Impact Displacement Pier Design)	Lump Sum
900.645 Special Provision (Impact Displacement Pier Mobilization)	Lump Sum