Intermediate Foundation Improvements (IFIs)

Design Manual
Chapter 200
Geotechnical Design
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In geotechnical design, sometimes the soil investigations indicate an underlying soil or subsurface condition that is inadequate to support the planned structure. Without proper mitigation of this layer and/or subsurface condition, abutments, foundations, culverts, MSE walls, and embankments will encounter settlement or global instability that will compromise the structure integrity. Thus, Intermediate Foundation Improvements (IFIs) are one of several ground remediations that may be used to improve the strength of the in-place soil in order to support the structures and meet the settlement and stability requirements. IFI is a term used by Iowa DOT for a ground improvement option chosen by and designed by the contractor of either stone columns or rammed aggregate piers. IFIs have become a practical and economical method of construction in numerous project cases.

IFIs are commonly used in soil for the following:

- Increase allowable bearing capacity.
- Improve slope stability of otherwise unstable soil.
- Control settlement.
- Reduce the risk of liquefaction, if required.

Quick Tips:

- IFI is a term used by Iowa DOT for a ground improvement option chosen by and designed by the contractor of either stone columns or rammed aggregate piers.
- IFI's must be designed by the contractor or his IFI subcontractor post-letting to meet the project-specific performance requirements identified in the Special Provisions, which are prepared by the DOT prior to letting.
- A qualified IFI contractor and designer must perform the design and installation of the system.

Methods

IFIs are used to improve poor/unsuitable subsurface soils and/or to improve the performance of embankments or structures. The type of IFI elements and their design are chosen by the contractor post-letting based on the soil and soil boring information provided in the S3 and S4 event submittal and shown in the letting plans, on additional borings conducted by the designer/contractor, and on the designer/contractor's expertise. IFIs approved for use by the Iowa DOT include stone columns and rammed aggregate piers (i.e., vibroreplacement methods). Stone columns and rammed aggregate piers are ground improvement techniques that create dense aggregate columns by means of a crane-suspended down-hole vibrator or a down-hole impact compactor to reinforce soils and densify granular soils.

The anticipated three dimension outline of the IFI as estimated by the DOT is included in the S3 or S4 event submittal and shown/included in the letting plans. However, the final three dimensional limits and the design and installation aspects/details of the IFI system are determined by the contractor post-letting and submitted for review by the DOT.

More information on the types, design, and construction of the above ground improvement methods can be found in Ground Improvement Methods, Volumes I and II, FHWA NHI-06-019 and FHWA NHI-06-020, August 2006 and at Geotech Tools: Geo-construction Information & Technology Selection Guidance for Geotechnical, Structural, & Pavement Engineers, http://www.geotechtools.org/.

Design Requirements

All intermediate foundation design documents must be signed and sealed by a Professional Engineer licensed in the State of Iowa. Only qualified contractor are allowed to perform installation of the system. The following information outlines design requirements for IFIs that are typically included in project Special Provisions.

IFI systems must be designed by the contractor post-letting and installed to meet the specific performance requirements outlined in the project Special Provisions, which are prepared by the Iowa DOT prior to letting.

General Criteria

IFIs typically penetrate into the underlying foundation soil. Depth of penetration varies with performance criteria, but typically has a minimum penetration of at least 2 feet.

MSE Wall Criteria

- Provide a minimum bearing capacity required for design (typically around 4000 to 6000 psf and a factor of safety greater than or equal to 2.5), designed to be compatible with the wall's bearing requirements as determined by the MSE wall vendor.
- Provide a factor of safety of 1.5 or greater against sliding of the proposed MSE wall, designed in conjunction with information exchanged with the MSE wall vendor.
- Overall global stability of the combined wall, abutment, and IFI system should be analyzed and the IFI system designed to provide a minimum factor of safety of 1.5.
- Limit settlement (e.g., typically to a maximum of 3 to 4 inches) under the weight of MSE embankment.
- Time rate of settlement should be considered and should meet the project criteria (e.g., a possible goal of 2 inches short-term settlement following embankment construction and 1 inch of long-term settlement following bridge construction).
- Differential settlement should be limited, typically to a maximum of 2 inches in 16.67 feet (1 percent).

Embankment Criteria

- Overall global stability of embankment slopes and the IFI system should be analyzed and the IFI system designed to provide a minimum factor of safety of 1.5.
- Limit total settlement, including elastic, consolidation, and secondary (frequently to a maximum of 3 inches) under the weight of the embankments and superimposed loading.
- Time rate of settlement should be considered and should meet the project criteria (e.g., a possible goal of 2 inches short-term settlement following embankment construction and 1 inch of long-term settlement following bridge construction).

Culvert Criteria

Limit total settlement, including elastic, consolidation, and secondary (frequently to a maximum of 6 inches) under the weight of the culvert, embankments, and superimposed loading. If the estimated settlement for a culvert is 6 inches or more, the designer will typically camber the culvert and provide bell joints. However, the culvert and the embankment in the vicinity of the culvert may have differing settlement criteria and goals.

Development of Design Parameters

The Soils Design Section's S3 or S4 event submittal consisting of site information, geotechnical analysis, and foundation recommendations can be used by designers/contractors to develop the design of an IFI. However, subsurface profile and conditions can change rapidly across the site, and specific laboratory testing for IFI design may not be included in the S3 or S4 event submittal. Thus, the contractor/designer may need to obtain additional subsurface information, including soil borings and water table information, as part of their design of the IFI system, as required to meet the performance requirements. Subsurface conditions must be fully known by the IFI subcontractor and the surface of the foundation soil must be delineated either before or during installation to ensure the IFI system penetrates to or into the foundation soil layer.

References

1. Elias, V., Welsh, J., Warren, J., Lukas, R., Collin, J.G., and Berg, R.R., 2006, Ground Improvement Methods, Volumes I and II, FHWA NHI-06-019 and FHWA NHI-06-020, US Dept. of Transportation, Federal Highway Administration.

2. Geotech Tools: Geo-construction Information & Technology Selection Guidance for Geotechnical, Structural, & Pavement Engineers, http://www.geotechtools.org/.

Chronology of Changes to Design Manual Section:

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