

# ICC-ES Evaluation Report

**ESR-4415**

Reissued October 2024

Revised November 2024

Subject to renewal October 2026


This report also contains:

- [City of LA Supplement](#)

- [CA Supplement](#)

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<p><b>DIVISION: 31 00 00— EARTHWORK</b></p> <p><b>Section: 31 66 00— Special Foundations</b></p>	<p><b>REPORT HOLDER:</b></p> <p><b>KELLER NORTH AMERICA, INC.</b></p>	<p><b>EVALUATION SUBJECT:</b></p> <p><b>VIBRO PIER INTERMEDIATE FOUNDATION/SOIL REINFORCEMENT SYSTEM</b></p>	
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## 1.0 EVALUATION SCOPE

**Compliance with the following codes:**

- 2024, 2021, 2018, 2015, 2012, 2009, 2006, and 2003 [International Building Code® \(IBC\)](#)
- 2024, 2021, 2018, 2015, 2012, 2009, 2006, and 2003 [International Residential Code® \(IRC\)](#)

**Property evaluated:**

Structural

## 2.0 USES

Vibro Piers are an intermediate foundation system involving the use of aggregate piers to create a supplemental foundation system to the shallow foundations specified in 2024, 2021, 2018, 2015, 2012 and 2009 IBC Section 1809(2006 and 2003 IBC Section 1805), as applicable. The Vibro Pier intermediate foundation system is a soil reinforcement system where aggregate piers work in conjunction with the native soils to support shallow footings, reinforced concrete mat foundations, and reinforced concrete floor slabs on-grade.

When Vibro Piers are installed under the IRC, an engineered design is required in accordance with the IRC Section R301.1.3.

## 3.0 DESCRIPTION

The Vibro Pier system is constructed using a vibratory probe to compact the aggregate pier material and increase the lateral stress in the surrounding soil. The aggregate pier material is placed and compacted in lifts. The aggregate pier material can be placed into a predrilled hole, or it can be fed through a pipe and delivered directly to the aggregate pier at the tip of the vibrator. The aggregate pier material must conform to the grading requirements for coarse aggregates of ASTM C33, the requirements of ASTM D1241, or other gradation requirements approved by Keller North America, Inc.

## 4.0 DESIGN AND INSTALLATION

### 4.1 Design:

The Vibro Pier soil reinforcement system, including aggregate type and size, Vibro Pier diameter and Vibro Pier depth, must be designed for its intended use, in accordance with IBC Chapter 18, and account for the site-specific geotechnical investigation, described in Section 4.1. The design must be prepared by a registered

design professional and designed in accordance with the Design Method for Vibro Piers by Keller North America, Inc. dated April 9, 2019. Each Vibro Pier design must be approved by Keller North America, Inc.

A geotechnical investigation must be conducted and reported in accordance with 2024, 2021, 2018, 2015, 2012 and 2009 IBC Section 1803(2006 and 2003 IBC Section 1802), as applicable. At a minimum, the geotechnical investigation must address the following: soil strength, ground-water table, the effect of moisture variation on soil bearing capacity, compressibility, liquefaction and expansiveness. For structures assigned to Seismic Design Category C, D, E or F, Site Class E or F sites, the geotechnical investigation must include an evaluation of potential geologic and seismic hazards, such as liquefaction, soil instability, differential settlement and surface displacement, and provide recommended mitigation measures. Drainage, and the effects of surcharges from new site grading fill, shall be considered, when applicable.

Loading imposed on the Vibro Pier system and the corresponding induced force and deformation, must be determined using accepted structural and geotechnical engineering procedures appropriate for the soil and geometric conditions specific for the Vibro Pier system, and must address the effect of geologic and seismic hazards described in Section 4.1, and consider soil-Vibro Pier supported shallow foundation-structure interaction, when applicable.

#### 4.2 Installation:

Vibro Piers are constructed using a vibratory probe which is often simply referred to as a vibrator. The vibrator can be either electrically powered or hydraulically powered. The motor spins eccentric weights mounted on a vertical shaft to create vibrations in the horizontal direction. The vibrator can be mounted on a mast, mounted on the arm of an excavator, or hung from a crane.

Vibro Piers are constructed a) by the top-feed method (See [Figure 1](#)), b) by the bottom-feed method (See [Figure 2](#)), or c) by a combination of the top-feed and bottom-feed methods. The installation method is selected by Keller North America, Inc. based on the subsurface conditions, soil strata, groundwater elevation, and other project specific characteristics.

The top-feed method of constructing Vibro Piers involves drilling a borehole of the Vibro Pier design diameter to the design tip elevation of the Vibro Pier. The vibratory energy of the vibrator is used to compact the aggregate in the hole as additional aggregate is added in lifts. The aggregate is added at the ground surface and free-falls through the annular space between the vibrator and the sidewall of the borehole.

In the bottom-feed method of constructing Vibro Piers, the vibratory probe is used to penetrate the ground to the design Vibro Pier tip elevation. Aggregate is fed through a pipe attached alongside the vibrator. As the vibrator is lifted, aggregate exits the pipe at the tip of the vibrator and fills the space created by lifting the vibrator. The vibrator is then lowered into the aggregate pier to expand the pier diameter and compact the aggregate while displacing and/or compacting the surrounding soil. This process is repeated and controlled to build a Vibro Pier with the required diameter in accordance with the design.

Depending mainly on the soil conditions at the site, a combination of the two methods discussed above may be used to construct a Vibro Pier. In this case, the upper portion of the Vibro Pier is pre-drilled and the lower portion of the Vibro Pier is constructed using the bottom-feed method. The bottom-feed vibrator is then used to construct the remaining upper portion of the Vibro Pier.

Typical Vibro Pier installation diameters range from 24 to 36 inches (30.5 to 61 cm), and typical installation depths range from 10 to 35 feet (3 to 10.7 m). The diameter and depth of each Vibro Pier must be determined by the Vibro Pier system designer based on the geotechnical site conditions and the performance requirements of the project.

The combined effect of the Vibro Pier elements and the resulting increase in lateral stress in the native soil surrounding the Vibro Pier elements results in a reinforced zone beneath the footing that extends to the depth of the installed Vibro Piers.

Spread footings must be placed over the top of the Vibro Pier elements in accordance with Chapter 18 of the IBC. Depending on the soil conditions and the loads to be supported for the structure, Vibro Pier elements are typically designed to cover 10 to 35 percent of the area of the supported spread footing. The Vibro Pier system designer must provide the allowable design bearing pressure for the spread footings, mats, or slabs placed over the Vibro Pier reinforced soil.

Vibro Pier elements are constructed to an elevation that is 6 to 12 inches (15 to 30 cm) above the elevation of the bottom of the shallow foundations. The remaining portion of the hole above this elevation will be loosely filled to the ground surface with site soil or other suitable material.

Before placement of concrete footings, mats, or slabs over the Vibro Pier system, the soil is excavated to the appropriate elevation, and the exposed Vibro Pier elements and the bottom of the excavation are compacted with a mechanical compactor.

#### 4.3 Special Inspection:

Special inspection must be provided in accordance with 2024, 2021, 2018, 2015 and 2012 IBC Section 1705(2009, 2006 and 2003 IBC Section 1704), as applicable. The special inspector's responsibilities include, but are not limited to, review of the Vibro Pier designer's use of soil parameters as presented in the project-specific soils report; and, during construction, verification of aggregate properties, type and quantity of aggregate, pier size and depths, top elevations of constructed Vibro Pier elements, and applied compaction energy (amperage). Additionally, results of qualitative tests on production Vibro Pier elements, such as modulus testing, must be reviewed to verify compliance with the design specifications. Testing must be conducted by Keller North America, Inc. or an approved testing laboratory and the results must be approved by the code official.

### 5.0 CONDITIONS OF USE:

The Vibro Pier Intermediate Foundation Soil Reinforcement System described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1 The installation of the system must comply with this evaluation report and the Design Method for Vibro Piers by Keller North America, Inc. dated April 9, 2019.
- 5.2 The system must be installed by Keller North America, Inc. or an installer approved by Keller North America, Inc. Evidence of such approval by Keller North America, Inc. must be submitted to the code official upon request.
- 5.3 Copies of the Design Method for Vibro Piers by Keller North America, Inc. dated April 9, 2019, must be provided to the code official upon request.
- 5.4 Special inspection must be provided in accordance with Section 4.3 of this report.
- 5.5 Engineering design of the Vibro Pier system in accordance with Section 4.1 of this report, prepared by a Keller North America, Inc. authorized registered design professional, must be submitted to the code official for approval at the time of permit application. In the event of conflict between the Design Method for Vibro Piers by Keller North America, Inc. dated April 9, 2019, and this report, this report governs.

### 6.0 EVIDENCE SUBMITTED

Descriptive information and the Design Method for Vibro Piers by Keller North America, Inc., dated April 9, 2019.

### 7.0 IDENTIFICATION

- 7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4415) along with the name, registered trademark, or registered logo of the report holder must be included in the design guide.
- 7.2 In addition, the engineering design of the Vibro Pier Intermediate Foundation Soil Reinforcement System must include reference to the company name (Keller North America, Inc.), and the ICC-ES evaluation report number (ESR-4415).
- 7.3 The report holder's contact information is the following:

**KELLER NORTH AMERICA, INC.**  
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**HANOVER, MARYLAND 21076**  
**(410) 551-8200**  
[www.Keller-NA.com](http://www.Keller-NA.com)

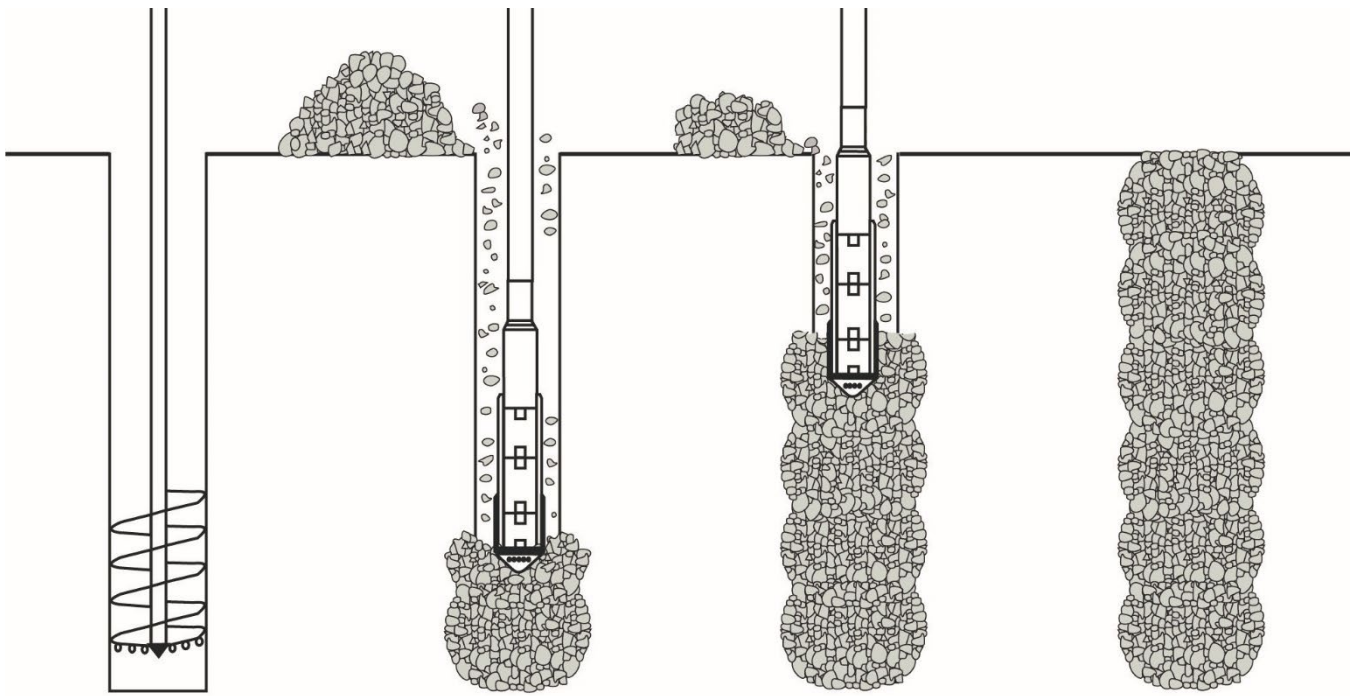


FIGURE 1—TOP-FEED VIBRO PIER CONSTRUCTION SEQUENCE

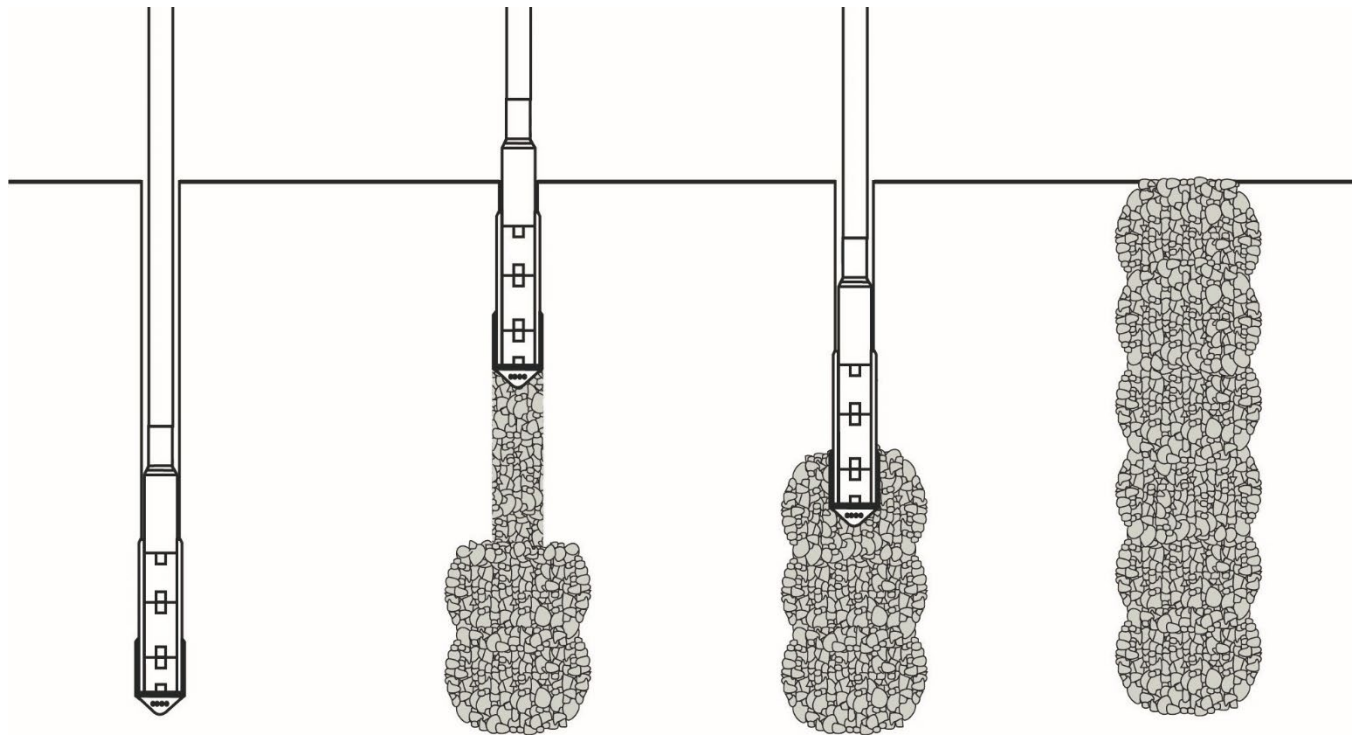


FIGURE 2—BOTTOM-FEED VIBRO PIER CONSTRUCTION SEQUENCE

DIVISION: 31 00 00—EARTHWORK  
Section: 31 66 00—Special Foundations

**REPORT HOLDER:**

KELLER NORTH AMERICA, INC.

**EVALUATION SUBJECT:**

VIBRO PIER INTERMEDIATE FOUNDATION/SOIL REINFORCEMENT SYSTEM

**1.0 REPORT PURPOSE AND SCOPE****Purpose:**

The purpose of this evaluation report supplement is to indicate that Vibro Pier Intermediate Foundation/Soil Reinforcement System, described in ICC-ES evaluation report [ESR-4415](#) has also been evaluated for compliance with the codes noted below as adopted by the Los Angeles Department of Building and Safety (LADBS).

**Applicable code editions:**

- 2023 *City of Los Angeles Building Code* ([LABC](#))
- 2023 *City of Los Angeles Residential Code* ([LARC](#))

**2.0 CONCLUSIONS**

The Vibro Pier Intermediate Foundation/Soil Reinforcement System, described in Sections 2.0 through 7.0 of the evaluation report [ESR-4415](#), complies with the LABC Chapter 18 and the LARC, and is subject to the conditions of use described in this supplement.

**3.0 CONDITIONS OF USE**

The Vibro Pier Intermediate Foundation/Soil Reinforcement System described in this evaluation report supplement must comply with all of the following conditions:

- All applicable sections in the evaluation report [ESR-4415](#).
- The design, installation, conditions of use and identification of the *Vibro Piers* are in accordance with the 2021 *International Building Code*® (IBC) provisions noted in the evaluation report [ESR-4415](#).
- The design, installation and inspection are in accordance with additional requirements of LABC Chapters 16, 17, 18 and 70 as applicable.
- The seismic design provisions for hillside buildings referenced in LABC Section 1801.1 have not been considered and are outside the scope of this supplement.
- Under the LARC, an engineered design in accordance with LARC Section R301.1.3 must be submitted.
- The aggregate pier material must comply with ASTM C33 #57 or #67, or Greenbook §200-1.4 Coarse Aggregate No. 3. No grout, concrete or alternative aggregates may be used.
- In addition to the soils report requirements indicated under Section 4.1 of the evaluation report ESR-4415, the soils report shall contain:
  - a. Engineering design of the Vibro Piers, including bearing capacity and settlement analysis with and without Vibro Piers, design calculations, range of pier diameters and depths, and acceptable aggregate types and size specifications.



- b. Requirements for indicator “Modulus Tests” (MT) program, and other field-testing methods and procedures.
- c. The location of the proposed MT, test pier dimensions, acceptable methods of installation and approval criteria.
- The Vibro Pier shall be located a minimum distance of 8 feet from adjacent property line to the perimeter of the pier. Excavations closer than 8 feet to the perimeter of the Vibro Pier shall be evaluated to determine the effect on the Vibro Pier.
- A minimum safety factor of 2.0 for the Vibro Pier capacity shall be demonstrated in the design calculations and verified by the MT.
- Settlement of pier group shall be evaluated based on the guidelines provided in the “Design Method for Vibro Piers” by Keller dated April 9, 2019.
- The static and seismic Soil-Vibro Pier supported shallow foundation-structure interaction should be analyzed when requested by the GEOR or the LADBS-Grading Division. A peer review will be required to evaluate the adequacy of the model and the results. The peer review panel will evaluate the method(s) of analyses.
- Full scale load testing and/or finite element analysis (FEA) may be required for major projects, as per the recommendation of the GEOR or as determined by LADBS-Grading Division.
- A preliminary soils report approval letter will be issued by the LADBS-Grading Division to conduct the MT.
- An initial grading permit shall be obtained for conducting the pre-production field testing (the permit will be classified as soil improvement that consists of removal and recompaction of earth materials)
- At least one (1) Vibro Pier, Modulus Test (MT) per every 500 piers constructed up to 1500 piers, and then one (1) test per every 1000 piers thereafter, shall be installed and tested to verify the installation methods, soil conditions, etc. The tested Vibro Pier shall be installed such that the testing conditions match the proposed conditions (i.e., top and tip Vibro Pier elevations, overburden pressures, etc. are the same for the test and production Vibro Piers)
- The maximum load applied during the modulus load test shall equal to 200% of the maximum design stress. Loading procedure B (Maintained Test) of ASTM D1143 is required.
- The load test evaluation method shall satisfy a deflection criteria established by the project specifications. In the absence of an over-riding criteria, use 1-inch deflection or less at 200% the design load. The project specifications shall not specify a deflection criteria of more than 1 inch deflection at 200% the design load
- The MT results shall be reviewed by the GEOR who shall write a letter of acceptance or rejection that shall be submitted to the City.
- The Department will review the GEOR letter and consider all aspects related to the field testing before approval.
- Vibro Pier production installation must not proceed until the pre-production report containing the MT results is submitted and approved.
- A final grading permit shall be obtained for installation of the production Vibro Piers.
- During Vibro Pier installation:
  - a. An appropriate metering device should be provided at a location that inspection of amperage increase may be verified during the operation of the equipment. The metering device may be an ammeter directly indicating the performance of the vibrator tip.
  - b. The vibrator shall be capable of providing at least 80 HP of rated energy and a centrifugal force of 15 tons. The free hanging amperage shall range between 70 and 140 amps.
  - c. The measured current consumption shall be greater than or equal to a 10% increase of the depth vibrator’s free hanging amperage. The 10% increase shall occur at a maximum spacing of 3 ft. If these criteria are not met, the vibro pier shall be reinstalled.
  - d. A data acquisition system (DAQ) or a Field Quality Control Representative (FQCR) shall provide site documentation to ensure performance and consistency of the aggregate pier work. This inspection shall include the recording of the minimum and maximum amperage for every vibro pier.
  - e. When a vibro pier diameter is less than 90% of design diameter pier, the pier shall be either re-installed or (an) additional pier(s) shall be installed as determined by the design engineer.
  - f. The vibro pier stiffness shall be verified by the modulus test. In production, Vibro Piers shall be installed in the same way as the modulus test pier(s), as follows.
    - i. Vibro piers shall be laid out like MT Pier.
    - ii. If a predrill rig is being used, same predrill diameter shall be employed.
    - iii. Recorded amperages should be similar to the MT Pier and should follow the criteria shown on item (c) under the same bullet point.
    - iv. Diameter of the production pier should not be less than 90% of the MT pier diameter.

- The engineering design shall be prepared and sealed by a licensed engineer registered in the State of California.
- The GEOR shall review and approve the detailed Vibro Pier plans prior to issuance of any permits. This approval shall be by signature on the plans that clearly indicates the GEOR has reviewed the plans prepared by the design engineer; and, that the plans include the recommendations contained in their reports (Section 7006.1 of the 2023 Los Angeles Building Code).
- The use of Vibro Piers to increase bearing capacity and reduce settlement on uncertified fill is beyond the scope of this approval.
- The use of Vibro Piers to resist tensile forces is beyond the scope of this approval.
- The use of Vibro Piers to be used in slope stabilization is beyond the scope of this approval.

This supplement expires concurrently with the evaluation report, reissued October 2024 and revised November 2024.

**DIVISION: 31 00 00—EARTHWORK**  
**Section: 31 66 00—Special Foundations**

**REPORT HOLDER:**

**KELLER NORTH AMERICA, INC.**

**EVALUATION SUBJECT:**

**VIBRO PIER INTERMEDIATE FOUNDATION/SOIL REINFORCEMENT SYSTEM**

**1.0 REPORT PURPOSE AND SCOPE****Purpose:**

The purpose of this evaluation report supplement is to indicate that Vibro Pier Intermediate Foundation/Soil Reinforcement System, described in ICC-ES evaluation report ESR-4415, has also been evaluated for compliance with the codes noted below.

**Applicable code editions:**

- 2022 *California Building Code* (CBC)

For evaluation of applicable chapters adopted by the California Office of Statewide Health Planning and Development (OSHPD) AKA: California Department of Health Care Access and Information (HCAI) and the Division of State Architect (DSA), see Sections 2.1.1 and 2.1.2 below.

- 2022 *California Residential Code* (CRC)

**2.0 CONCLUSIONS****2.1 CBC:**

The Vibro Pier Intermediate Foundation/Soil Reinforcement System, described in Sections 2.0 through 7.0 of the evaluation report ESR-4415, complies with CBC Chapter 18, provided the design and installation are in accordance with the 2021 *International Building Code*® (IBC) provisions noted in the evaluation report and the additional requirements of CBC Chapters 16, 17 and 18, as applicable.

**2.1.1 OSHPD:** The applicable OSHPD Sections and Chapters of the CBC are beyond the scope of this supplement.

**2.1.2 DSA:** The applicable DSA Sections and Chapters of the CBC are beyond the scope of this supplement.

**2.2 CRC:**

The Vibro Pier Intermediate Foundation/Soil Reinforcement System, described in Sections 2.0 through 7.0 of the evaluation report ESR-4415, complies with CRC Chapter 3, provided the design and installation are in accordance with the 2021 *International Residential Code*® (IRC) provisions noted in the evaluation report.

This supplement expires concurrently with the evaluation report, reissued October 2024 and revised November 2024.