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**NOTE TO DESIGNERS:**

The following section is “non-standard”. It shall be numbered consecutively in the supplementary specifications starting with number 428 regardless of the number shown. For example, if you want to use section 432 - Mechanically Stabilized Earth (MSE) Walls, but no other non-standard section, it shall be renumbered 428. If another non-standard section is required, it shall be numbered 429, ff.

Designers shall consult the New Jersey Turnpike Procedures and Design Manuals for parameters for site investigation, geotechnical and structure design and plan presentation and vendor coordination requirements for Mechanically Stabilized Earth (MSE) Walls.

Designers shall select wall systems to be included in this contract from the list of systems in Section 432.02 (A) hereinafter. Only wall systems participating in the design consultation as described in the Procedures Manual shall be included in the contract.

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**SECTION 432 - MECHANICALLY STABILIZED EARTH (MSE) WALLS**

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**432.01      DESCRIPTION**

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This work shall include the design and construction of mechanically stabilized earth (MSE) wall structures composed of precast concrete facing panels, cast-in-place and/or precast parapets, moment slabs, copings, concrete leveling pads, soil reinforcement elements, joint materials, fasteners, Select Backfill, and all other appurtenant items of construction within the Common Structure Volume as shown on the Plans, included as part of the selected MSE Wall System, or as specified herein.

Design and construction of MSE walls shall be in accordance with AASHTO LRFD Design and Construction Specifications with modifications herein and in accordance with the NJTA Design Manual wherein:

- Load Factor Design (LFD): Internal Strength and Stability for Barrier Parapet and Moment Slab System
- Allowable Stress Design (ASD): External Stability for Moment Slab and Leveling Pad.

All labor, materials, equipment, and tools as required to prepare the site, construct the leveling pad, construct the wall, place and compact the Select Backfill, and construct the coping and traffic barrier shall be supplied by the Contractor.

Where an MSE wall is constructed supporting a roadway that will be subjected to chemical deicing, installation of a High Density Polyethylene (HDPE) geo-membrane liner system, as shown on the Plans and specified in 432.02(C), shall be included. All labor, materials, transportation, handling, storage, supervision, tools and other equipment that may be necessary to install and test the HDPE liner system shall be included.

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**432.02      MATERIALS**

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Materials shall conform to the current editions of AASHTO LRFD Bridge Design Specifications with Interims and AASHTO LRFD Bridge Construction Specifications with

Interims with modifications herein and the provisions of the wall system selected for construction in this contract.

Bearing pads shall conform to the requirements of the wall manufacturer.

Filter fabric shall conform with Subsection 923.21.

Where select backfill may be inundated with chemically aggressive tidal, flood or ground water, the use of soil reinforcements of stainless steel Grade 316L may be considered. In such a case, minimum corrosion rates shall be 0.5 mil/year for the first 10 years and 0.2 mil/year for subsequent years. The wall system supplier shall make recommendations regarding the corrosion rates that shall provide the required 75 or 100 year service life. The determination of corrosion rates shall be based on data presented in the most recent edition of "Underground Corrosion", by Melvin Romanoff.

**(A) MSE Wall Systems**

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The following MSE Wall Systems are permissible for use in this Contract:

Reinforced Earth as manufactured by  
Reinforced Earth Company  
8614 Westwood Center Drive, Suite 1100  
Vienna, VA 22182-2233  
Telephone Number: 703-749-9246

Retained Earth as manufactured by  
Reinforced Earth Company  
8614 Westwood Center Drive, Suite 1100  
Vienna, VA 22182-2233  
Telephone Number: 703-749-9246

SSL MSE Plus Retaining Wall System as manufactured by  
SSL  
4740 Scotts Valley Drive, Suite E  
Scotts Valley, CA 95066  
Telephone Number: 831-430-9300  
Fax Number: 831-430-9340

Isogrid Retaining Wall System as manufactured by  
The Neel Company  
8328-D Traford Lane  
Springfield, VA 22152  
Telephone Number: 703-913-7858

Tricon Retained Soil Wall System  
Tricon Precast, Ltd.  
Main Office

15505 Henry Rd.  
Houston, Tx 77060  
Info@Triconprecast.Com  
281-931-9832 Office  
281-931-0061 Fax  
877-387-4266 Toll Free

Earth Tec Retaining Wall System  
EarthTec, Inc.  
413 Browning Court  
Purcellville, VA 20132  
703-771-7305 (tel)  
703-771-7306 (fax)

Selection of only one (1) wall system will be permitted for use on this Contract. The Contractor shall make its own arrangements to purchase the materials and services from one of the manufacturers of a permissible MSE Wall Systems listed herein.

An on-site technical representative from the selected MSE Wall Systems manufacturer shall be present to assist and instruct during the installation of the first two-panel courses, as a minimum.

Except as may be modified within this Section, all applicable provisions of Sections 400 and 900 shall apply in furnishing MSE Wall Systems.

**(B) Select Backfill Material**

Unless otherwise noted on the Plans, Select Backfill conforming to the requirements herein shall be used within the Common Structure Volume as shown on the Plans and specified in Subsection 432.06 and may be procured from off-site sources or from on-site borrow excavation.

Select Backfill used in the MSE Common Structure Volume shall be reasonably free from deleterious materials, shale or poor durability particles and shall conform to the following gradation limits as determined by AASHTO T 27:

<b>Sieve Size</b>	<b>Percent Passing</b>
4 inches	100
¾ inch	30-100
No. 4	5-85
No. 40	0-60
No. 200	0-10

Material that is composed primarily of gravel (material having less than 40 percent passing a ¾ in sieve) should be considered to be a coarse backfill. When such material is used, a Class 1 high survivability geotextile filter, in accordance with AASHTO M 288 designed for filtration performance following the guidelines in FHWA NHI-07-092 (Holtz et al., 2008), should encapsulate the coarse graded backfill to within 3 ft (1 m) below the wall coping. Adjoining sections of separation fabric should be overlapped by a minimum of 12 in. (0.30 m). Additionally, the upper 3 ft (1 m) of fill should contain no

stones greater than 3 in. (75 mm) in their greatest dimension, and should be composed of material not considered to be gravel backfill, as defined herein.

Recycled concrete shall not be permitted to be used as select backfill material.

Select Backfill shall meet the following electrochemical limits:

Property	Standard	Test Procedure
Resistivity, $\Omega$ - cm	Greater than 3,000 at 100% saturation	AASHTO T 288
PH	Acceptable Range of 5 - 10	AASHTO T 289
Organic Content	1.00% Maximum	AASHTO T 267
Chloride	Less than 100 ppm	AASHTO T 291 or ASTM D 4327
Sulfates	Less than 200 ppm	AASHTO T 290 or ASTM D 4327
Magnesium Sulfate Loss	Less than 30% after 4 Cycles	AASHTO T 104
Sodium Sulfate Loss	Less than 15% after 5 Cycles	AASHTO T 104

Prior to any construction (Preconstruction), the Contractor shall take the specified number of test samples from all proposed Select Backfill material sources and submit the results to the Engineer for review and approval. For the design of the wall including soil reinforcing elements, the wall system supplier shall use:

- the friction angle determined from test results
- an appropriate unit weight
- the electrochemical limits for select backfill specified herein

No materials shall be delivered to the site until approved by the Engineer.

Test sampling shall be performed throughout the course of the MSE wall construction (During Construction) as materials are delivered to the site and at the prescribed rates. Except as noted below, sample tests that fail to meet the specified requirements may be repeated at the Contractor's option. Repeated sample tests shall be averaged with the failing sample test to determine the final tested soil properties. A maximum of two (2) repeated sample tests will be permitted.

The frequency of sampling and testing shall be performed as described below for all limits noted above. A minimum of two samples per structure shall be taken.

Additional samples shall be taken whenever the appearance or behavior of the Select Backfill changes and as directed by the Engineer.

Select Backfill Test Sampling Frequency:

Range of Resistivity ( $\Omega$ -cm)	General Description	Pre-construction	During Construction	Comments
		No. Samples	Sample Interval (yd <sup>3</sup> )	

>10,000	Crushed rock and Gravel <10% passing No. 10 sieve	1/3 <sup>1</sup>	4000 / 2000 <sup>1</sup>	A. pH outside the specified limits is not allowed for any sample.  B. Backfill sources shall be rejected if resistivity measured for any one sample is less than 700 Ω-cm, chloride content > 500 ppm or sulfate content > 1000 ppm.  C. For materials with resistivity <5000 Ω-cm, Chloride and Sulfate testing requirements shall apply.
5,000 to 10,000	Sandy Gravel and Sands	3/6 <sup>1</sup>	4000 / 2000 <sup>1</sup>	
<5,000	Silty sands and Clayey sands screenings	5/10 <sup>1</sup>	2000 / 1000 <sup>1</sup>	
<sup>1</sup> # resistivity tests / # tests for pH, Cl <sup>-</sup> , and SO <sub>4</sub>				

If the resistivity is greater or equal to 5,000 ohm-cm the chloride and sulfates requirements may be waived.

The angle of internal friction for the Select Backfill, as determined by the direct shear test in accordance with AASHTO T 236 or the tri-axial compression test in accordance with AASHTO T 234-85, shall not be less than 30 degrees.

Where greater than 75% of the particles of the Select Backfill are retained on the 3/4" sieve, the direct shear and tri-axial compression test requirements may be waived in lieu of an assumed 34 degree soil angle of internal friction.

The Plasticity Index (PI) of the Select Backfill, as determined by AASHTO T 90 shall not exceed 6.

AASHTO T-267 shall report the organic content as a percent by weight of the total soil fraction and not only what is passing the number 10 sieve. Organic content of select backfill shall be limited to 1 percent by weight of the total soil fraction.

ASTM G187 may be substituted for AASHTO T 288 in instances where insufficient material passing the number 10 sieve is present. This test shall be completed on materials passing the number 4 sieve with an appropriately sized resistivity box utilized.

The Contractor shall furnish to the Engineer a Certificate of Compliance certifying that the Select Backfill complies with this Subsection prior to the installation of the wall.

A copy of all test results performed by the Contractor's Testing Agency which are necessary to ensure compliance with these Specifications shall also be furnished prior to delivery and placement of the select backfill.

#### **(C) High Density Polyethylene (HDPE)**

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HDPE geo-membrane liner systems shall have a nominal thickness of 30 mils. The geo-membrane shall be manufactured of new, first quality resin and shall be

compounded and manufactured specifically for the intended purpose. The resin manufacturer shall certify each batch for the following properties:

Property	Test Method	Requirements
Specific Gravity	ASTM D 792	> 0.940
Melt Index	ASTM D 1238	< 0.4g/10 min.
Carbon Black Content	ASTM D 1603	2% - 3%

The HDPE supplier shall submit this certification for the Engineer's verification of the material.

The surface of the HDPE geo-membrane liner system shall not have striations, roughness, pinholes or bubbles and shall be free of holes, blisters and any foreign matter, such as soil or oil accumulation.

## **432.03 METHODS OF CONSTRUCTION**

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Methods of construction shall conform to the current editions of AASHTO LRFD Bridge Design Specifications with Interims and AASHTO LRFD Bridge Construction Specifications with Interims with modifications herein and the provisions of the permitted wall system selected for construction in this contract.

### **(A) Precast Panel Unit Production/Tolerances**

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All units shall be manufactured within the following tolerances:

- (1) All dimensions within 3/16 inch.
- (2) Deviation from vertical or horizontal, 1/8 inch per 5 feet.

Units shall be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects as assessed by the Engineer shall be sufficient cause for rejection:

- (1) Defects that indicate imperfect molding.
- (2) Defects indicating honeycombed or open texture concrete.
- (3) Defects in the physical characteristics of the concrete units, such as:
  - (a) Stained front face due to excess form oil or other reasons.
  - (b) Signs of aggregate segregation.
  - (c) Broken or cracked corners.
  - (d) Tie strips bent or damaged.
  - (e) Lifting inserts not usable.
  - (f) Exposed reinforcing steel.
  - (g) Cracks at the PVC pipe or pin.
  - (h) Insufficient concrete compressive strength.
  - (i) Panel thickness in excess of 3/16 inch from that shown on the plans.
  - (j) Deviation from flatness of exposed surface in excess of 1/8 inch per 5 feet

An additional inspection shall be made prior to erection to determine any damage which may have occurred during storage.

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if allowed, shall be done in a manner satisfactory to the Engineer at no additional cost to the Authority.

Repair to concrete surfaces which will be exposed to view after completion or construction shall be approved.

#### **(B) Wall Construction/Tolerances**

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Finished MSE walls shall be erected within the following tolerances:

1. The overall vertical alignment tolerance, or plumbness, from top to bottom of the structure, shall not exceed 1/2 inch per 10 foot of wall height.
2. Deviation from horizontal alignment shall not exceed 3/4 inch.
3. Vertical and horizontal alignment tolerance, or plumbness, shall not exceed 3/4 in. when measured with a 10 ft. straight edge on a selected wall section.
4. The maximum allowable offset between any two panels shall not exceed 3/4 inch.

Soil reinforcement shall be uniformly tensioned to remove any slack in the material or in the connections to the facing panels. Where an individual soil reinforcement element has multiple connections to a facing panel, a minimum of two connections per layer per panel shall be in full contact upon tensioning the element with maximum gaps of 1/16 inch at remaining connections.

The compacted density of the Select Backfill shall be determined by taking one test series for each half height of wall panel of elevation, to a maximum of 3 feet, placed in accordance with AASHTO T310 Method B. Select Backfill shall be compacted to a minimum of 95% maximum density or greater if specified by the MSE wall system manufacturer. Optimum Select Backfill moisture content to achieve minimum required compacted soil density shall be as determined by AASHTO T99.

The specified compaction of the Select Backfill shall be accomplished by use of large, smooth drum, vibratory rollers with the exception of the 5 foot zone directly behind the facing panels. No sheepsfoot rollers shall be used.

Within the 5 foot zone, small, single or double drum, hand operated, walk-behind vibratory rollers, or walk-behind vibrating plate compactors shall be used, and at least three passes shall be made.

When there is evidence of wall displacement or disturbance, compaction shall be accomplished by use of a smooth drum static roller.

The compaction equipment shall be capable of providing uniform density throughout the depth of the layer of the Select Backfill being compacted with no disturbance to the vertical or horizontal alignments of the previously placed panels.

#### **(C) High Density Polyethylene (HDPE) Construction**

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Before liner installation, it shall be assured that the area that is to be lined shall be smooth and free of sharp objects or debris of any kind. Atmospheric exposure of geo-membrane to the elements following lay down shall be a maximum of fourteen

(14) days. The Contractor shall install HDPE geo-membrane liner free of holes and tears.

The HDPE shall be placed below the pavement, above the first row of reinforcements and over the parapet moment slab (where present) and over specified areas as shown on the plans. The HDPE shall be sloped to drain away from the facing panels.

HDPE shall not be installed during periods of precipitation or in conditions of excessive moisture such as fog or dew in accordance with the HDPE manufacturers recommendations and as approved by the Engineer.

All seams of the HDPE geo-membrane liner system shall be, as per the manufacturer's specifications, sealed or overlapped to prevent leakage. Seams shall be oriented parallel to the line of maximum slope. Seams shall have a minimum finished overlap of 4 inches unless a greater overlap is specified by the HDPE manufacturer.

Field testing of seams, according to the manufacturer's specifications, shall be conducted to verify satisfactory seaming conditions.

When backfilling, care shall be taken to prevent damage to the HDPE system. Any tears, punctures or holes incurred during the installation process shall be assessed by the Engineer and the membrane shall either be repaired in accordance with recommendations of the membrane manufacturer or replaced at the Engineer's discretion at no additional cost to the Authority.

Perforations through the liner shall be limited. Where penetrations are necessary, the Contractor shall provide details demonstrating the method(s) of sealing the penetration for approval by the Engineer.

#### **(D) Construction Stormwater Management**

At the end of each construction period, the Contractor shall slope the last placed level of backfill away from the wall facing to direct runoff or rainwater away from the wall face. Surface runoff shall not be allowed to enter the wall construction site from adjacent areas.

## **432.04**

### **WORKING DRAWINGS**

Working drawings shall be prepared and submitted in accordance with the requirements specified under Subsection 104.08. The Common Structure Volume shown on the Plans is anticipated to envelop the majority of potential wall system reinforced earth volume requirements. However, should the limits of structure volume for the proposed wall system extend beyond the limits of the Common Structure Volume, the wall system shall be submitted as a Substitution in accordance with subsection 432.05. The Substitution must be approved prior to submitting working drawings. At a minimum, working drawings shall include the following:

- (A) Design calculations, signed and sealed by a Professional Engineer licensed in the State of New Jersey, in conformance with current edition of AASHTO LRFD Bridge Design and Construction Specifications with Interims and modifications herein and the provisions of the approved wall system selected for construction in this contract. MSE



walls shall be designed for a minimum 75 year design life. MSE walls which support embankments under bridge abutments shall be designed for a 100 year design life.

- (B) General notes, design parameters, soil characteristics of Select Backfill, and factors of safety and/or load and resistance factors.
- (C) An elevation view of the wall showing:
  - (1) Elevations along the top of the wall, at beginning and end of wall, at 25 foot intervals, at changes in grade, at changes in Common Structure Volume limits; and at precast panel unit joints where indicative of wall geometry.
  - (2) Elevations and step locations for leveling pads and/or footings.
  - (3) The location of the final ground line.
  - (4) Number and type of precast panel units.
  - (5) A numbered panel layout for fabrication and erection purposes.
  - (6) Designation of breaks in vertical alignments and elevations.
  - (7) Locations and elevations/inverts of any utilities or drainage which passes through the retaining wall or the Common Structure Volume.
- (D) A plan view of the wall showing:
  - (1) The offset from the construction baseline to the face of precast wall units at all changes in horizontal alignment.
  - (2) ROW limits and their relationship to the wall with offsets and stations to wall corners and ends.
  - (3) Locations of piles, drilled shafts, noise walls, sign structures, or other appurtenant items which are supported by the wall or its parapet/coping.
  - (4) Locations and alignments of any utilities or drainage which passes through the retaining wall or the Common Structure Volume.
  - (5) The offset from the construction baseline to limits of Common Structure Volumes at all changes in horizontal alignment and offsets of CSV limits.
- (E) Typical sections of walls showing:
  - (1) Limits of cut and fill work.
  - (2) Limits of Select Backfill, retained backfill behind the Common Structure Volume, and drainage materials.
  - (3) Limits of Common Structure Volume and associated appurtenant items such as drainage features and soil reinforcing elements.
  - (4) Location of final ground lines.
- (F) Precast panel unit details for all panel types, including non standard panels, with all dimensions necessary to construct the panels with locations in the member of all appurtenant items such as reinforcement steel, soil reinforcing element attachment points, and lifting devices.
- (G) Details for footings, leveling pads and footing or leveling pad step details, where required.
- (H) Details for precast barriers, copings, connections to all appurtenant items such as railings, fences, lighting standards, and noise barriers.
- (I) Details for wall construction and soil reinforcing element placement to accommodate any obstructions such as piles, drilled shafts, utilities, acute corners, slip joints, highway lighting systems, drainage structures and any other obstructions.
- (J) Details for any cast in place elements with all dimensions necessary to construct the elements with locations in the member of all appurtenant items such as reinforcement steel.
- (K) Detail for any architectural treatments such as facing finish, texture, and color.
- (L) The manufacturer's installation manual including sequence of construction. Two bound copies of the approved manual shall be furnished to the Engineer.

**432.05****SUBSTITUTIONS**

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Wherever requirements for wall components, proprietary components, or methods of construction are specified, it is intended to establish a standard of quality and shall not be interpreted to preclude substitutions by Contractors subject to conditions given hereinafter.

Substitution will be considered when such proposed substitution equals or exceeds that specified with respect to quality, workmanship, service, maintenance, economy, reliability of operation, code compliance, and aesthetics.

When the Contractor requests substitution, it shall first thoroughly investigate its proposed substitution and certify to the Engineer, in writing, that said proposed substitution is equal to that specified. It shall include with said certification all required data, samples, reports and tests to substantiate its findings. The Engineer will decide if such substitution is equal to that specified; and if found to be so, may then approve the substitution. The Engineer's decision will be final and binding to all parties.

Where proposed substitution requires modifications to the Common Structure Volume shown on the Plans or the selected wall system extends beyond the limits of the Common Structure Volume shown on the Plans, the Contractor shall quantify all impacts and adjustments to affected item quantities such as but not limited to excavation, backfill, and sheeting and the Project schedule as a part of its substitution request. Additional costs which arise from quantity or schedule impacts of the substitution shall be borne solely by the Contractor. Approval of the disposition of the pay limits and quantities to accommodate the substitution shall be part and parcel to the approval of the substitution.

Approved substitutions shall be at no additional cost to the Authority. Rejection of a requested substitution shall not be considered as a basis for a claim against the Authority.

**432.06****MEASUREMENT**

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Mechanically Stabilized Earth Walls will be measured by the total number of square feet of retaining wall face area. The area measured will be the product of the average vertical height between final rear face and front face ground lines and the total lengths of the wall as given on the Plans. Within the Common Structure Volume or except as may otherwise be provided for, no quantity other than the square foot wall area as defined above will be measured for payment.

Common Structure Volume

The Common Structure Volume (CSV) is the volume that contains all components of all retaining wall systems considered for construction at a given site. The limits of the CSV are defined as:

- End Limit Planes: Vertical planes, normal or radial to the wall alignment, at begin and end stations of the wall system.
- Forward Limit Plane: Vertical plane(s) two feet or other designated distance shown on the Plans forward of the fascia. The fascia is defined as the forward limit of wall coping or barrier parapet face, wall panel or unit face or other physical feature as shown on the plans

- Rear Limit Plane: Vertical plane(s) at the rear limits of the Select Backfill. For the purposes of defining the CSV, this limit will be located parallel to the Forward Limit Plane and at minimum distance of 70% of the average vertical dimension between the Bottom Limit Plane and the Top Limit Plane, plus one (1) foot and will include any porous fill, all wall appurtenances such as drainage systems, pertinent retained fill and any work to be included in the wall pay item.
- Bottom Limit Plane: Horizontal Plane(s) at the lower elevations of the wall to include the leveling pad(s)/footing(s), the undersides of the select backfill or modular units and excavations required for the construction of the select backfill or modular units, extending between the Forward and Rear Limit Planes of the CSV.
- Top Limit Plane: Plane(s) defining the configuration (slope, roadway, pavement box, etc) at the top of the wall extending between the forward and rear limits of the CSV. Where finished grade of an MSE wall is defined by a pavement system, the CSV Top Limit Plane shall be defined as the underside of the pavement system subgrade material as noted in the Plans.

Unless otherwise noted in the Plans or Specifications, all components of the wall system and all components, elements or appurtenances, such as copings, parapets, barriers, moment slabs, wall underdrains, geo-membrane liner systems, etc., founded on or located within the CSV or attached to any component of the wall system within the CSV shall be included in the CSV.

#### 432.07

#### PAYMENT

Payment will be made under:

<i><u>PAY ITEM</u></i>	<i><u>PAY UNIT</u></i>
Mechanically Stabilized Earth Walls.....	Square Foot

No additional payment will be made for Substitutions under Subsection 432.05.

No additional payment will be made for costs resulting from submission, approval or rejection of Substitutions under Subsection 432.05.

Payment for electrical items will be made in accordance with Division 600 unless otherwise noted on the Plans.