

**Field**

**Installation Manual**

**For**

**KeySystem™ I**

**Highway and Heavy Construction**

**Retaining Wall System**

**Using**

**Inextensible Reinforcing**

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# TABLE OF CONTENTS

<b>I. PURPOSE</b>	<b>1</b>
<b>II. RESPONSIBILITIES FOR CONSTRUCTION COMPLIANCE</b>	<b>1</b>
<i>A) Contractor</i>	<i>1</i>
<i>B) Engineer or Owner's Representative</i>	<i>1</i>
<i>C) Keystone Technical Representative</i>	<i>1</i>
<b>III. MATERIALS, HANDLING, EQUIPMENT AND SUPPLIES:</b>	<b>2</b>
<i>A) KeySystem I Supplied Materials and Accessories</i>	<i>2</i>
<i>B) Handling KeySystem I Materials</i>	<i>3</i>
<i>C) Contractor Supplied Materials</i>	<i>3</i>
<b>IV. PREPARATORY WORK FOR WALL CONSTRUCTION</b>	<b>4</b>
<i>A) Preconstruction Checklist.</i>	
<i>B) Review drawings to plan leveling pad and reinforcement layout.</i>	<i>4</i>
<i>C) Wall Excavation</i>	<i>4</i>
<i>D) Foundation Preparation</i>	<i>5</i>
<b>V. WALL CONSTRUCTION</b>	<b>5</b>
<i>A) First Course of KeySystem™ Units</i>	<i>5</i>
<i>B) Unit, Reinforcement, and Backfill Placement</i>	<i>6</i>
<i>C) Wall Cap and Coping Installation</i>	<i>9</i>
<i>D) Clean Area and Remove or Dispose of Any:</i>	<i>9</i>
<b>VI. EFFECTS AND CAUSES</b>	<b>10</b>
<b>VII. GLOSSARY</b>	<b>11</b>

## List of Figures

Figure 1: KeyStrip Materials	2
Figure 2: Leveling Pad Construction	5
Figure 3: First Course Placement	6
Figure 4: Unit Placement	6
Figure 5: Running Bond Placement	6
Figure 6: KeyStrip Placement, Side View	7
Figure 7: Keystrip Placement	8
Figure 8: Barrier Detail	9

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# I. Purpose

This manual provides installation procedures and guidelines for the KeySystem™ I retaining wall system. The system is specifically designed for use in the highway and heavy construction industries, and uses inextensible (metallic) soil reinforcement with KeyStone™ units engineered to accept this type of reinforcing.

KeySystem I retaining walls are designed, supplied and technically supported by KeyStone Retaining Wall Systems, Inc. and its worldwide network of licensees. When KeySystem I is specified, a complete retaining wall system is engineered and supplied to meet site specific conditions. Through local licensees, KeyStone furnishes designs, materials and can suggest local experienced installation contractors. KeyStone also provides on-site start up assistance and training for the contractor and agency inspectors. Additional support is available upon request.

## II. Responsibilities for Construction Compliance

### A) Contractor

- 1) The contractor is responsible for providing construction in accordance with the contract documents, plans and specifications<sup>1</sup>. The contractor, at a minimum, is responsible for:
  - a) verification of line and grade, and other physical features;
  - b) verification that the latest issue of approved plans and specifications for construction are being used; and
  - c) verification that the correct materials are delivered and in sufficient quantity to complete the work.

### B) Engineer or Owner's Representative

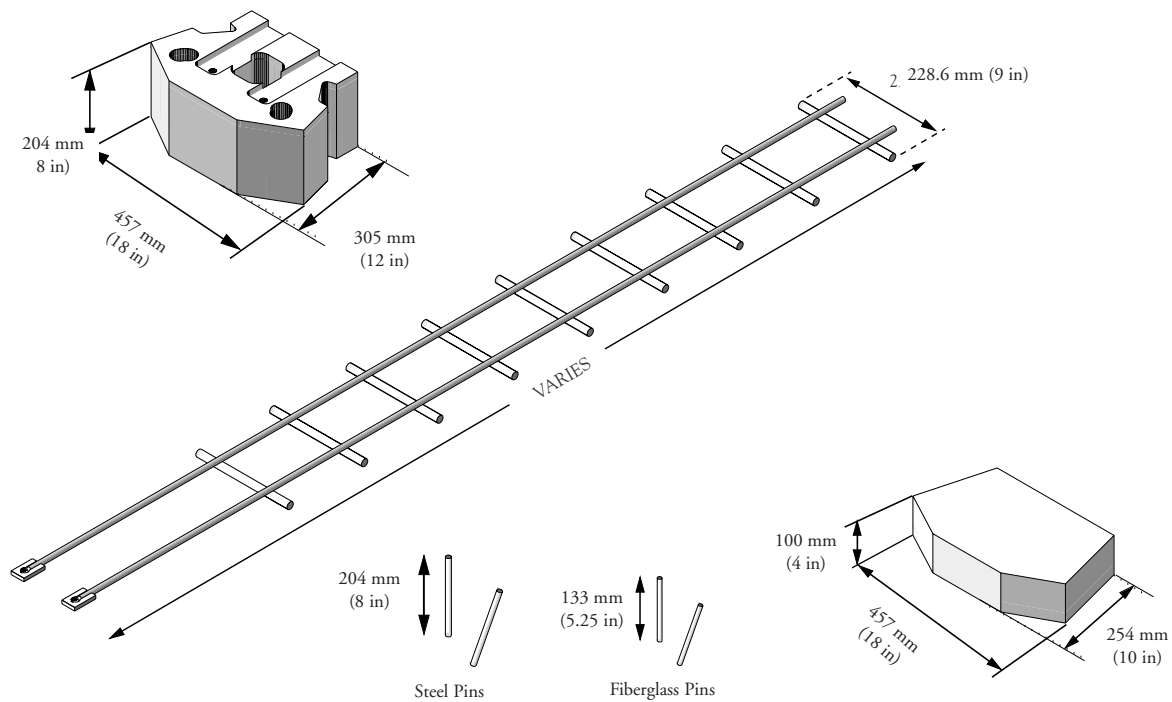
The engineer or Owner's designated representative is responsible for the enforcement of the contract documents, plans and specifications.

### C) Keystone Technical Representative

KeySystem technical representatives may assist the contractor in scheduling material deliveries and advising the contractor and inspection staff on recommended construction procedures within the guidelines of this manual, contract documents, plans and specifications. The representatives are available at the start of the wall construction for assistance and training of the contractor and agency inspectors, and thereafter, only as requested and necessary.

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<sup>1</sup> In the event of a conflict between the plans, specifications and contract documents and this manual, the contract documents shall govern.



**Figure 1: KeyStrip Materials**

## III. Materials, Handling, Equipment and Supplies:

### A) KeySystem I Supplied Materials and Accessories

- 1) **KeySystem Units** - Engineered units are of two types.
  - a) The KeySystem I unit is:
    - 204 mm (8 in) high
    - 457 mm (18 in) wide
    - 305 mm (12 in) deep.
  - b) The **Cap unit** is:
    - either 204 mm (8 in), or 102 mm (4 in) high
    - 457 mm (18 in) wide
    - 254 mm (10 in) deep
- 2) **KeyStone Connection and Alignment Pins** - Connection pins are galvanized steel, 14 mm (9/16 in) diameter x 204 mm (8 in) long. Alignment pins are pultruded fiberglass, 12 mm (1/2 in) diameter x 133 mm (5 1/4 in) long.
- 3) **KeyStrip Reinforcement Elements** - KeyStrips are galvanized, welded wire pieces 229 mm (9 in) wide and vary in length depending upon design requirements.

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## B) Handling KeySystem I Materials

- 1) KeySystem Units are delivered on pallets to be unloaded and stored by the contractor. The transport unit must have firm ground upon which to travel and the pallets must be placed on a reasonably level and stable base. Pallets can be handled by forklifts or properly rigged double slings. Empty pallets should be stored by the contractor for pickup by the KeyStone supplier.
- 2) The Connection and Alignment Pins are delivered with the KeyStone Engineered Units. These pins should be stored in a secure, dry location to avoid loss, theft or damage.
- 3) The KeyStrip Reinforcing Elements are bundled by type and can weigh up to 1fi tons. Bundles should be handled by a spreader bar capable of reaching the first and third quarter points. Care should be taken not to bend the KeyStrips or damage the zinc coating during unloading or later during placement. Any damaged KeyStrips shall be repaired to the satisfaction of the engineer with zinc rich paint.
- 4) Additional information and guidance:
  - a) It is the contractor's responsibility to verify the quantities and general condition of the materials before accepting delivery. The contractor shall immediately notify the KeySystem Representative of any shortages or damage to the materials and note the shortages or damage on the delivery ticket.
  - b) The materials are F.O.B. the job site with a two hour off-loading allowance.
  - c) The contractor will receive certification for the KeyStrips with each shipment or invoice. It is the contractor's responsibility to furnish this certification information to the engineer.

## C) Contractor Supplied Materials

The following tools are recommended, but should not be limited to this list. Conditions may require other equipment, tools and material.

- 1) Tools
  - a) Carpenter's hammer
  - b) Mason's hammer
  - c) 1.8 meter (6') Rule
  - d) Sledge hammer/dead blow
  - e) Chalk line
  - f) 0.6 meter (2') and 1.2 meter (4') level
  - g) String line
  - h) Builders (optical) level
  - i) Broom
  - j) Masonry saw
  - k) Drill & 16 mm (5/8 in) concrete bit
  - l) Flat nose & spade shovels

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2) Materials

- |                           |  |
|---------------------------|--|
| a) Leveling pad materials | e) Under drain materials (if required) |
| b) Drainage fill          | f) Any top treatment                   |
| c) Reinforced fill        | g) Shimming material (if req'd)        |
| d) Random fill            |  |

3) Equipment:

- a) Forklifts, small cranes, or boom trucks capable of lifting a minimum of 1 1/2 tons to handle the palletized units.
- b) Small dozer, small front end loader or skid steer equipment to deliver and place drainage fill, reinforced fill, and common fill.
- c) Plate compactors and a smooth drum vibratory roller (up to 1.4 m (54 in)) to compact the backfill.
- d) Labor and supervision for wall construction.

## IV. Preparatory Work for Wall Construction

### A) Preconstruction Checklist.

- 1) Preconstruction meeting.
- 2) Verify approval of drainage fill and structural backfill material.
- 3) Verification of foundation soils and conditions.
- 4) Verify lines and grades by survey.

### B) Review drawings to plan leveling pad and reinforcement layout.

- 1) The construction drawings should be reviewed to confirm:
  - a) leveling pad elevations and location are correct and do not interfere with other site utilities or right-of-way
  - b) reinforcing layout should be reviewed to confirm there is sufficient room for a safe excavation for installation of reinforcing.

### C) Wall Excavation

Unclassified excavation shall be in accordance with the specification and in reasonably close conformity to the limits and construction stages shown on the plans. Evaluation and approval of foundation suitability is the responsibility of the engineer. Any foundation soils found to be unsuitable by the engineer shall be removed and replaced with reinforced fill as per 3.3.5 Reinforced fill Material of the specification.

## D) Foundation Preparation

- 1) The foundation for the structure shall be graded level for a width equal to the length of the KeyStone units and reinforcing elements, plus 300 mm (1 ft), or as shown on the plans. Prior to wall construction, except where constructed on rock, the foundation shall be proof rolled and compacted with a smooth wheel vibratory roller.
- 2) At each unit foundation level, a leveling pad of the type shown on the plans shall be provided. If an unreinforced concrete leveling pad is used it is typically a minimum of 150 mm (6 in) thick and 600 mm (2 ft) wide. The pad should be placed to within a tolerance of 3 mm (1/8 in) of plan elevation. Any minor imperfections (e.g. dips, ridges, etc.) can be corrected by grinding, or with a thin layer of sand or mortar. Concrete leveling pads shall be cured a minimum of 12 hours before placement of wall units.
  - a) When installing the concrete leveling pad it is recommended that the sides be formed. This will help ensure a smooth finish and a level pad.
  - b) The KeySystem units are 204 mm high (8 in)  $\pm$  3 mm (1/8 in). All leveling pad steps must accurately reflect that height increment; therefore, the contractor should verify the unit height before construction of the leveling pad.

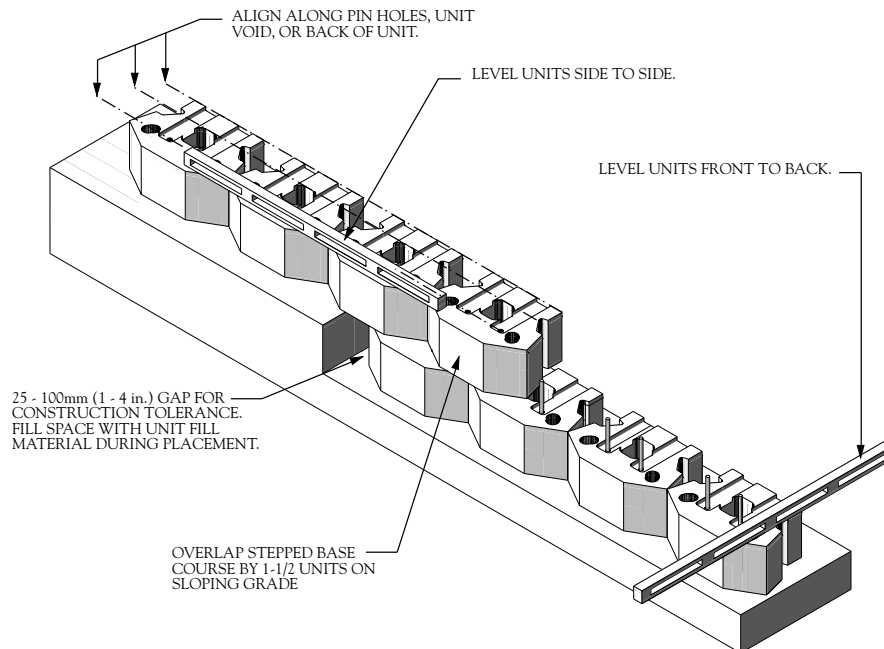


Figure 2: Leveling Pad Construction

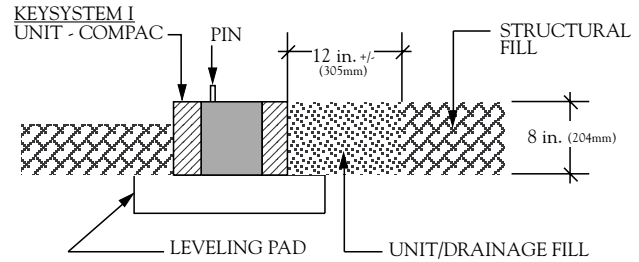
## V. Wall Construction

### A) First Course of KeySystem™ Units

- a) Proper placement of the first course of units is critical to the proper installation, alignment and appearance of the wall. Proper alignment may be achieved with the aid of a string line or with a chalk line to mark the back of the units.

b) Start building from the lowest elevation of the wall.

c) The first course shall be placed in full contact with the leveling pad and checked for proper elevation and alignment. Maintain the 305 mm (12 in) pinhole spacing between units.



**Figure 3: First Course Placement**

d) Install the connecting and alignment pins in the holes in the top of the units. The connection pins (steel) shall be located where the KeyStrip is to be connected to the units. The alignment pins (fiberglass) shall be used for alignment in the other units.

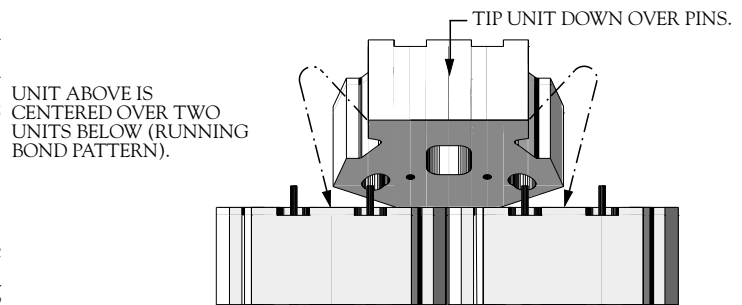
e) Backfill and compact behind the first course before installing other courses.

f) Install first layer of KeyStrip reinforcing.

## B) Unit, Reinforcement, and Backfill Placement

1) Subsequent courses of units should be stacked one high, backfilled, and placed so that complete in-filling is achieved.

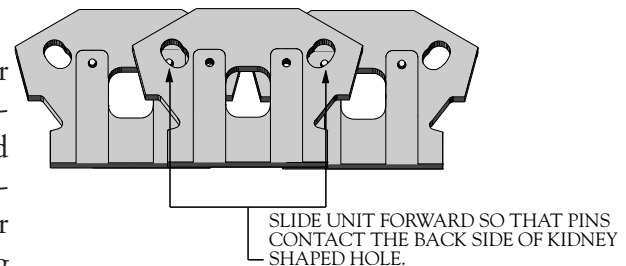
2) Clean all excess material from the top of the units prior to installing the next course. Install each succeeding course so that the units bridge the two units below it. Place the unit's



**Figure 4: Unit Placement**

kidney shaped holes so that they cover one pin from each of the two lower units. Slide the unit forward toward the exposed wall face until restrained by the pins in the previous course. Before backfilling the course check and correct the alignment at the units.

3) Fill all voids in and between the units and for 300 mm (12 in) behind the units with specified drainage fill. Place the specified reinforced fill behind this course and compact to the specified density. (Some projects may use a filter fabric behind the facing and not require filling the unit voids.)

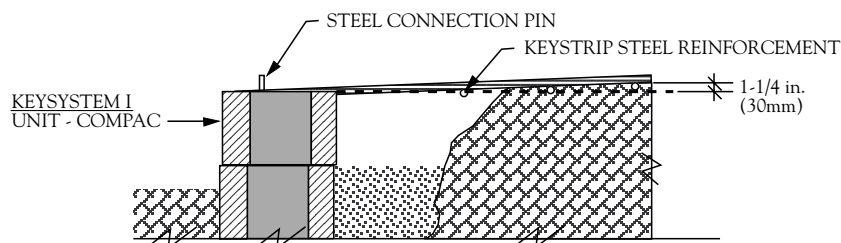


**Figure 5: Running Bond Placement**

a) The maximum lift thickness shall not exceed 204 mm (8 in). The contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

4) At each reinforcement level, the reinforced fill shall be placed to the level of the connection + 30 mm (1 1/4 in) before placing the soil reinforcement.



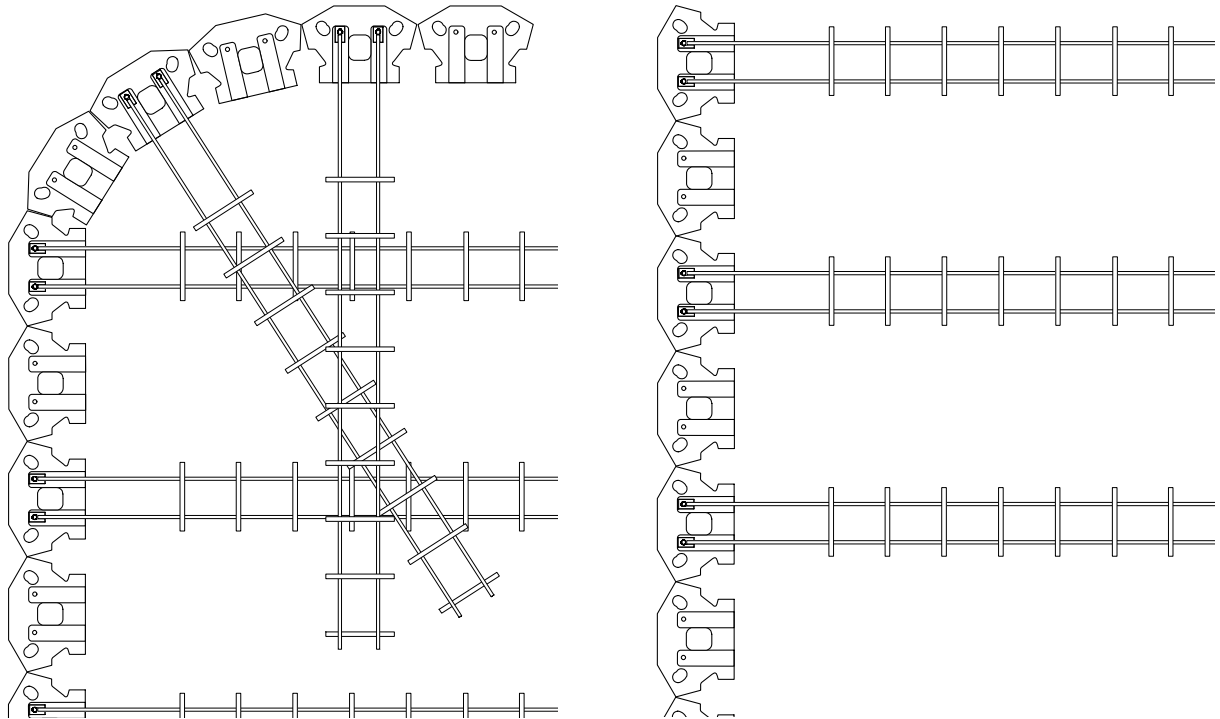


**Figure 6: KeyStrip Placement, Side View**

- 5) The soil reinforcement shall be placed over the connection pins and pulled back against the pin.
- 6) The soil reinforcement shall then be covered with 70 - 100 mm (3 - 4 in) of reinforced fill for protection. The top of the unit is swept off and the next unit placed and aligned. The unit and reinforced fill are then placed in 204 mm (8 in) lifts and compacted. Repeat this procedure to the extent of the wall height.
  - a.) Structural and drainage fill shall be placed, spread and compacted to avoid any damage or disturbance of the wall materials or misalignment of the facing units or reinforcing elements. As reinforced fill material is placed behind the units, the units are maintained in position by means of the alignment pin.
  - b.) Reinforced fill shall be compacted to 95 percent of the maximum density as determined by AASHTO T-99, Method C or D (with oversized corrections as outlined in Note 7 of that test). For reinforced fills a method of compaction consisting of at least 3 passes by a heavy roller shall be used. For applications where spread footings are used to support bridge or other structural loads, the top 1.5 meter (5.0') below the footing elevation should be compacted to 100 percent AASHTO T-99.
  - c.) The moisture content of the reinforced fill material prior to and during compaction shall be uniformly distributed throughout each layer. Reinforced fill materials shall have a placement moisture content less than or equal to the optimum content. Reinforced fill, with a placement moisture content in excess of 2 percentage points greater than optimum moisture content, shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift.
- 7) Reinforcement elements shall be placed perpendicular to the face of the wall, transverse bars down, unless otherwise shown on the plans. Prior to placement of the reinforcing elements the reinforced fill shall be compacted in accordance with the specifications.

The reinforcement elements can be overlapped in curves with the elements resting on each other. The reinforced fill is then placed on top. The openings in the elements are large enough to allow the fill through when it is placed and compacted.

- 8) Alignment and batter should be checked at each coarse. Corrections to alignment shall made as required before proceeding. Wall facing vertical tolerances and horizontal alignment shall not exceed 19 mm (3/4 in) when measured with a 3 meter (10 ft) straight edge. During construction, the maximum allowable offset in any unit joint shall be 9.5 mm (3/8 in). The overall vertical tolerance of the wall (top to bottom) shall not exceed 13 mm. If out of tolerance, conservative measures of shimming and back-jacking should be applied.



**Figure 7: Keystrip Placement**

- a) Shimming is accomplished by running a resilient material between the units around the alignment pins. This can be a 6 mm (1/4 in) rope, strips of fiberglass shingles, or other approved materials.
  - b) Back-jacking is accomplished by hand driving a wrecking bar into the drainage fill directly behind the facing and then prying the face forward. The drainage fill will hold the facing in-place when the bar is removed. All care should be taken not to push the facing beyond the desired location.
- 9) Tracked and rubber-tired construction equipment shall not operate directly on the reinforcing elements. Turning shall be minimized to prevent damage and keep the reinforcing elements from pushing the units out of alignment.
- a) Only lightweight, hand operated, compaction equipment will be operated within 1 meter (3 ft) of the tails of the units. Compaction shall be achieved by at least 3 passes of a lightweight mechanical tamper, roller or vibratory system.

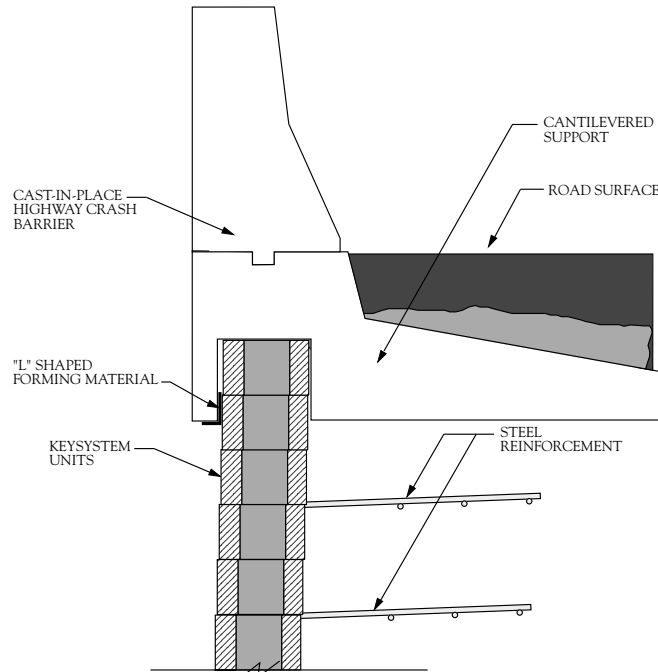
- b) In this 1 meter (3 ft) transitional zone, between the unit and drainage fill and the reinforced fill, effort should be made to compact the fill in lifts. Reduction in compaction effort in this zone may be required to maintain wall alignment.

10) At the end of each day's operation, the contractor shall slope the backfill away from the wall face to rapidly direct runoff away from the wall. In addition, the contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

## C) Wall Cap and Coping Installation

- 1) Cap - Position the KeyStone Cap Unit in place. The cap unit shall be fastened to the engineered units by using KeyStone KapSeal.

- 2) Coping with Traffic Barrier - Install the KeyStone wall per general installation instructions. Set and secure forming materials along the top course of the KeyStone wall using standard forming procedures. If the design requires an overhanging coping, form the edge using an L-shaped



**Figure 8: Barrier Detail**

galvanized steel or plastic

forming material. Fasten this material to the KeyStone wall. Pour and finish the traffic barrier per by engineered design. Insert control joints at a maximum of 3 meters (9') on center along the length of the coping, or as specified by the engineer. These expansion joints must align with the vertical joints of the KeySystem units as they exit the coping.

## D) Clean Area and Remove or Dispose of Any:

- 1) broken or unused units
- 2) extra connection or alignment pins
- 3) extra reinforcing strips
- 4) on-site or imported fill materials

Unused Keysystem materials may be returned to the supplier (Contractor shall negotiate with supplier). Unused material may be (with the Owner's permission) incorporated into the reinforced fill.

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## VI. Effects and Causes

### Effect

### Cause

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>1. Horizontal Alignment<ul style="list-style-type: none"><li>a. Bulging</li><li>b. Wall Leaning In (Excessive Batter)</li><li>c. Wall Leaning Out</li></ul></li><li>2. Vertical Alignment<ul style="list-style-type: none"><li>a. Hump</li><li>b. Dip</li></ul></li><li>3. Units Won't Stack Flat<ul style="list-style-type: none"><li>a. Leveling Pad</li><li>b. Units</li><li>c. Drainage fill</li></ul></li><li>4. Units Pinch or Gap<ul style="list-style-type: none"><li>a. Horizontal Spacing</li></ul></li></ul> | <ul style="list-style-type: none"><li>a1. Excessive compaction or compacting in too thick of lifts.</li><li>a2. Compacting too close to the back of the units.</li><li>a3. Compaction of soil wet of optimum.</li><li>b1. Unit heights not consistent.</li><li>b2. Inconsistency of front to rear level of the units.</li><li>b3. Inconsistency in shimming in of the units tail.</li><li>c1. Loading too close to the back of the units. (typically trucks or rubber tired equipment.)</li><li>c2. Excessive compaction too close to the units.</li><li>c3. Not enough coverage on the KeyStrips and as the backfill is placed and spread toward the wall causing pushing and movement of the units.</li><li>a1. Particles in between units.</li><li>a2. Core bar in marks in on the top of the units not removed during placement.</li><li>b1. Footing not level.</li><li>b2. Utility crossing.</li><li>a1. Base course not level.</li><li>b1. Top of unit has production imperfections.</li><li>c1. Top of unit not swept clean</li><li>a1. Horizontal spacing not 305 mm (12 in) between pinholes of adjacent units.</li></ul> |
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## VII. Glossary

<b>Agency Inspector:</b>	Person authorized by the agency to conduct detailed inspections of the project and materials used.
<b>Contract Documents:</b>	The contract drawings, specifications including addenda and other modifications issued prior to the execution of the Contract
<b>Contractor:</b>	The individual, firm, or corporation acting through its agents or employees to undertake the execution of the Work under the terms of the contract.
<b>Engineer:</b>	The Owner designated firm or persons with authoritative charge over engineering functions and responsibilities.
<b>KeySystem Representative:</b>	KeyStone representative available to provide technical assistance on KeySystem I to the Contractor, Agency Inspector and Engineer.
<b>Plans:</b>	The part of the Contract documents consisting of the approved plans, profiles, typical cross sections, working drawings and supplemental drawings or exact reproductions thereof, which show the location, character, dimensions and details of the work to be performed.
<b>Specifications:</b>	A description of the quality and quantity of the materials and workmanship that will be required of the Contractor in the execution of the work under the Contract between the Owner and the Contractor.
<b>Owner:</b>	The Owner of the project with whom a contract has been made for payment for the Work performed under the terms of that Contract.