



SMART CUSHION®

CRASH ATTENUATOR

INSTALLATION INSTRUCTIONS



TABLE OF CONTENTS

OVERVIEW

Product	1
Maintenance	1
Crash Performance.....	1

SPECIFICATIONS

Description.....	2
System Dimensions & Weight.....	2

DESIGN CRITERIA

General.....	2
Foundations.....	2
Support Structure.....	3
Location	3
Transition Design.....	3
Transitions.....	4
Determining Side of Transition.....	4

INSTALLATION

Installation & Performance Statements.....	5
Safety	5
Equipment List.....	Appendix B
Site Preparation.....	5
Foundations.....	5
Placement of Crash Cushion.....	6
Anchor Installation.....	6
Delineator Panel Attachment.....	7
Transition Installation.....	7
Final Inspection.....	8

RESETTING SMART CUSHION® AFTER IMPACT

Site Preparation.....	8
Re-Extension & Inspection After Frontal Impact.....	8
Side Impact Inspection & Repair.....	9
Cable Inspection Procedure.....	9
Cylinder Inspection.....	10
Anchor Bolt Inspection.....	10
Side Panel Inspection.....	10
Side Guide Inspection.....	10
Final Inspection.....	10
Non-Repairable Impacts.....	10
Periodic Maintenance.....	10

APPENDICES

SCI SMART CUSHION® PARTS LIST A

EQUIPMENT LIST B

ATTENUATORS

SMART CUSHION®, TEST LEVEL II.....C

SMART CUSHION®, TEST LEVEL IIID

FOUNDATIONS

Test Level II FoundationE

Test Level III Foundation.....E(2)

TRANSITIONS

Jersey / F Barrier NCHRP 350.....F

Jersey / F / K Shape Barrier - MASH.....G

Median Barrier, Single Slope 24-26.75-Inch Base (610-679 mm).....H

Jersey / F Shape, 30-38-Inch (762-965 mm), Variable Width Base.....I

Concrete Block, 24-Inch (610 mm)J

Concrete Block, 30-Inch (762 mm)K

Concrete Block, 36-Inch (914 mm) - MASHL

Concrete Block, 38-44-Inch (965-1118 mm).....M

Thrie-Beam Wide Taper.....N

Thrie-Beam (Bidirectional Traffic Design).....O

W-Beam (Bidirectional Traffic Design).....P

W-Beam 28-Inch High (Unidirectional Traffic Design).....Q

W-Beam 31-Inch High (Unidirectional Traffic Design).....R

Spanner For Concrete BlockS

Offset Concrete Block.....T

OVERVIEW

PRODUCT

The Smart Cushion® impact attenuators are manufactured by Hill and Smith Inc. The Test Level 3 model is NCHRP 350/MASH approved by the FHWA. The Test Level 2 is NCHRP 350 approved and has passed the MASH capacity test #2-31. Based on that test, it is MASH approved in many states. They are fully redirective, non-gating, and bi-directional. Smart Cushion® impact attenuators are used to help protect motorists from hazards in both permanent and temporary work zone locations. They can be attached to most types of median and roadside barriers.

The Smart Cushion® attenuators use a patented system for stopping vehicles. The system is speed dependent and stops small and large vehicles by automatically regulating the stopping force exerted on a vehicle. Essentially, the system provides the necessary forces based on the speed of the vehicle automatically compensating for the mass of the vehicle.

The Smart Cushion® attenuators are slightly tapered from front to rear. This allows the side panel sections to collapse over the next section without stress or damage. During collapse, the parts move freely past each other and do not become wedged during the impact.

Wide temperature variations and temperature extremes do not affect the performance of Smart Cushion® impact attenuators.

MAINTENANCE

Smart Cushion® impact attenuators are low-maintenance units. A trained, two-person maintenance crew can return most impacted Smart Cushion® attenuators to full service within 30 minutes. This short repair time reduces the maintenance workers' exposure to traffic and minimizes traffic congestion. Side impacts rarely require a repair which eliminates worker exposure, repair costs and traffic delays / exposure.

CRASH PERFORMANCE

The Smart Cushion® broke new ground during NCHRP Report 350 crash testing. In the high-speed test, 100 kilometers per hour (63 miles per hour), the small vehicle's deceleration rate was significantly lower than any previously recorded value (-9.8 G's as compared to previous low of -13.4 G's). This means less impact forces on the vehicle's occupants and a reduced risk of injury due to a much lower impact severity.

The NCHRP 350 Test Level 3 Smart Cushion® performed and passed ALL MASH tests to exact MASH standards with no modifications. The NCHRP Test Level 2 Smart Cushion® also performed and passed the pickup capacity test #2-32 with no modifications. These tests were performed by an accredited independent testing facility. As with the NCHRP 350 tests, MASH frontal impacts only needed two shear bolts to reset the unit back to full operation status.



SPECIFICATIONS

DESCRIPTION

The Smart Cushion® is a re-directive, non-gating crash attenuator that consists of a base, supporting frames, a sled, side panels, a wire rope cable, sheaves, and a shock-arresting cylinder. The base is anchored to the mounting surface and provides support for the frames that are mounted on it. The support frames hold the side panels that provide a flat outer redirective surface for side impacts. The sled provides redirective support for side impacts and deceleration force for frontal impacts. The Smart Cushion® telescopes rearward upon frontal impact and can be reset with minimal repair parts.

DIMENSIONS & WEIGHT

	SCI 70 GM	SCI 100 GM
Width	24-inch (610 mm)	24-inch (610 mm)
Length	13 1/2-feet (4115 mm)	2 1/2-feet (6550 mm)
Height	33-inch (840 mm)	33-inch (80 mm)
Weight	2465 lbs. (1120 kg)	3450 lbs. (1570 kg)
Test Level	MASH / NCHRP 350 Level 2	MASH / NCHRP 350 Level 3

DESIGN CRITERIA

GENERAL

Smart Cushion® impact attenuators comply with MASH and NCHRP Report 350. They are designed for temporary work zone and permanent applications.

FOUNDATIONS

Foundations must be a flat surface with longitudinal and cross slopes of 10:1 (horizontal:vertical) or less. Smart Cushion® impact attenuators should not be located over drainage basins or expansion joints. Portland cement concrete foundation pads are preferred for permanent installations; asphaltic concrete foundation pads are appropriate for temporary work zone installations. The following table describes the foundations that may be used. See Appendices for drawings.

PAD MATERIAL AND THICKNESS	ANCHOR EMBEDMENT
6-inch (150 mm) reinforced PPC ¹	5 1/2-inch (140 mm)
8-inch (205 mm) non-reinforced PPC	5 1/2-inch (140 mm)
3-inch (75 mm) AC ^{2,3} over 3-inch (75 mm) non-reinforced PPC	16 1/2-inch (420 mm)
6-inch (150 mm) AC over 6-inch compacted subgrade ³	16 1/2-inch (420 mm)
8-inch (205 mm) AC ³	16 1/2-inch (420 mm)

Notes: 1. Portland cement concrete 2. Asphaltic concrete 3. Minimum compaction: 95% of optimal



Concrete compressive strength shall be 4000 psi (28 MPa) at 28 days.
Foundation lengths may vary when using wide transitions.

SUPPORT STRUCTURE

Smart Cushion® impact attenuators are self-supporting and do not require an additional support structure.

LOCATION

The Smart Cushion® impact attenuator's location determines its position and transition requirements.

1. Approach Zone – Smart Cushion® impact attenuators should not be placed directly behind raised curbs that exceed 4-inches in height. The longitudinal and cross slopes in front of the device should not exceed 10:1 (horizontal:vertical).
2. Barrier Width – Smart Cushion® impact attenuators are 24-inch (610 mm) wide at the rear. Barriers 24-inch (610 mm) wide, or less, can be shielded without using a transition if there is no reverse direction traffic. Barriers that are wider than 24-inch (610 mm) and / or have reverse direction traffic require a transition, available from Hill and Smith Inc.
3. Barrier Height – Smart Cushion® impact attenuators are approximately 33 3/8-inch (848 mm) high.
4. Barrier Shape – Smart Cushion® transitions allow for connection to many barrier shapes.

TRANSITION DESIGN

Smart Cushion® impact attenuators can be attached to many different barrier shapes. The attenuators are designed for direct attachment to 24-inch wide barriers and Jersey / F-Shape barriers. The Smart Cushion® side panels must have an unobstructed travel zone for 30-inch behind the attenuator to allow a full collapse. Smart Cushion® transitions provide this travel zone in front of wide hazards.

See appendices for Smart Cushion® transition drawings. Additional transitions are available for other frequently used applications. Contact us for drawings and details.



TRANSITIONS

Necessary Locations (see Figure 1 – Necessary Locations):

- There is reverse direction traffic within the clear zone.
- The barrier intrudes into the side panels' travel zone.

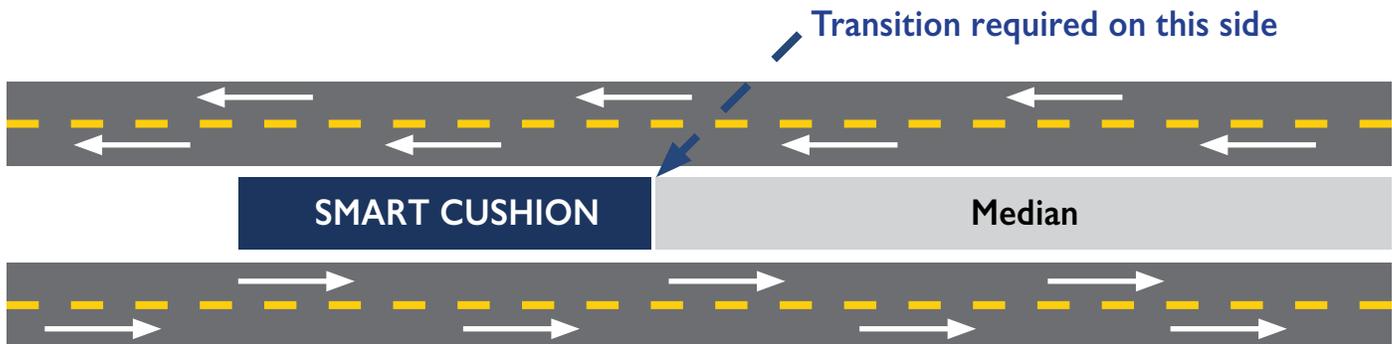


Figure 1 - Necessary Locations

Examples are median applications with bidirectional traffic, two lane roads with crossover potential, etc.

Unnecessary Locations (see Figure 2 – Unnecessary Locations):

- No reverse direction traffic within the clear zone.
- The barrier does not intrude into the side panels' travel zone.

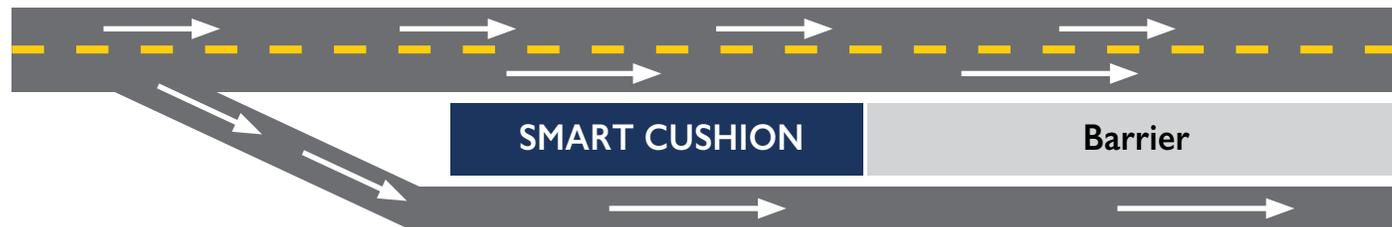


Figure 2 - Unnecessary Locations

Examples are traffic splits, shoulder applications with no crossover potential, one-way roads, etc.

DETERMINING SIDE OF TRANSITION

The transition's side is determined by standing at the front of the attenuator looking rearward toward the barrier to choose between left and right.

INSTALLATION

INSTALLATION AND PERFORMANCE STATEMENTS

Proper performance within MASH / NCHRP 350 design limits depends on correct installation of the Smart Cushion® on an approved foundation. Any Smart Cushion® not installed according to the drawings and the requirements of this installation manual may present an unsafe condition and should be reinstalled accordingly.

Impacts with vehicles whose size or mass are outside of those tested according to MASH / NCHRP 350 or with vehicles traveling at speeds greater than those tested according to MASH / NCHRP 350 will not necessarily produce results within the test criteria. The crash cushion is in conformance with all requirements of MASH Test Level 3, MASH Test Level 2 test #2-31 and NCHRP 350 Test Levels 2 & 3.

SAFETY

All work during installation, repair and inspection of the Smart Cushion® should be performed according to federal, state and local laws.

EQUIPMENT LIST

See Appendix B

SITE PREPARATION

Check to make sure there are no drains, expansion joints, or buried conduit, cables or utility lines in the footprint space where the attenuator will be placed. Remove any curbs >4-inch or obstacles in front of or beside where the attenuator will be installed for a minimum distance of 12 feet from any edge of the attenuator. Be sure to set up proper traffic control before beginning any installation or repair work at the site.

FOUNDATIONS – (reference Appendices E and E2)

New foundations should be installed according to Appendix E – Foundation Drawing. Concrete cure strength should reach 4,000 psi minimum before use. The surface of the foundation must be cleaned of all debris, dirt, mud, sand, etc., as the crash cushion must sit on a flat plane, although longitudinal and/or cross slope of up to 10:1 (horizontal:vertical) is allowed.

Any of the following foundations will meet the minimum requirements:

- 6-inch reinforced concrete pad
- 8-inch non-reinforced concrete pad
- 3-inch asphalt over 3-inch of concrete
- 6-inch asphalt over 6-inch of compacted sub base
- 8-inch asphalt

Note: Concrete should be 28 MPa or 4000 psi minimum at full cure. The slope should not exceed 10:1.



Installing the Smart Cushion® on an existing foundation may result in anchor bolt locations corresponding to rebar positions in the foundation. When rebar is encountered, rebar bits should be used as concrete bits may bend around the rebar and continue to drill at an angle while the anchors will not bend.

Prior to installing the Smart Cushion® on an existing foundation, the concrete must be thoroughly inspected for slope, signs of cracking, surface wear, shifting from original position, undercut of earth below or to the sides supporting the foundation, settling, and any other signs of age or deterioration which may make the foundation unusable. If any of these signs are evident, the foundation should be removed and a new one must be installed according to requirements stated. If prior bolt patterns are present, use proper engineering calculations to assure adequate strength in the new holes.

PLACEMENT OF THE SMART CUSHION®

Measure the correct distance and offset of the Smart Cushion® according to the type of object being shielded and the type of transition being used. The dimensions shown on the transition drawings may be used as a guide for this. System drawings are also available.

The crash cushion is shipped in one piece, fully assembled. Use a choked four-point attachment on panel support frames 3 & 4 behind the sled for the Test Level 3 unit. **Do not lift using the side panels only!** The lift points on the Test Level 2 unit are the 1st and 2nd frames behind the sled. Lift the Smart Cushion® off the transporting vehicle with a boom or forklift of sufficient capacity and place it in the position marked on the foundation.

Once in place, double-check the measurements to be sure of the proper location of the Smart Cushion®.

Warning: On a full collapse, the last set of side panels will telescope 30-inches beyond the last terminal brace at the rear of the crash cushion. All objects that may interfere with this motion can affect the performance of and cause undue damage to the crash cushion.

ANCHOR INSTALLATION

Embedment Requirements are as follows:

1. 6-inch reinforced concrete pad – anchor embedment of 5 1/2-inch / torque value of 170 N-m (125 ft-lbs)
2. 8-inch non-reinforced concrete pad – anchor embedment of 5 1/2-inch / torque value of 170 N-m (125 ft-lbs)
3. 3-inch asphalt over 3-inch of concrete – anchor embedment of 16 1/2-inch / torque value of less than N-m (10 ft-lbs)
4. 6-inch asphalt over 6-inch of compacted sub base – anchor embedment of 16 1/2-inch / torque value of less than 14 N-m (10 ft-lbs.)
5. 8-inch asphalt – anchor embedment of 16 1/2-inch and a torque value of less than 14 N-m (10 ft-lbs)

Using the holes in the base as a template, drill 7/8-inch diameter holes to the proper depth as previously defined. If the Smart Cushion® is being installed on an existing foundation and the drills are hitting rebar, use a core drill or rebar cutter to ensure that straight, vertical holes are made at each location. Take care that the holes do not break out the bottom of the foundation as this may result in loss of epoxy during anchor placement.



Once the holes are drilled, clean the hole of all debris using suitable means. To ensure epoxy adhesion, **concrete holes MUST be cleaned with a bottle brush to remove embedded dust**, and a final check conducted that all holes are clean of debris. Inject the epoxy into each hole at an angle to avoid air entrapment. Use a sufficient amount of epoxy so that the hole will be filled when the bolt is inserted. Screw the nut on the anchor bolt flush with the end, put the washer on the stud, and immediately insert the anchor stud all the way to the bottom while turning the anchor. This method assures the anchor bolts are vertically plumb and the threads are coated with epoxy. **Bolts should not project more than 1/2-inch above the nut after final torque is completed.**

There is a quantity of 48 anchors for the SCI 100 GM, TL-3 attenuator.

There is a quantity of 34 anchors for the SCI 70 GM, TL-2 attenuator.

The epoxy should be ready for bolt tightening after 30 minutes at 80 degrees F (27 degrees C). See the container label for other temperatures and bolt up times. Allow the epoxy to cure. Torque the anchor nuts to 170 N-m (125 ft-lbs). Substitute epoxy must match our specifications. Asphalt anchors are longer and should have a torque value of 14 N-m (10 ft-lbs). The SCI uses Redhead A7+ Epoxy. Concrete TL2 and TL3 units require 3 and 4 tubes of epoxy, respectively while Asphalt TL2 and TL3 units require 9 and 12 tubes of epoxy, respectively.

DELINEATOR PANEL ATTACHMENT

Installation of the front delineation plate will be determined by the location of the attenuator and state regulations. A delineation plate is shipped with a yellow powder coat background and no striping. It is attached with four bolts. Applying the striping to the plate is easier while it is removed from the attenuator. Examples of the delineation plate are as follows:



Left Shoulder



Chevron for Median



Right Shoulder

TRANSITION INSTALLATION

Transitions may be required. Any use of a Smart Cushion® with a possible reverse direction impact will require a the transition drawings for details of the required anchor locations. For horizontal stud installation in concrete use mechanical anchors. Transition drawings and parts explosions are in the appendices. System drawings are available for additional details such as foundation lengths. Transition Concrete Drop-in anchors only expose the head of the anchor to reduce snag potential. For guardrail transition connections <30" behind the attenuator, you must use guardrail bolt heads (not nuts) to provide unobstructed side panel travel.

FINAL INSPECTION

After the anchor bolts have been tightened to the proper torque value, check that the Smart Cushion® is not distorted in any way as might happen if the unit is secured to a foundation which is not a flat plane. Check that the front section is pulled out to within 1-inch of the front stop bolts and that no part of the unit has been damaged by shipping and handling. Verify that all assembly bolts are tight and have not come loose during shipping or installation. Finally, check that no tools or other equipment have been left within the Smart Cushion® structure.



RESETTING SMART CUSHION® AFTER IMPACT

In the event of any impact, the crash cushion will require a full evaluation to determine the necessary repairs to return it to service. To do this, proceed as follows:

SITE PREPARATION

Do not begin work until the area is declared safe and accessible.

RE-EXTENSION AND INSPECTION AFTER FRONTAL IMPACT

1. Remove the front delineator panel and attach pulling means to the **bottom brace** of the front sled.
2. Use wire / bungee cord on the bottom brace at the front of the sled to hold the spelter socket up in the air while pulling out or it will catch on the base frame cross braces. (See Fig. 1)
3. Remove the front cable bracket that is located on the front sheave at the front of the attenuator. (See Fig. 2)
4. Attach a 1/2-inch Grade 100 chain to the bottom brace of the front sled.
5. Pull the sled forward one to two feet to give you slack on the cable.
6. If necessary, use the cable release tool to break cable loose from the sheave at the front of the attenuator if the zinc coating has attached the cable to the sheave. (See Fig. 3)
7. Pull out in two foot increments while helping the cable feed out of the front of the unit. (See Fig. 4)
8. Pull the sled out the rest of the way in **short smooth increments** so you can help feed the cable out the front of the attenuator. This will give you a cable loop in front of the attenuator. **When you are past the last cross brace, you will need to remove the strap or wire to allow the cable to follow the path down into the front sheave.** The sled must be fully extended to replace the shear bolts. The sled should be no more than 1-inch from the stop bolts in the front. ****During any pullout, do not stand within the snap radius of the chain in case of failure**.**
9. During frame pullout, inspect the front part of the cable from the spelter socket, as it will be partially obscured after extension of the mobile frames and sheaves. **See the cable inspection procedure.**
10. Remove the front and rear sheave cover plates at each end of the cylinder by removing the two hex bolts that hold them down. Perform steps 11 and 12 when you have access to them. Access may be restricted until the unit is fully pulled out.



Fig. 1

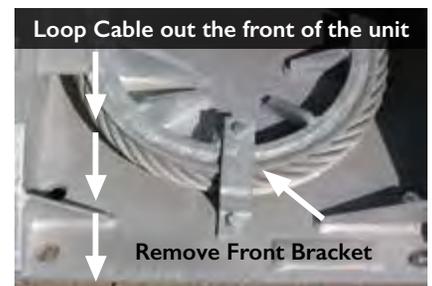


Fig. 2



Fig. 3

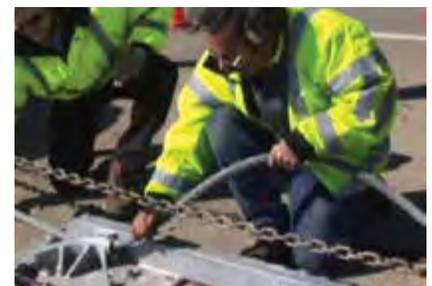


Fig. 4



1. Remove the anti-rotation pins, which are the two outer pins, inserted through the holes in the sheaves from both the front and back sheaves. This will be easily done with the anti-rotation pin removal tool. **Caution: Do not remove the center pin. The rear sheave pins are longer than the front sheave pins and cannot be intermixed so leave them by their locations.** (See Fig. 5)
2. Remove shear bolt remnants in the holes on both sides of the mobile sheaves. These are grade 8 bolts so they can be difficult to remove without a 90 degree pry bar with a claw to pry out. (See Fig. 6)
3. Attach a pulling means to the shackle on the mobile sheave assembly. (See Fig. 6)
4. Slowly pull out the mobile sheaves. **Do not stand inside the cable loop or be in the pulling strap danger zone.**
5. Finish pulling out the mobile sheaves until you can see through the shear bolt holes **but do not put in the shear bolts yet.**
6. If the cable passes inspection, release any tension on your pulling means and reinstall the anti-rotation pins in the front and back sheave assemblies and reinstall the cover plates for those sheaves using marine grade anti-seize on the bolt threads. The sheaves may be aligned by inserting a pry bar into the sheave holes. Work your way from the bottom up.
7. Re-tension your chain and replace the two 1/4-inch **Grade 8** shear bolts in the front corners of the mobile sheaves.
8. Inspect the cylinder, anchor bolts and side panels according to the subsequent procedures listed.



Fig. 5



Fig. 6

SIDE IMPACT INSPECTION AND REPAIR

1. Inspect and replace any damaged side panels.
2. Inspect and replace any damaged side keeper bolts on all panels. There are three styles of side keeper bolts. The winged style is for the panel connected to the sled and bolts through the first frame behind the sled. The center side keepers have a 1/2-inch shoulder while the last side keeper, which is bolted to the terminal frame, has a 1/4-inch shoulder.
3. Inspect and repair any damaged side guides.

CABLE INSPECTION PROCEDURE

The cable should be visually inspected for damage. The most common sign of rope deterioration is broken wires. The wire must be clean to perform a visual inspection. The visual inspection should include looking for broken wire strands, localized wear or crowns. A sharp awl or marlin spike can be used to separate wires to check if internal damage is present, indicated by loose wires or crowns. If internal inspection shows any damage to any core wires, remove the unit from service. If there are more than six random broken wires in one rope lay or three broken wires in one strand in one rope lay, remove the unit from service. A rope lay is the length along the rope in which one strand makes a complete revolution around the rope. (See Fig. 7)

Inspect the spelter socket for broken wires, damaged eyes or other fatigue. Any signs of broken wires at the spelter socket will require the unit to be removed from service.

Cable damage is the indication of an over-design impact. You should replace the attenuator if the cable does not pass inspection. This is a clear sign that an over design impact occurred and other parts could possibly be compromised.

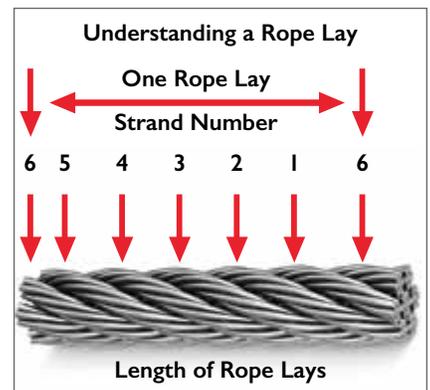


Fig. 7



CYLINDER INSPECTION

The cylinder should be inspected for:

- Dented or swollen tube jacket
- Visible cracks in any welds and fluid leakage from the welds
- Piston rod surface damage, bending or fluid leakage in seal area

If any of these inspections are suspect, remove the unit from service. Current models have PTFE seals with an unlimited static life.

ANCHOR BOLT INSPECTION

Loose or damaged anchor bolts should be extracted and reinstalled.

SIDE PANEL INSPECTION

Side Panels are designed to nest and collapse with minimal or no damage upon frontal impact. The side keepers sustain a shock upon impact. These side keepers should be replaced if there are any signs of fatigue, bending or other visible damage. Inspect the side panels for any bending or torn metal. If damage is found, any side panel is removable by removing four bolts. The side keepers used to hold the large front sled panels are different than the side keepers on the center panels. Also, the side keeper used on the last terminal brace, which is the rearmost support, has a shorter collar (1/4-inch vs. 1/2-inch), as it does not have a panel overlap. These shoulders must seat into the outer overlapping panel and pin the inside panel to the frames using a torque value of 270 N-m (200 ft-lbs). Be careful to fully insert the collar into the panel slot so you do not pin the edge of the outside panel as it will restrict free sliding of that panel.

SIDE GUIDE INSPECTION

At the bottom of each support frame, there are two guides to stabilize and guide collapse of the attenuator. Inspect each side guide for damage. The torque value for the side guides is 920 N-m (680 ft-lb). These side guides are stronger than the rail, so visually inspect the rail for crowns. Any crowning of the rail can be straightened using a large maul to flatten it back to its' original position.

FINAL INSPECTION

After the resetting of the SMART CUSHION® is complete, verify by visual inspection that all assembly bolts are tight and show no sign of damage. Finally, check that no tools and other equipment or debris have been left within the SMART CUSHION® structure. Verify that no other damage unrelated to the most recent impact has occurred and that no significant corrosion or other deterioration has taken place.

NON-REPAIRABLE IMPACTS

There can be instances where the impact is outside the scope of the Smart Cushion® design. This may render the Smart Cushion® unsafe to reuse and it should be replaced.

PERIODIC MAINTENANCE

Maintenance is site dependent. Small amounts of debris and trash will not affect the performance of the Smart Cushion®. Accumulations of dirt/mud can impede the collapse of any system. We suggest an annual clean-out of the system in the fall of the year. If sites are in locations prone to heavy rain/mud runoff, a bi-annual cleaning may be required.



APPENDIX A - SCI SMART CUSHION PARTS LIST

Prod No.	Description	Unit of Measure
270128-C	Attenuator 24" wide w/ Concrete Anchors TL3	
270128-A	Attenuator 24" wide w/ Asphalt Anchors TL3	
270126-C	Attenuator 24" wide w/ Concrete Anchors TL2	
270126-A	Attenuator 24" wide w/ Asphalt Anchors TL2	
270667	Bolt Concrete Anchor 3/4" x 7" TL3 (Included in P/N 270128-C)	KIT / 48 pcs.
270663	Bolt Asphalt Anchor 3/4" x 18" TL3 (Included in P/N 270128-A)	KIT / 48 pcs.
270666	Bolt Concrete Anchor 3/4" x 7" TL2 (Included in P/N 270126-C)	KIT / 34 pcs.
270664	Bolt Asphalt Anchor 3/4" x 18" TL2 (Included in P/N 270126-A)	KIT / 34 pcs.
271242	Epoxy 28 oz. Cartridge and Nozzle	Each
273113	Nozzle Epoxy Mixing	Each
272612	Epoxy Kit for TL3 Concrete Attenuator	Each
272610	Epoxy Kit for TL3 Asphalt Attenuator	Each
272611	Epoxy Kit for TL2 Concrete Attenuator	Each
272609	Epoxy Kit for TL2 Asphalt Attenuator	Each
270683	Bolt Shear	Each
270770	Brace Terminal	Each
272527	Keeper Side #3 (Sled Panels) TL2 & TL3	Each
272593	Keeper Side #1 (Side Panels) TL2 & TL3	Each
272595	Keeper Side #2 (Rear Panels) TL2 & TL3	Each
273378	Panel Delineator (Painted Yellow) TL3	Each
273386	Panel Delineator (Painted Black) TL3	Each
273381	Panel Delineator Diamond Grade Chevron 6-inch stripes TL3	Each
273383	Panel Delineator Diamond Grade Left 6-inch stripes TL3	Each
273389	Panel Delineator Diamond Grade Right 6-inch stripes TL3	Each
273380	Panel Delineator (Painted Yellow) TL2	Each
273385	Panel Delineator (Painted Black) TL2	Each
273382	Panel Delineator Diamond Grade Chevron 6-inch stripes TL2	Each
233928	Panel Delineator Diamond Grade Left 6-inch stripes TL2	Each
273388	Panel Delineator Diamond Grade Right 6-inch stripes TL2	Each
273401	Panel Side TL2 & TL3	Each
273402	Panel Sled	Each
273399	Panel Rear	Each
274649	Sled (with guide rollers) 24" TL3	Each
274648	Sled (with guide rollers) 24" TL2	Each
271946	Dispenser Epoxy	Each
270707	Boot Cylinder TL3	Each
233937	Boot Cylinder TL2	Each
272621	Reset Parts Kit TL3	Each
272620	Reset Parts Kit TL2	Each
273994	Tool Anti Rotation Pin Removal	Each
270069	Anchor Drop In	Each
275224	Cable Release Tool	Each
238247	Shear Bolt Removal Tool	Each
270952	Hole Brush-Nylon	Each
264383	Drop-In Anchor Setting Tool	Each
262004	SCI Debris Hood Assembly - DH3	Each
262006	Fiberglass Stay Kit for Debris Hood - DH3	Kit



APPENDIX B - EQUIPMENT LIST

The following tools and equipment will be required to install and repair the Smart Cushion®:

- Standard roadside work area safety equipment
- Personal safety equipment (gloves, latex gloves for epoxy, eye / face protection, etc.)
- Means of safely unloading 3500 lbs.
- Compressed air source / vacuum
- 1-inch nylon bottle brush (Part #270952)
- Safety goggles
- Four lifting slings or four-point sling
- Bosch rotary hammer drill 13 1/2 amp #11263EVS Model 0 611 263 739 or equal
- 7/8-inch x 22-inch concrete drill bit for concrete installations or 7/8-inch X 28-inch drill bit for asphalt installations
- Relton rebar eater bit #RB-14 - 7/8-inch rebar cutter bit or equal
- 1-inch x 12-inch concrete drill bit for drop-in anchors on transitions
- Punch or setting tool for drop in anchors (Part #264383)
- 1/2-inch electric drill for rebar bit and bottle brush (cordless will work for bottle brush)
- Epoxy dispenser for 28 oz. dual cartridge system. A spare is recommended in case of malfunction. (Part #271946)
- Socket wrench and breaker bar
- Torque wrench (225 ft lb capacity) with 3 ft extension
- Measuring and layout equipment (tape measure, chalk line, markers, etc.)
- Combination wrenches, deep sockets (Including 7/16-inch - 5/8-inch, 1 1/4-inch, 1 1/2-inch, 1 5/8-inch) and 3+ inch extension
- 5-foot wedge and round-ended pry bar
- Loctite #34395 marine grade anti-seize
- Suitable pulling means – Chain 20-foot x 1/4-inch Grade 100
- Misc. small tools (hammers, pliers, screw drivers, vise grips, etc.)
- Bear claw pry bar to remove 1/4-inch shear bolt remnants (Part #238247)
- Anti-rotation pin removal tool (Part #273994)
- Cable release tool (Part #275224)
- Piece of wire or bungee cord to hold up spelter socket during pullout

This list is adequate for general installation and repair. Depending on site conditions, additional tools and equipment may be required.

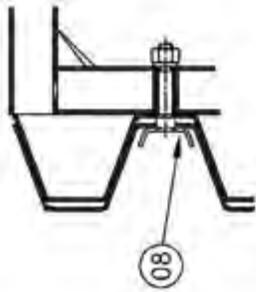




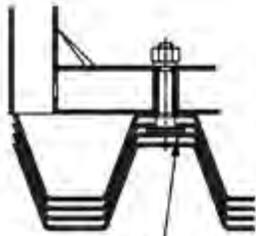
APPENDIX C - SMART CUSHION, TEST LEVEL II

- 01 - Front TL2 Sled Item 274648
- 02 - Cable Assembly
- 05 - Sled Panel Item 273402
- 07 - Terminal Brace Item 270770
- 09 - Anchor Bolts
- 12 - Side Panels Item 273401
- 14 - Mobile Sheave Assembly
- 17 - Cable Adjuster Bolt
- 18-20 - Mobile Frames 4-6
- 27 - Real Panel Item 273399
- 28 - TL2 Cylinder
- 08 - Sled Side Keeper #3 Item 272597
- 06 - Center Side Keeper #1 Item 272593
- 29 - Rear Side Keeper #2 Item 272595

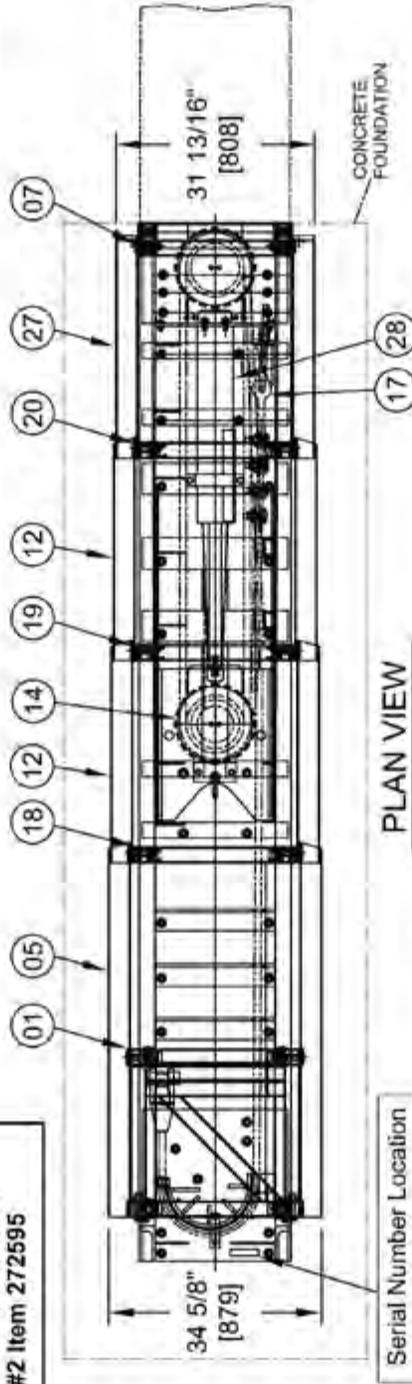
270126-C - Test Level 2, Concrete
 270126-A - Test Level 2, Asphalt



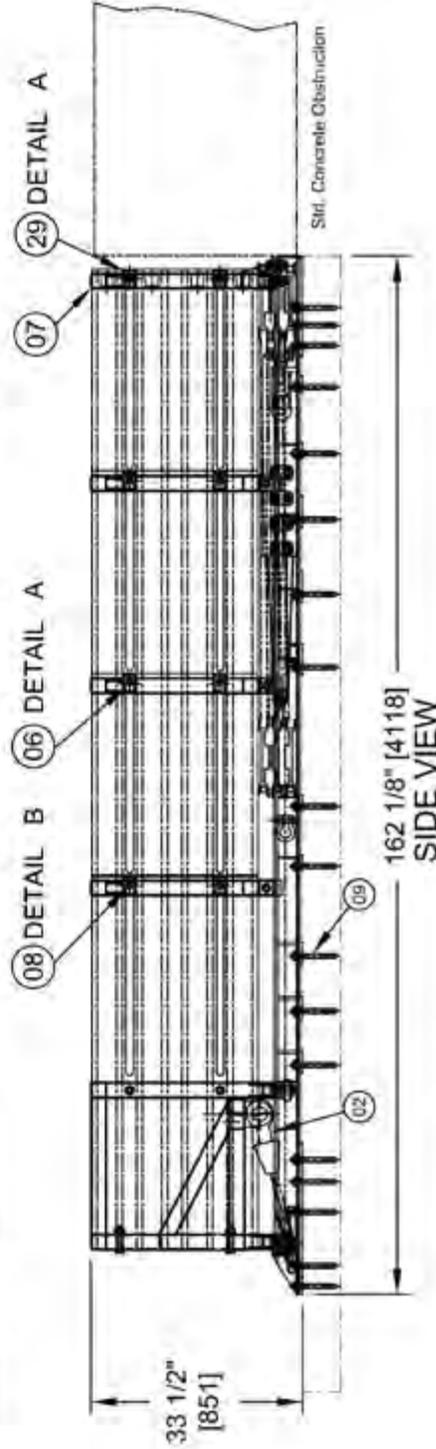
DETAIL B



DETAIL A



PLAN VIEW



SIDE VIEW

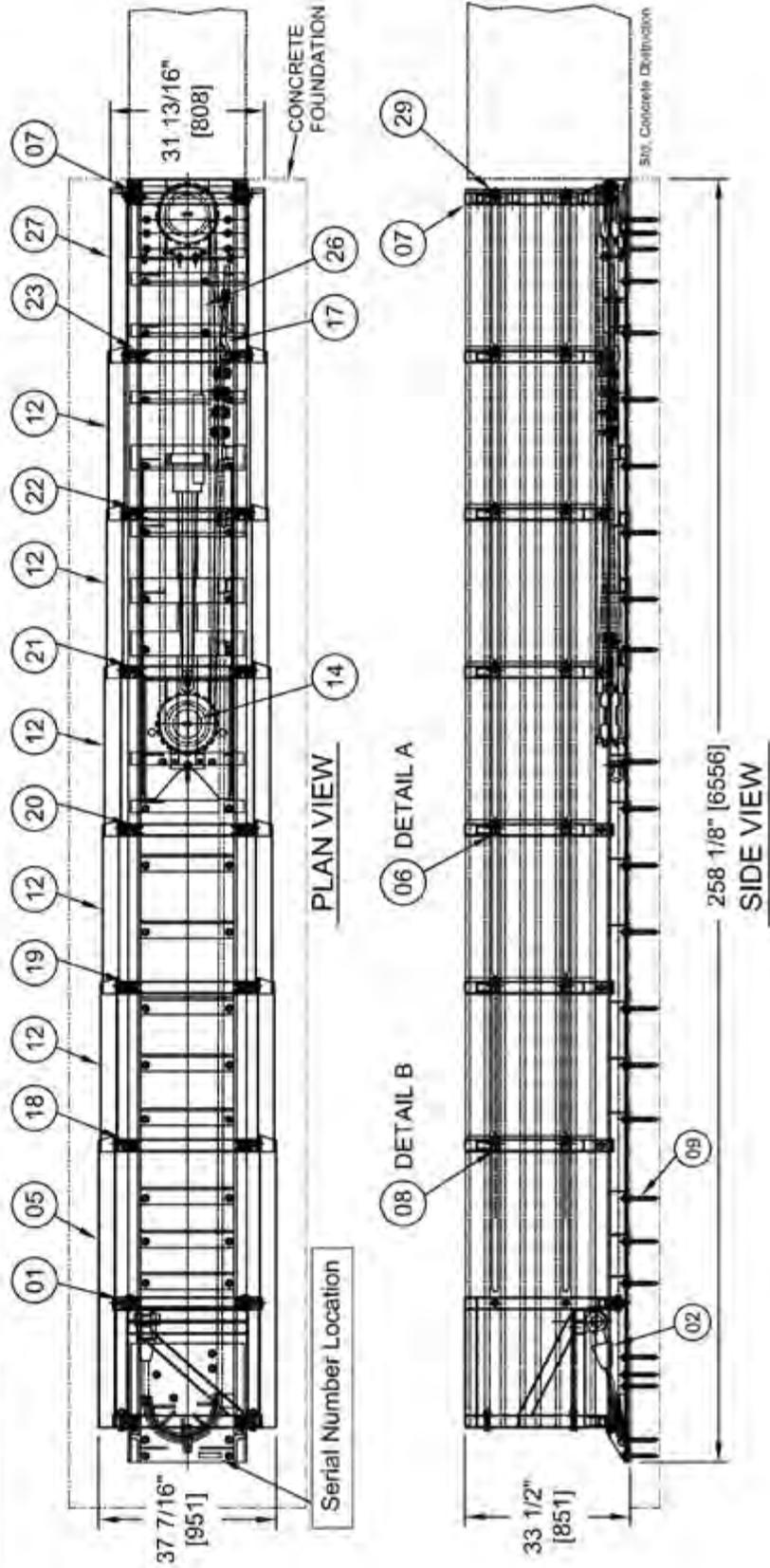
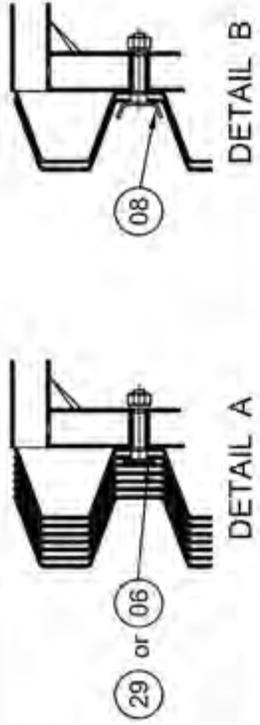




APPENDIX D - SMART CUSHION, TEST LEVEL III

- 01 - Front TL3 Sled Item 274649
- 02 - Cable Assembly
- 05 - Sled Panel Item 273402
- 07 - Terminal Brace Item 270770
- 09 - Anchor Bolts
- 12 - Side Panels Item 273401
- 14 - Mobile Sheave Assembly
- 17 - Cable Adjuster Bolt
- 18-23 - Mobile Frames 1-6
- 26 - TL3 Cylinder
- 27 - Real Panel Item 273399
- 08 - Sled Side Keeper #3 Item 272597
- 06 - Center Side Keeper #1 Item 272593
- 29 - Rear Side Keeper #2 Item 272595

- 270128-C - Test Level 3, Concrete
- 270128-A - Test Level 3, Asphalt





APPENDIX E - TEST LEVEL II FOUNDATION

Cross Slope at Top Surface not to Exceed 1 in 10
Foundation must be a Level Plane

*** Wide Hazards and Transitions may require
the foundation to be longer. See Transition Drawings.

SPECIFICATIONS

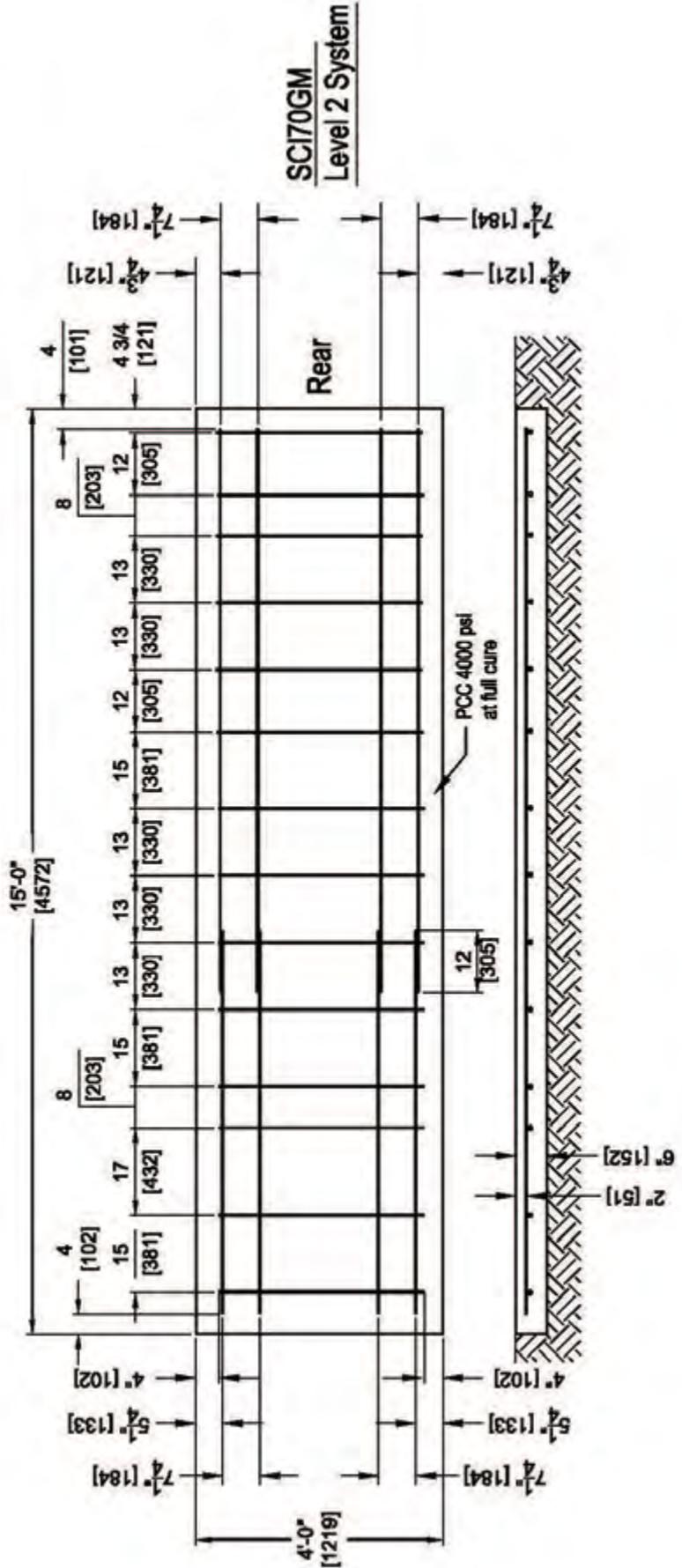
All reinforcing steel - straight #4 ASTM-A36

Embedment requirements:

- 8" reinforced concrete pad with anchor embedment of 5 1/2"
- 8" non-reinforced concrete pad with anchor embedment of 5 1/2"
- 3" asphalt over 3" concrete with anchor embedment of 16 1/2"
- 6" asphalt over 6" of compacted subbase with anchor embedment of 16 1/2"
- 8" asphalt with anchor embedment of 16 1/2"

The contractor shall furnish a certification for material installed to the following requirements:

- 6" reinforced concrete (PCC) sampling per ASTM C31-84, testing per ASTM C39-84
- 8" non-reinforced concrete (PCC) sampling per ASTM C31-84, testing per ASTM C39-84
- 3" asphalt over 3" concrete - Type SP 12.5 Level C or higher
- 6" asphalt over 6" of compacted subbase - same as above
- 8" asphalt (AC) - Type SP 12.5 Traffic Level C or higher





APPENDIX E(2) - TEST LEVEL III FOUNDATION

Cross Slope at Top Surface not to Exceed 1 in 10
Foundation must be a Level Plane

*** Wide Hazards and Transitions may require
the foundation to be longer. See Transition Drawings.

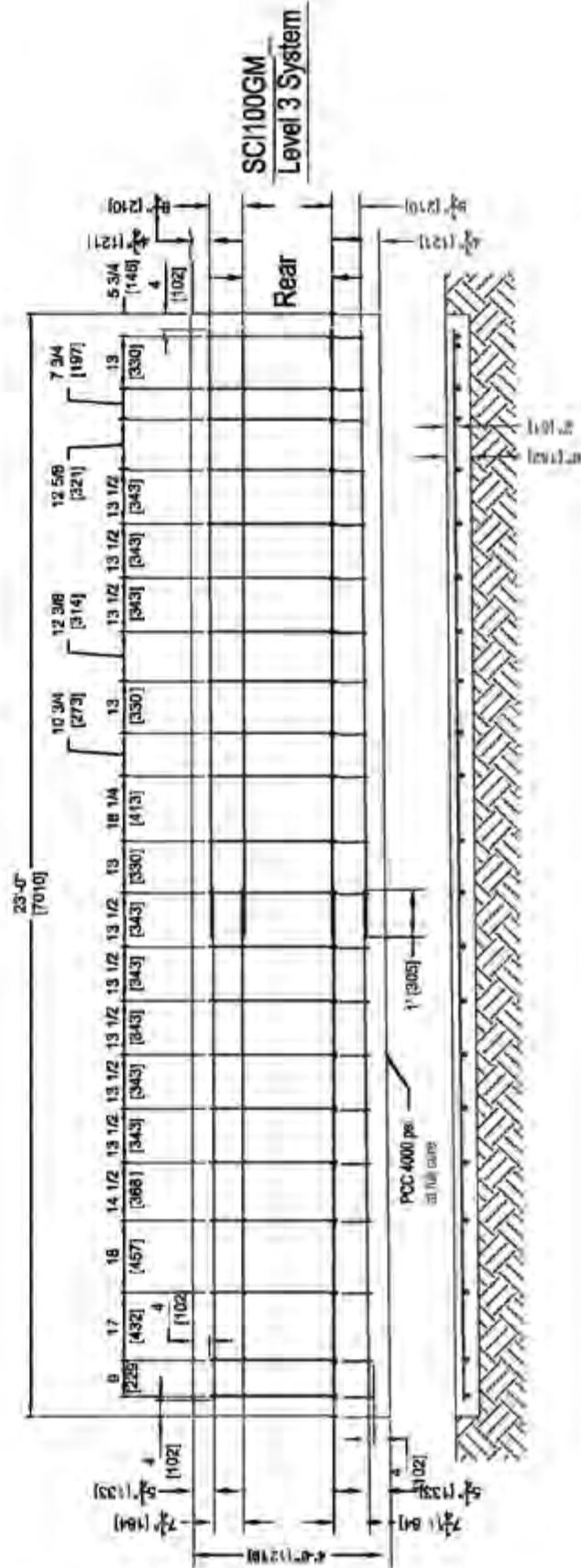
SPECIFICATIONS

All reinforcing steel - straight #4 ASTM-A36
Embedment requirements:

- 6" reinforced concrete pad with anchor embedment of 5 1/2"
- 6" non-reinforced concrete pad with anchor embedment of 5 1/2"
- 3" asphalt over 3" concrete with anchor embedment of 16 1/2"
- 6" asphalt over 6" of compacted subbase with anchor embedment of 16 1/2"
- 8" asphalt with anchor embedment of 16 1/2"

The contractor shall furnish a certification for material installed to the following requirements:

- 6" reinforced concrete (PCC) sampling per ASTM C31-84, testing per ASTM C39-84
- 8" non-reinforced concrete (PCC) sampling per ASTM C31-84, testing per ASTM C39-84
- 3" asphalt over 3" concrete - Type SP 12.5 Level C or higher
- 6" asphalt over 6" of compacted subbase - same as above
- 8" asphalt (AC) - Type SP 12.5 Traffic Level C or higher



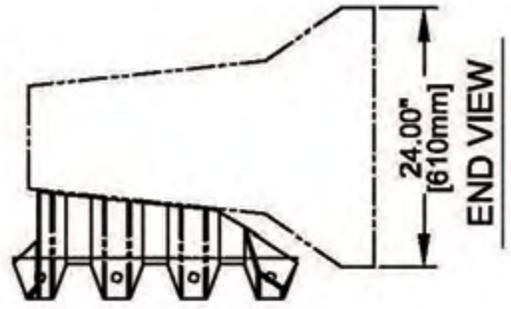
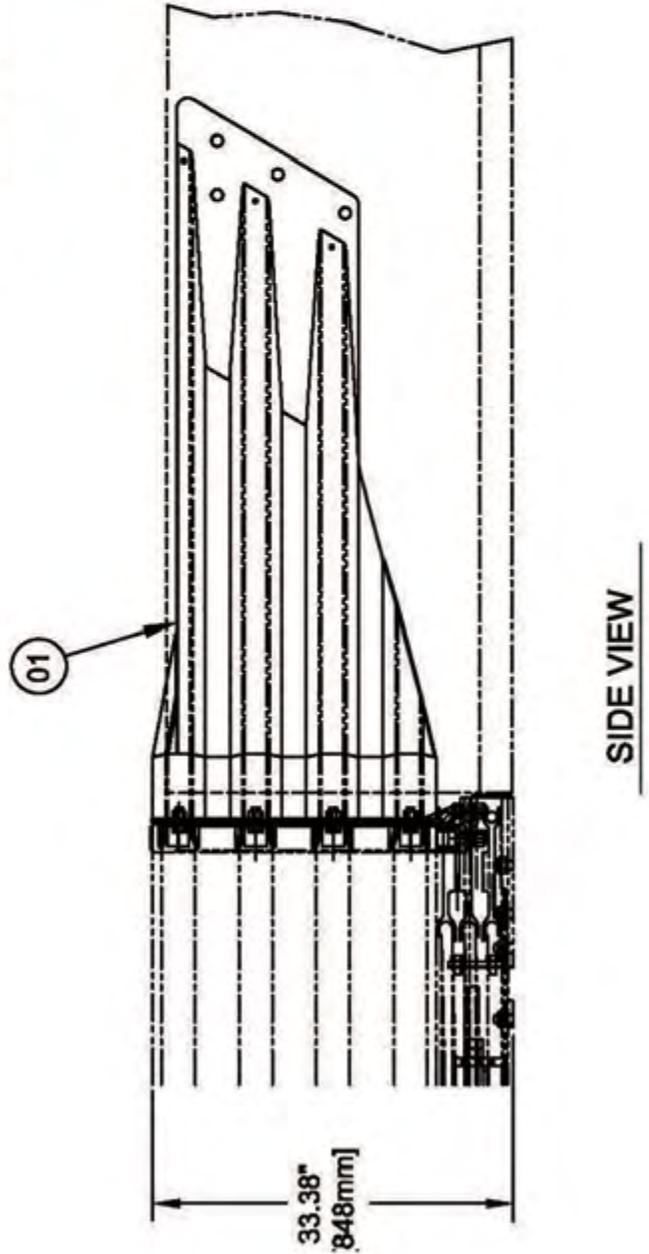
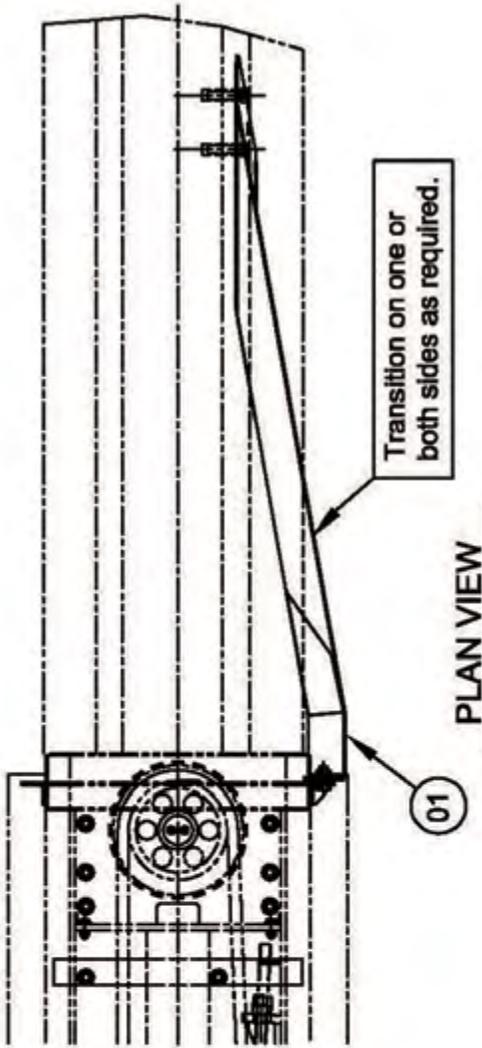


APPENDIX F - NCHRP 350 TRANSITION, JERSEY/F SHAPE BARRIER

Parts List:

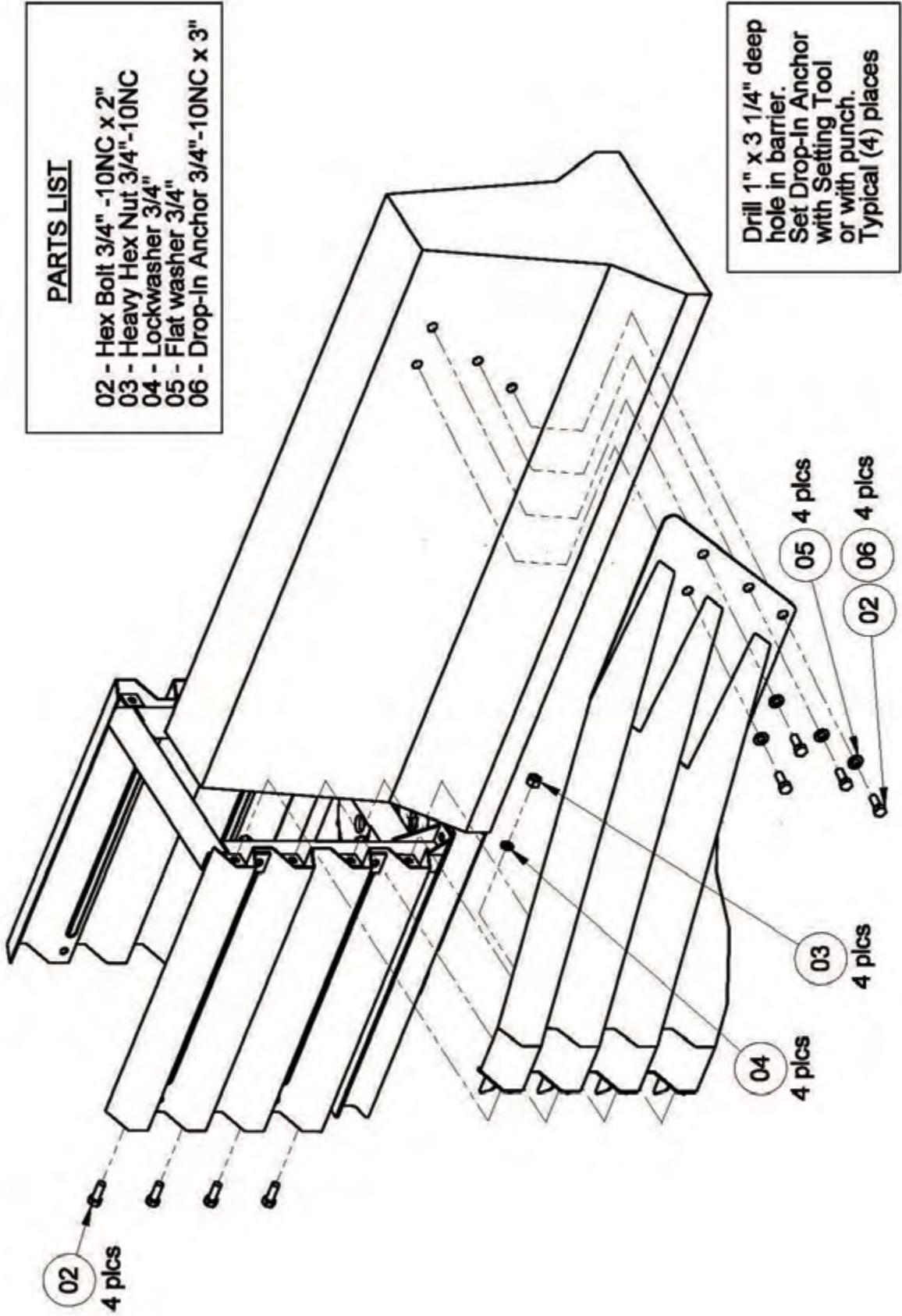
01 - Transition Jersey Barrier Right #275297 (shown)

01 - Transition Jersey Barrier Left #275294 (not shown)





APPENDIX F(2) - NCHRP 350 TRANSITION, JERSEY/F SHAPE BARRIER



- PARTS LIST**
- 02 - Hex Bolt 3/4" -10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lockwasher 3/4"
 - 05 - Flat washer 3/4"
 - 06 - Drop-In Anchor 3/4"-10NC x 3"

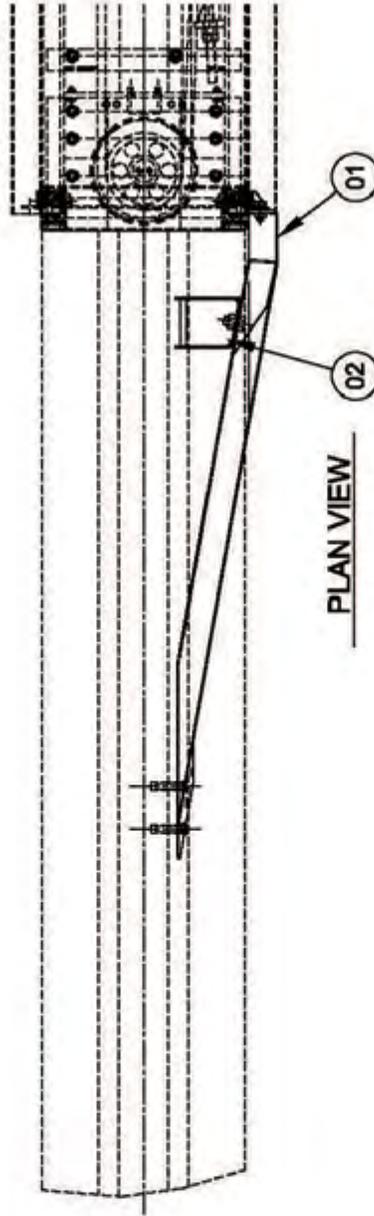
Drill 1" x 3 1/4" deep hole in barrier.
Set Drop-In Anchor with Setting Tool or with punch.
Typical (4) places





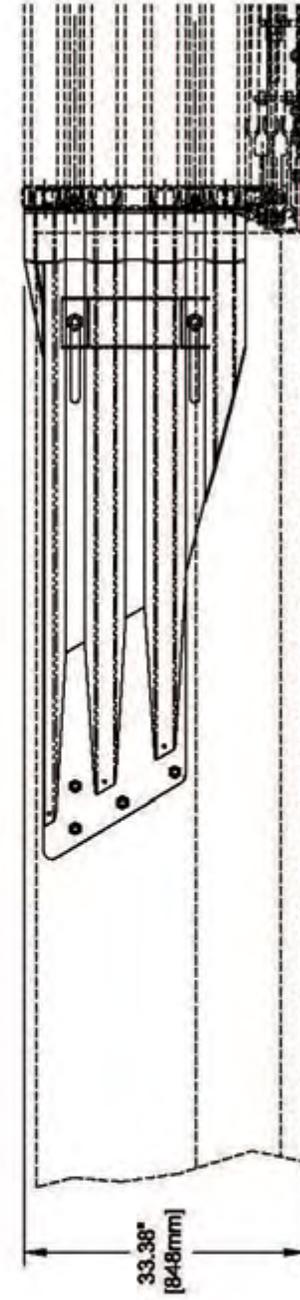
APPENDIX G - MASH TRANSITION, JERSEY/F SHAPE BARRIER PERMANENT

Parts List:	Jersey/K-Rail
01 - Transition Panel MASH Left (shown)	#268891
01 - Transition Panel MASH Right (not shown)	#268892
02 - Support Bracket MASH Left (shown)	#268893
02 - Support Bracket MASH Right (not shown)	#268894

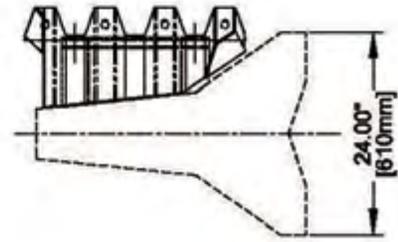


PLAN VIEW

Not required for unidirectional traffic



SIDE VIEW



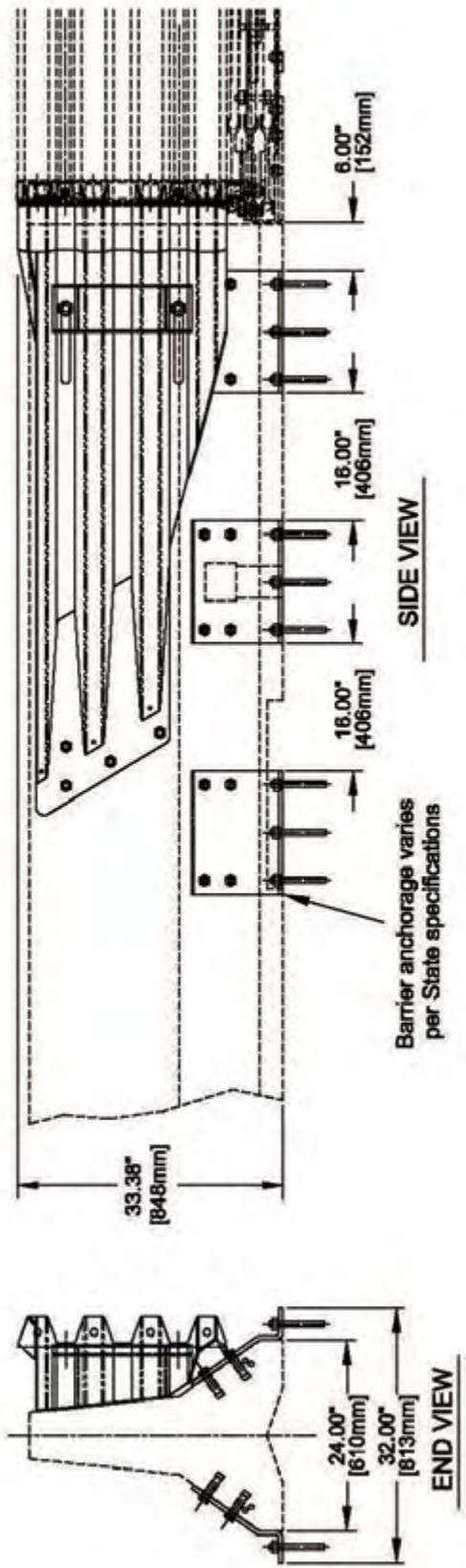
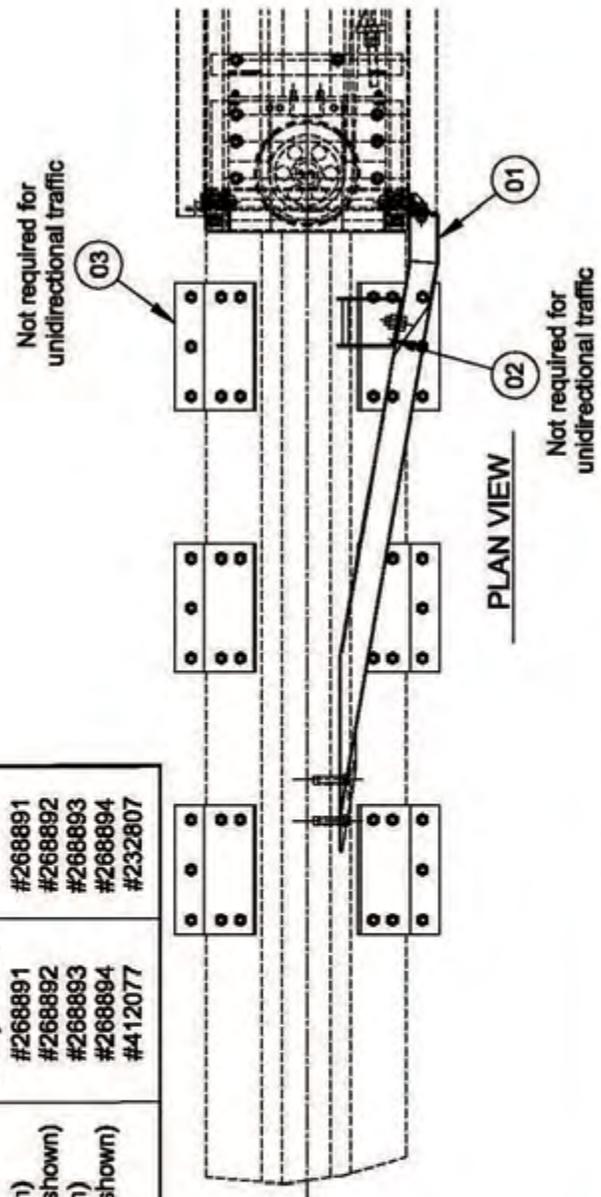
END VIEW





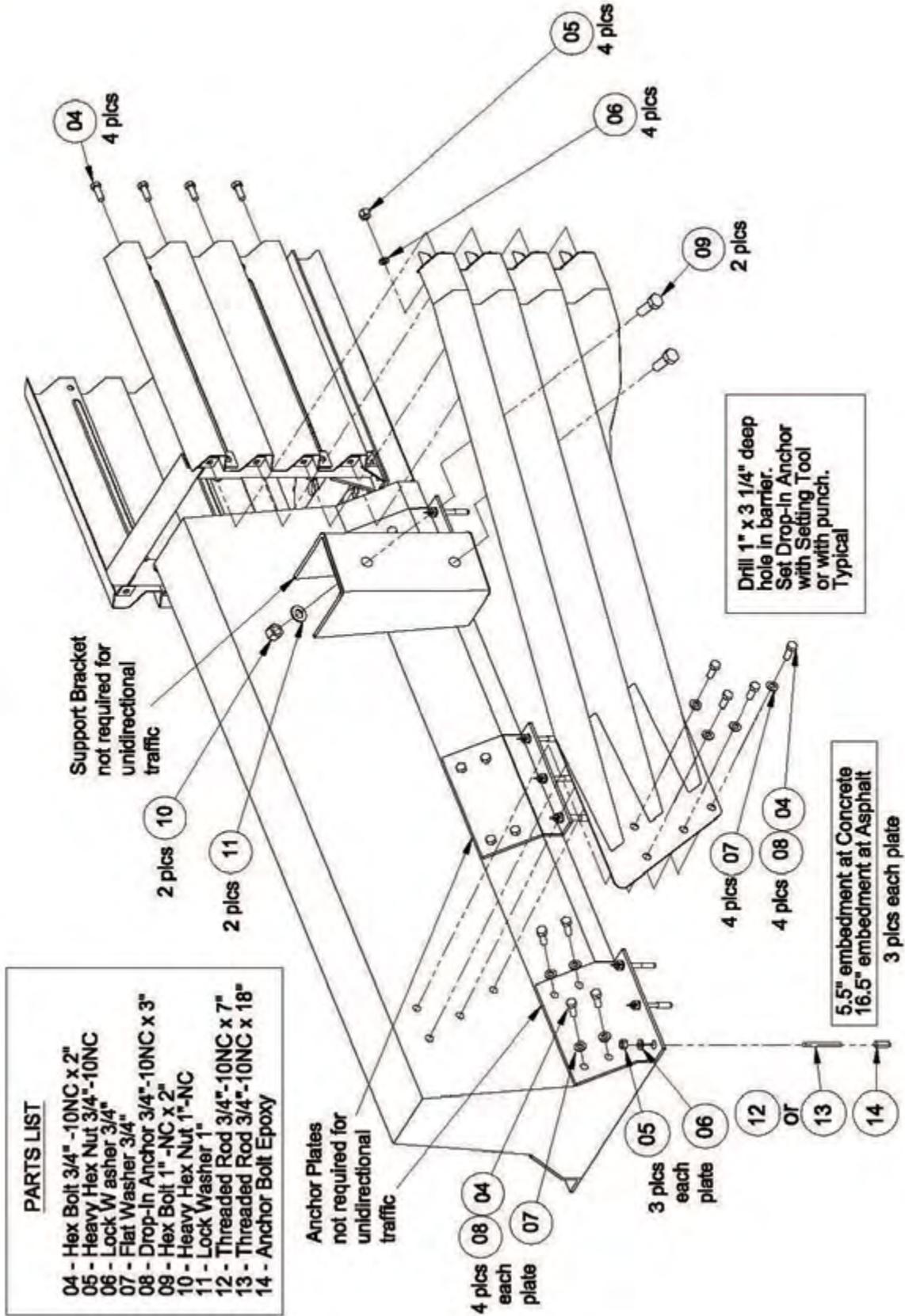
APPENDIX G(2) - MASH TRANSITION, JERSEY/F SHAPE BARRIER TEMPORARY

Parts List:	Jersey Barrier	K-Rail
01 - Transition Panel MASH Left (shown)	#268891	#268891
01 - Transition Panel MASH Right (not shown)	#268892	#268892
02 - Support Bracket MASH Left (shown)	#268893	#268893
02 - Support Bracket MASH Right (not shown)	#268894	#268894
03 - Median Barrier Support Plate	#412077	#232807





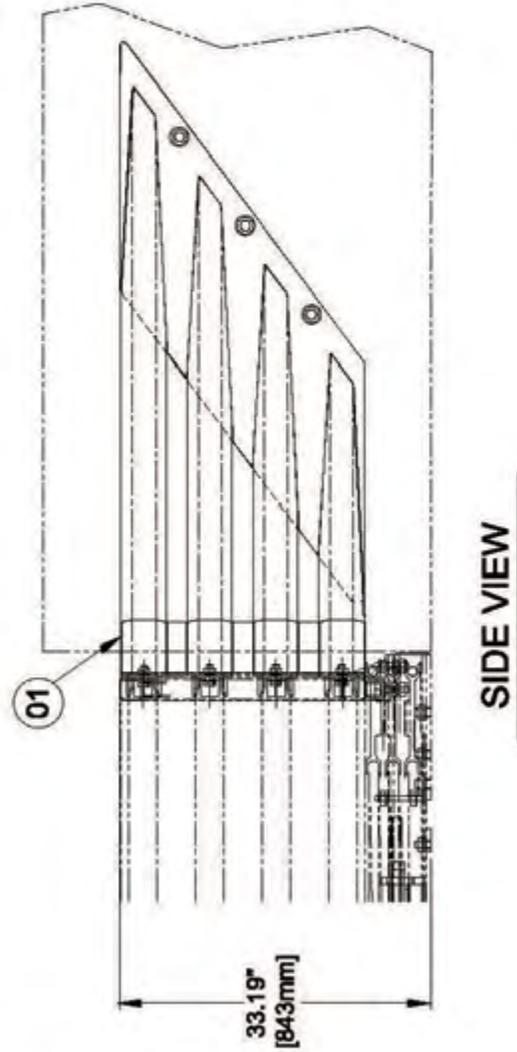
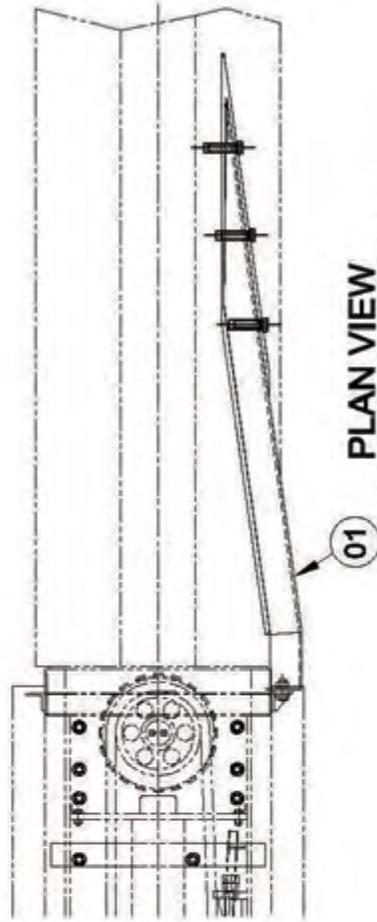
APPENDIX G(3) - MASH TRANSITION, JERSEY/F SHAPE BARRIER PERM. & TEMP





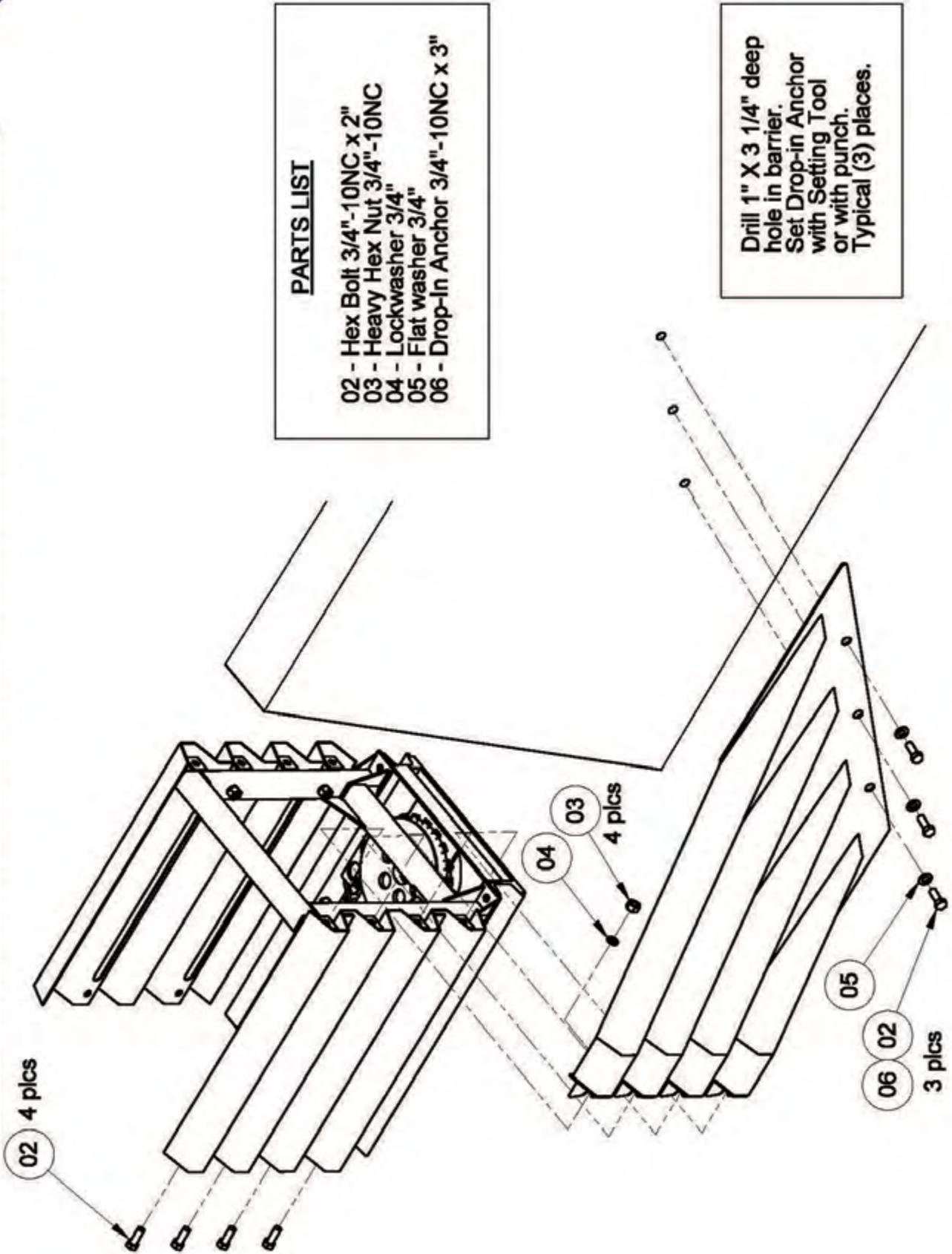
APPENDIX H - TRANSITION, MEDIAN BARRIER - SINGLE SLOPE 24" - 26.75" (610 - 679mm) Base

- Parts List:
01 - Transition Single Slope Median Barrier - Right #275299 (shown)
01 - Transition Single Slope Median Barrier - Left #275302 (not shown)





APPENDIX H(2) - TRANSITION, MEDIAN BARRIER - SINGLE SLOPE 24" - 26.75" (610 - 679mm) Base



PARTS LIST

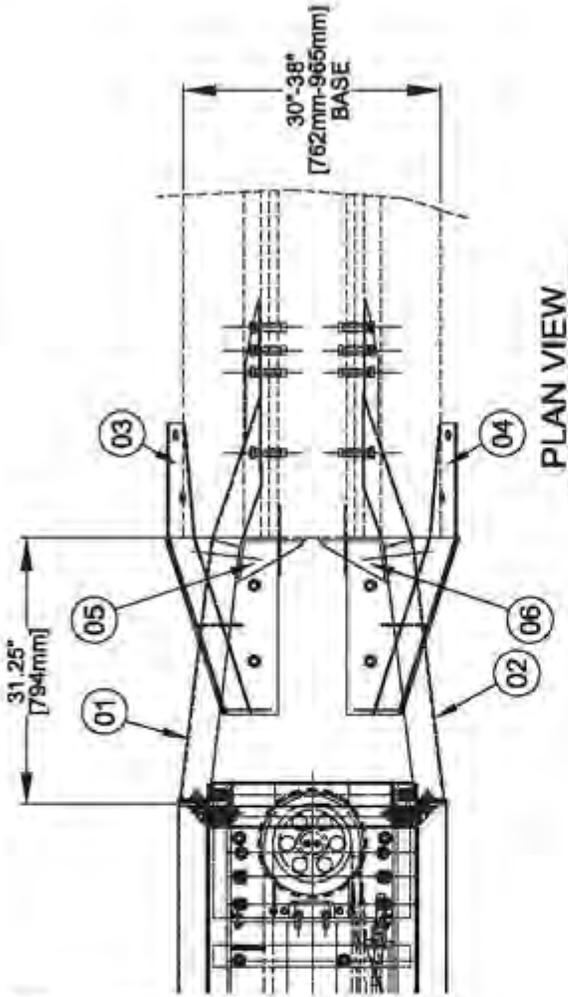
- 02 - Hex Bolt 3/4"-10NC x 2"
- 03 - Heavy Hex Nut 3/4"-10NC
- 04 - Lockwasher 3/4"
- 05 - Flat washer 3/4"
- 06 - Drop-In Anchor 3/4"-10NC x 3"

Drill 1" X 3 1/4" deep hole in barrier.
Set Drop-in Anchor with Setting Tool or with punch.
Typical (3) places.



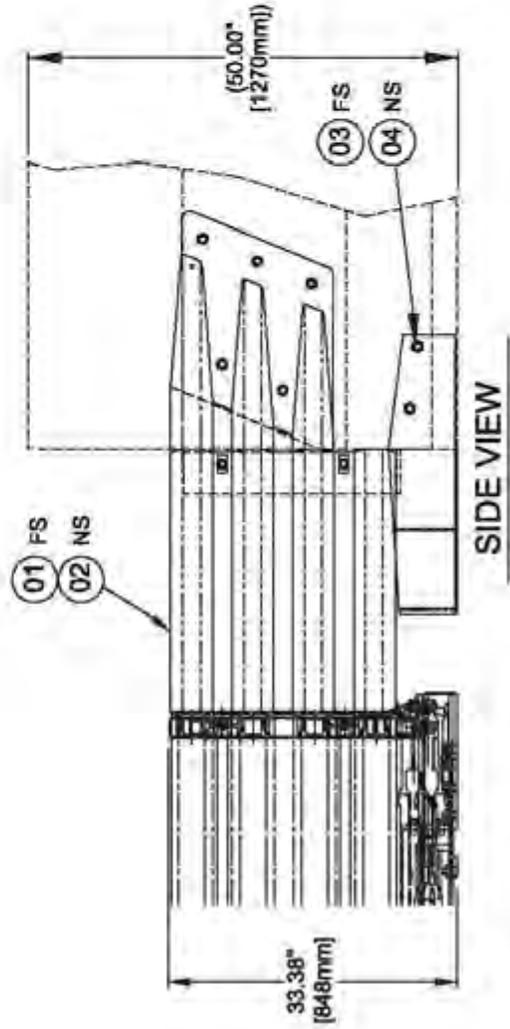


APPENDIX I - TRANSITION, JERSEY/F SHAPE, VARIABLE WIDTH BASE



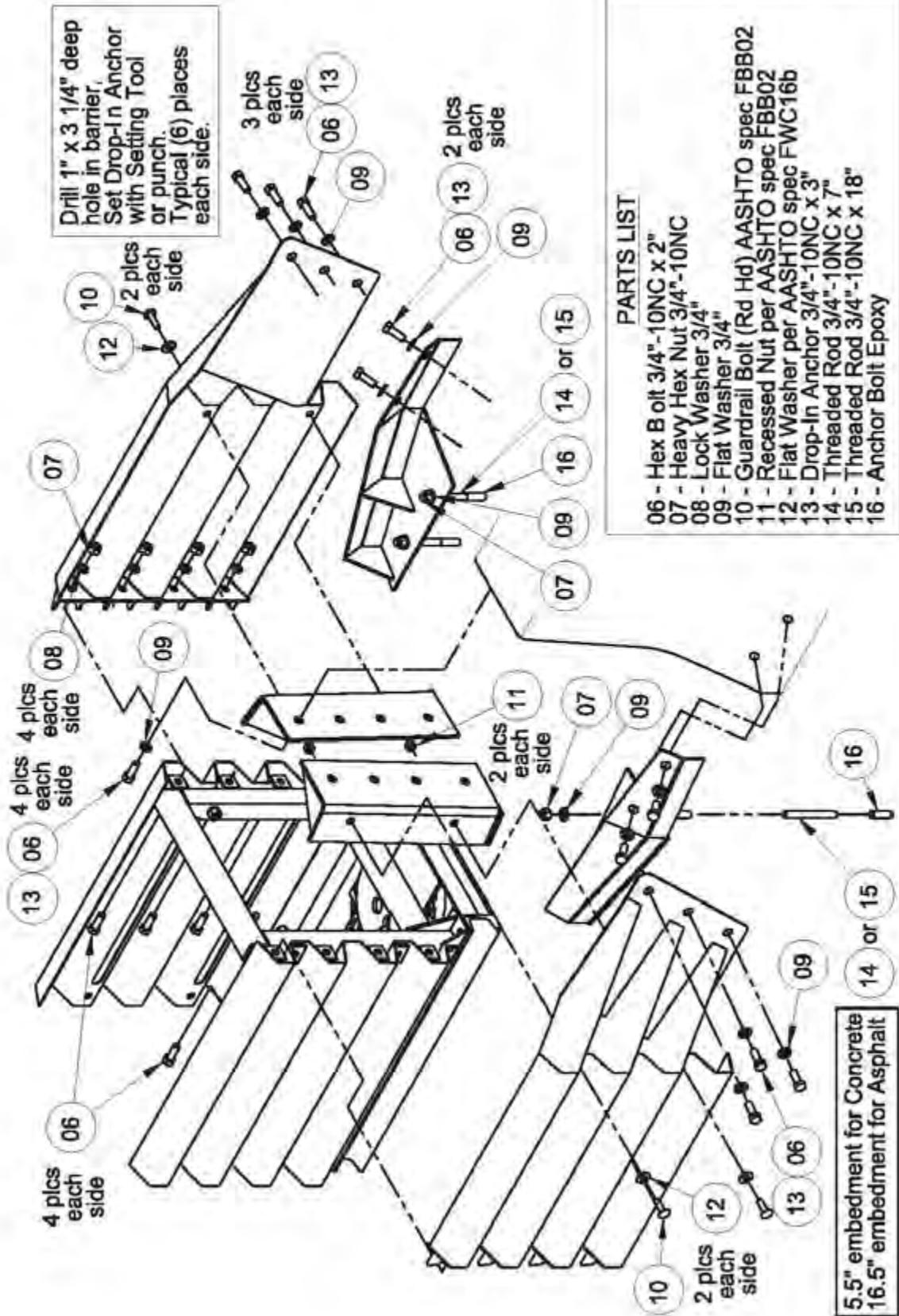
- Parts List for Double Sided Median Barrier 30"-38" Base:
 Two-Sided Full Assembly #239542 (with rub rail),
 #239545 (without rub rail)
 01 - Transition - Left #275272
 02 - Transition - Right #275273
 03 - Transition Rub Rail - Left #275270
 04 - Transition Rub Rail - Right #275271
 05 - Transition Support Bracket - Right #239471
 06 - Transition Support Bracket - Left #239472

For use with barriers with base widths of 30"-38"
 Rub rails only required for base widths > 34"



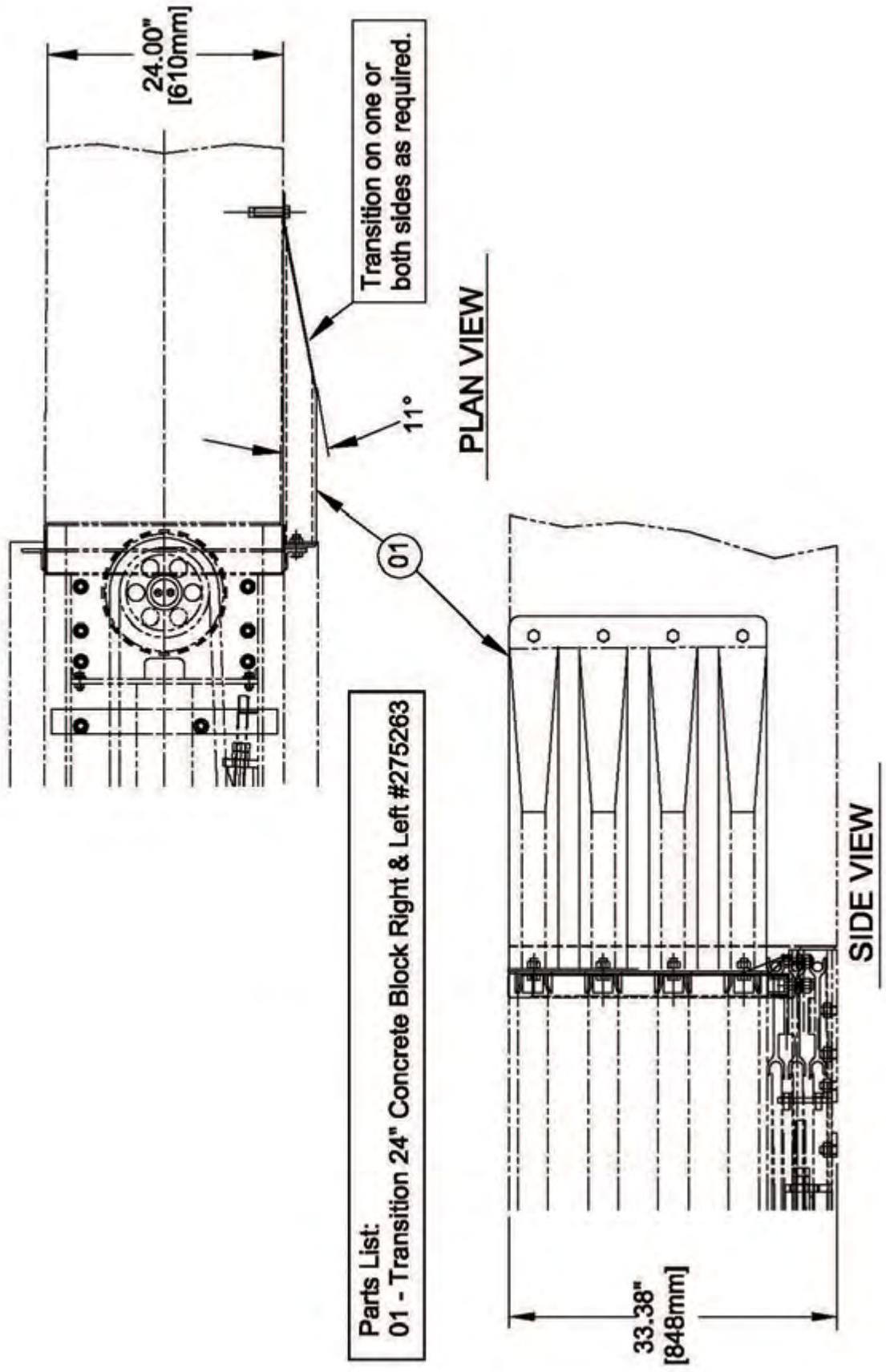


APPENDIX I(2) - TRANSITION, JERSEY/F SHAPE, VARIABLE WIDTH BASE





APPENDIX J - TRANSITION, CONCRETE BLOCK, 24 INCH (610mm)

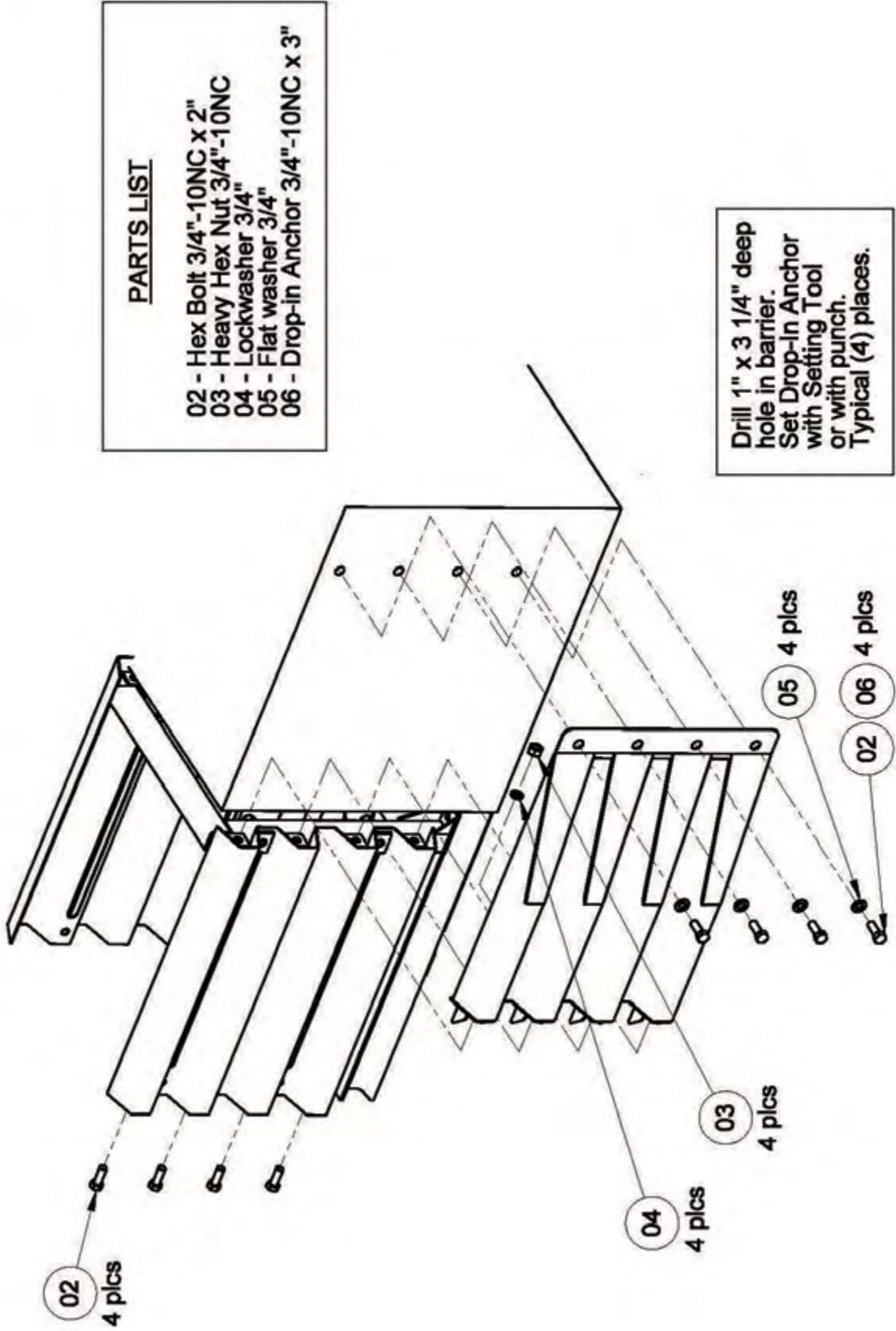


Parts List:
01 - Transition 24" Concrete Block Right & Left #275263





APPENDIX J(2) - TRANSITION, CONCRETE BLOCK, 24 INCH (610mm)



- PARTS LIST**
- 02 - Hex Bolt 3/4"-10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lockwasher 3/4"
 - 05 - Flat washer 3/4"
 - 06 - Drop-in Anchor 3/4"-10NC x 3"

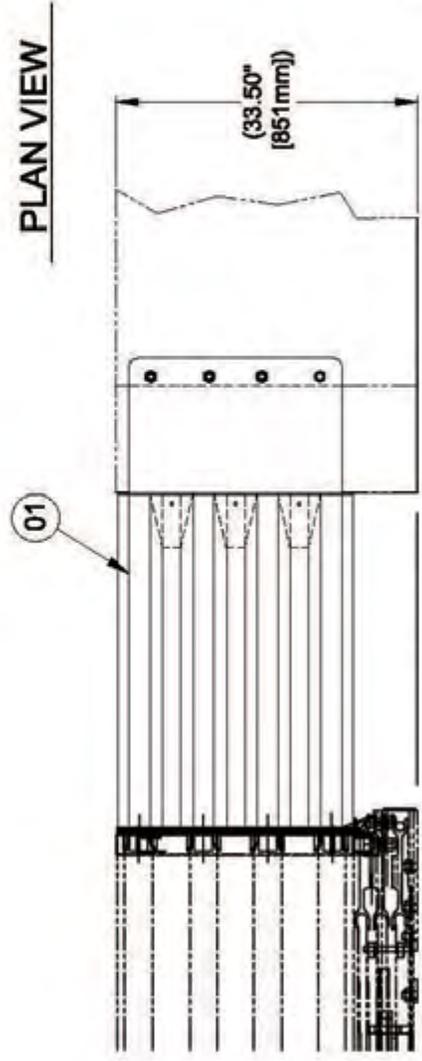
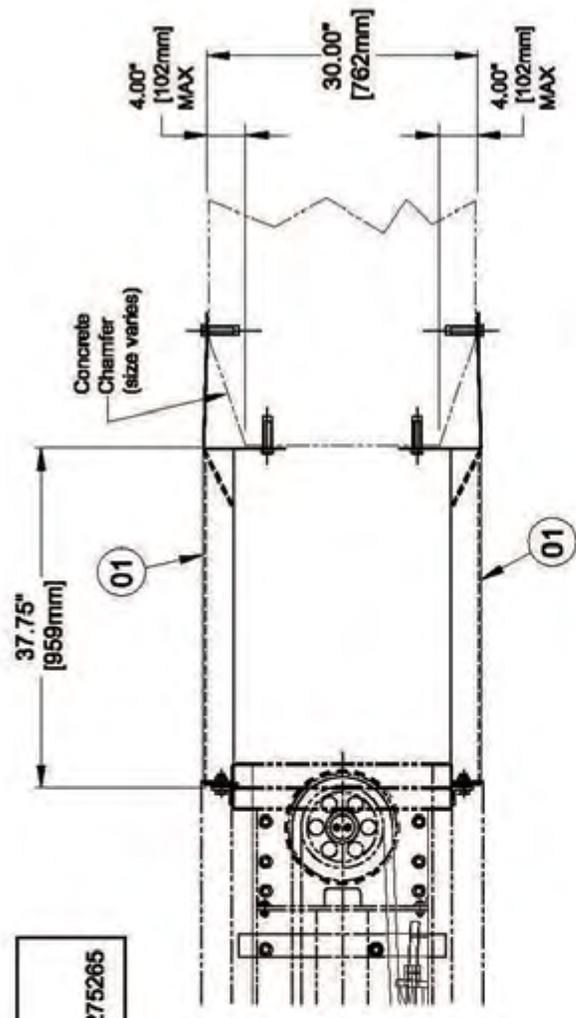
Drill 1" x 3 1/4" deep hole in barrier.
Set Drop-in Anchor with Setting Tool or with punch.
Typical (4) places.





APPENDIX K - TRANSITION, CONCRETE BLOCK, 30 INCH (762mm)

Parts List:
Two-Sided Full Assembly #275279
01 - Transition 30" Concrete Straight Connection #275265



PLAN VIEW

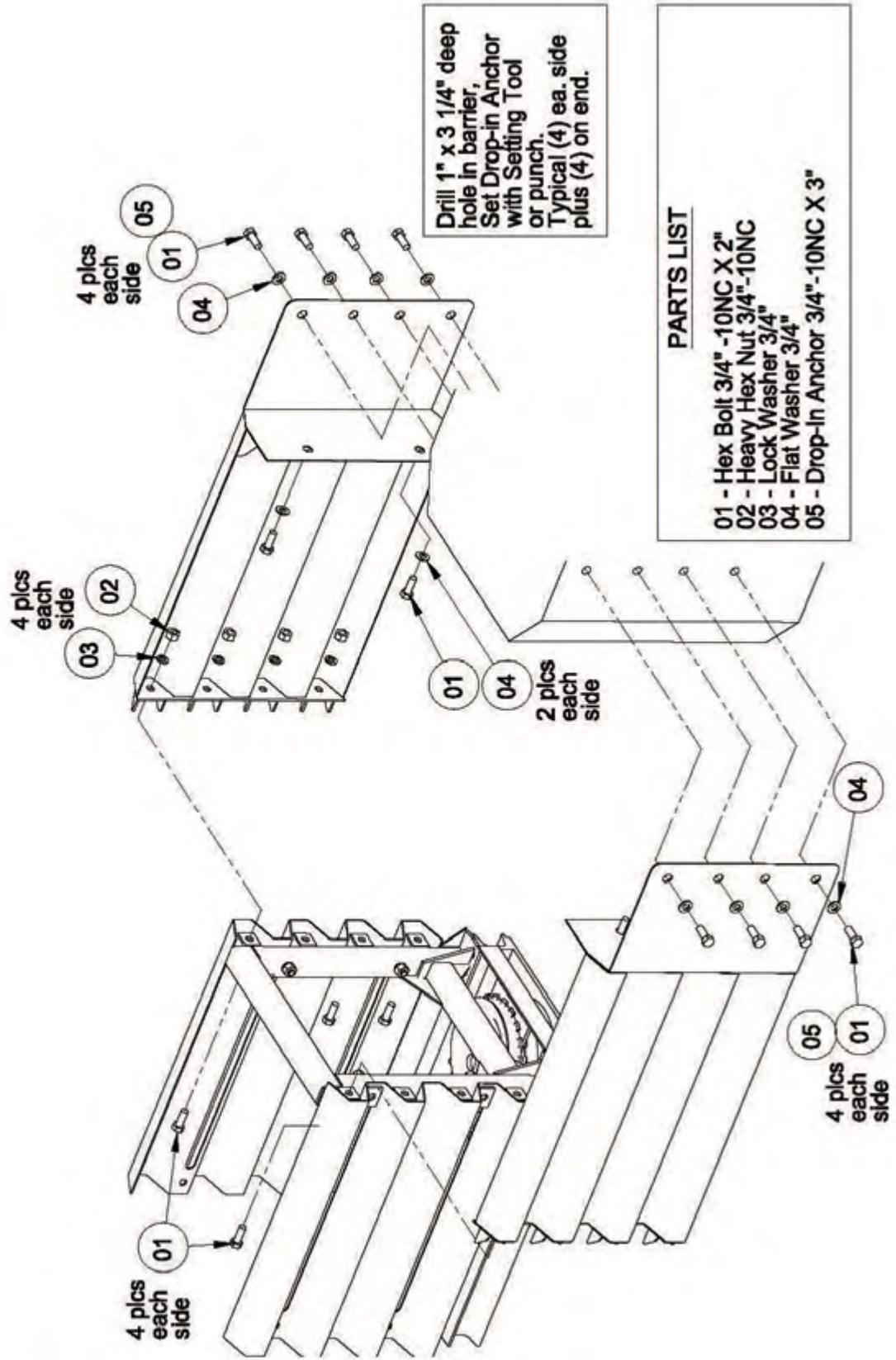
SIDE VIEW

USED FOR:
1. Unchamfered Concrete Block ***
2. Chamfered Concrete Block ***
*** Chamfer limited to <4" ***





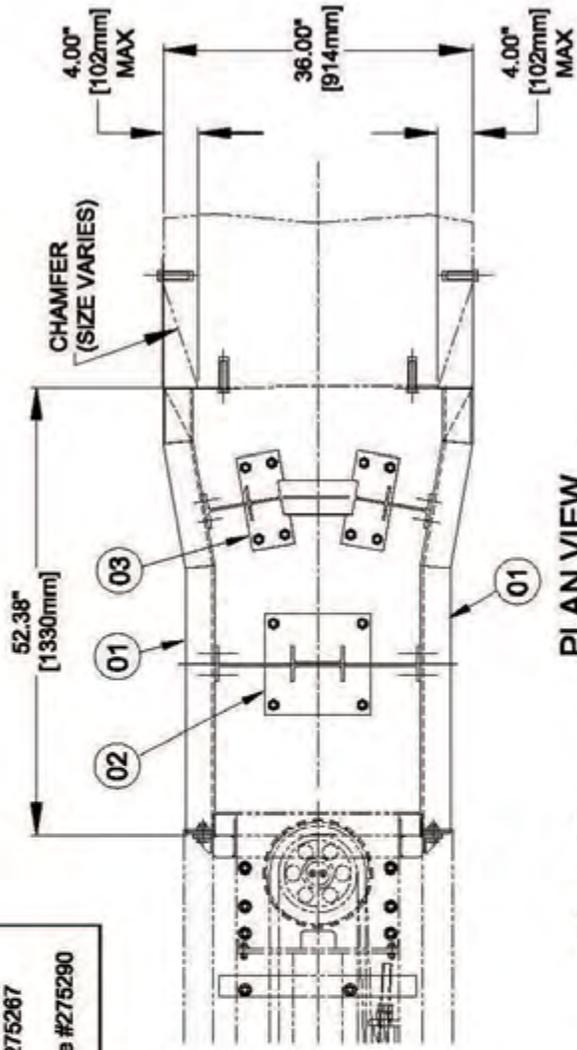
APPENDIX K(2) - TRANSITION, CONCRETE BLOCK, 30 INCH (762mm)



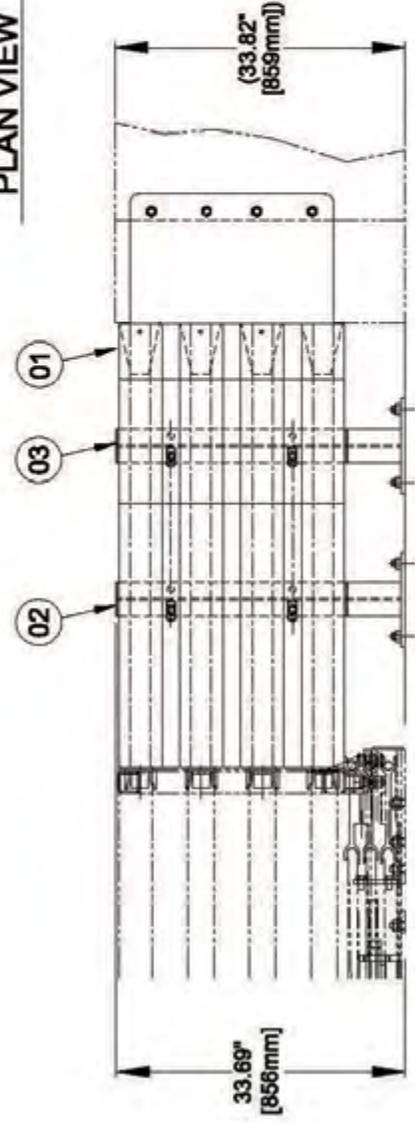


APPENDIX L - MASH TRANSITION, CONCRETE BLOCK, 36 INCH (915mm)

- Parts List:
 Two-Sided Full Assembly #275283
 01 - Transition 36" Concrete Straight Connection #275267
 02 - Transition Concrete Spanner Braces #275291
 03 - Transition Concrete #1 Tapered Spanner Brace #275290



PLAN VIEW



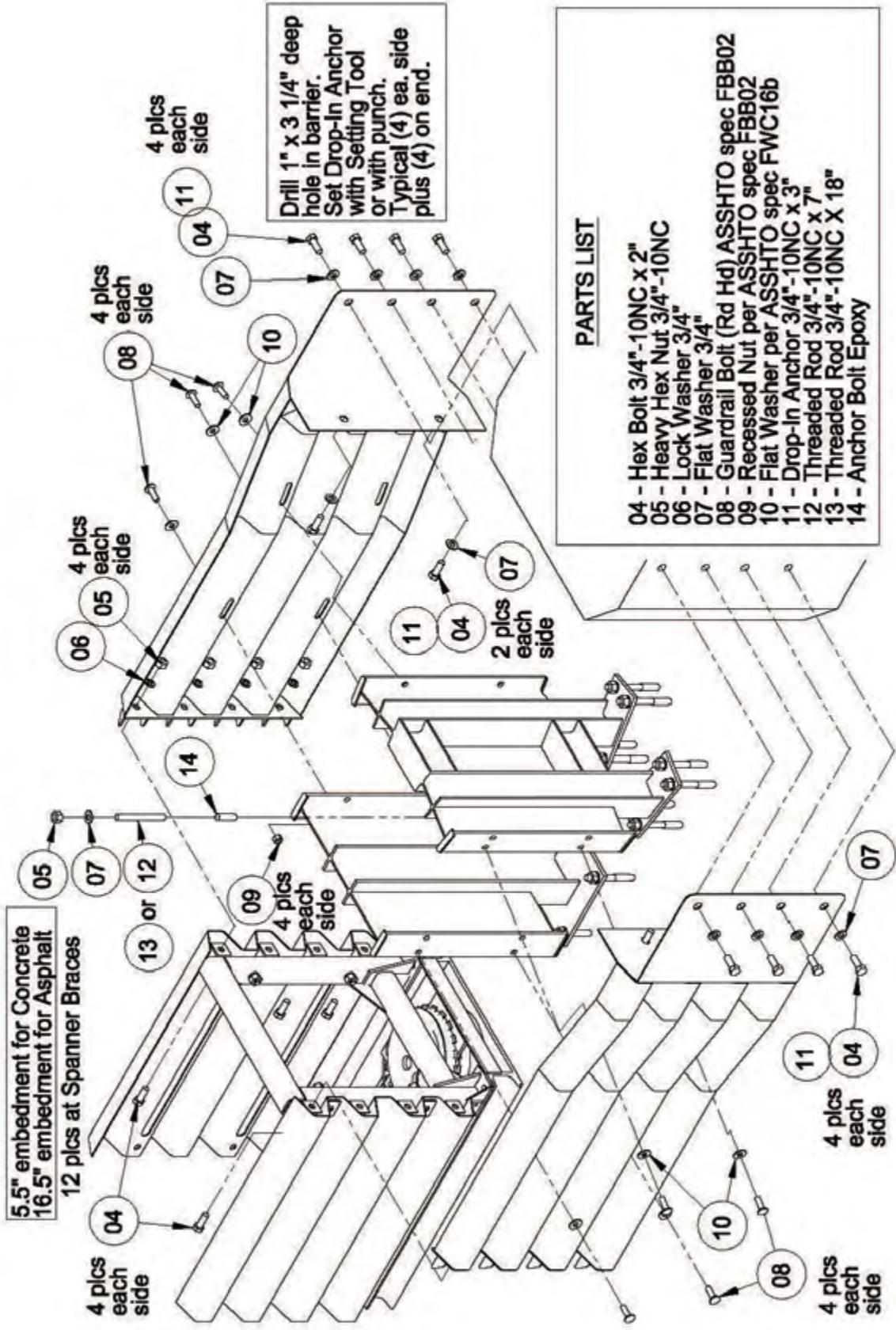
SIDE VIEW

USED FOR:
 1. Unchamfered Concrete Block ***
 2. Chamfered Concrete Block ***
 ***Chamfer limited to <4"





APPENDIX L(2) - MASH TRANSITION, CONCRETE BLOCK, 36 INCH (915mm)



5.5" embedment for Concrete
16.5" embedment for Asphalt
12 pcs at Spanner Braces

Drill 1" x 3 1/4" deep hole in barrier. Set Drop-In Anchor with Setting Tool or with punch. Typical (4) ea. side plus (4) on end.

- PARTS LIST**
- 04 - Hex Bolt 3/4"-10NC x 2"
 - 05 - Heavy Hex Nut 3/4"-10NC
 - 06 - Lock Washer 3/4"
 - 07 - Flat Washer 3/4"
 - 08 - Guardrail Bolt (Rd Hd) ASSHTO spec FBB02
 - 09 - Recessed Nut per ASSHTO spec FBB02
 - 10 - Flat Washer per ASSHTO spec FWC16b
 - 11 - Drop-In Anchor 3/4"-10NC x 3"
 - 12 - Threaded Rod 3/4"-10NC x 7"
 - 13 - Threaded Rod 3/4"-10NC x 18"
 - 14 - Anchor Bolt Epoxy

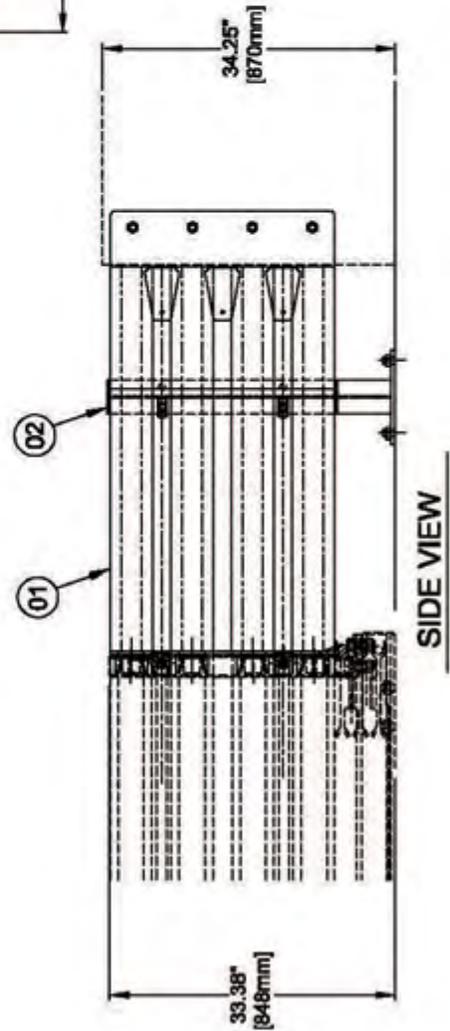
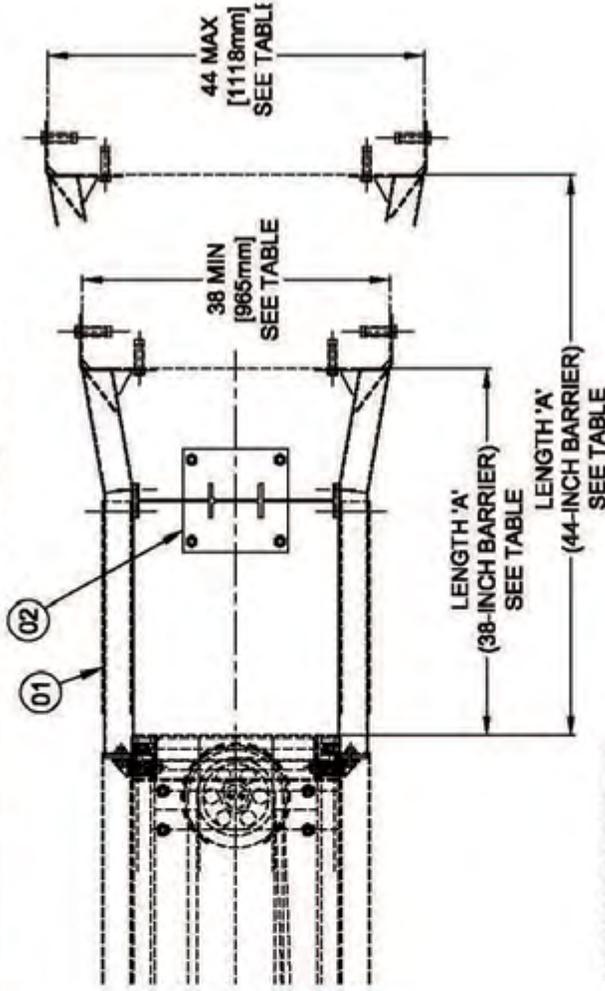




APPENDIX M - TRANSITION, CONCRETE BLOCK, 38-44 INCH (965-1118mm)

BARRIER WIDTH	ASSEMBLY PART NO JDE	PANEL ET-06-38 PART NO (ITEM 01) JDE	STEEL POST ET-06-22 PART NO (ITEM 2) JDE	LENGTH 'A'
38"	254621	254953	275291	48 1/2"
40"	254622	254954	275291	54 1/4"
42"	254623	254955	275291	60"
44"	254624	254956	275291	65 3/4"

PLAN VIEW

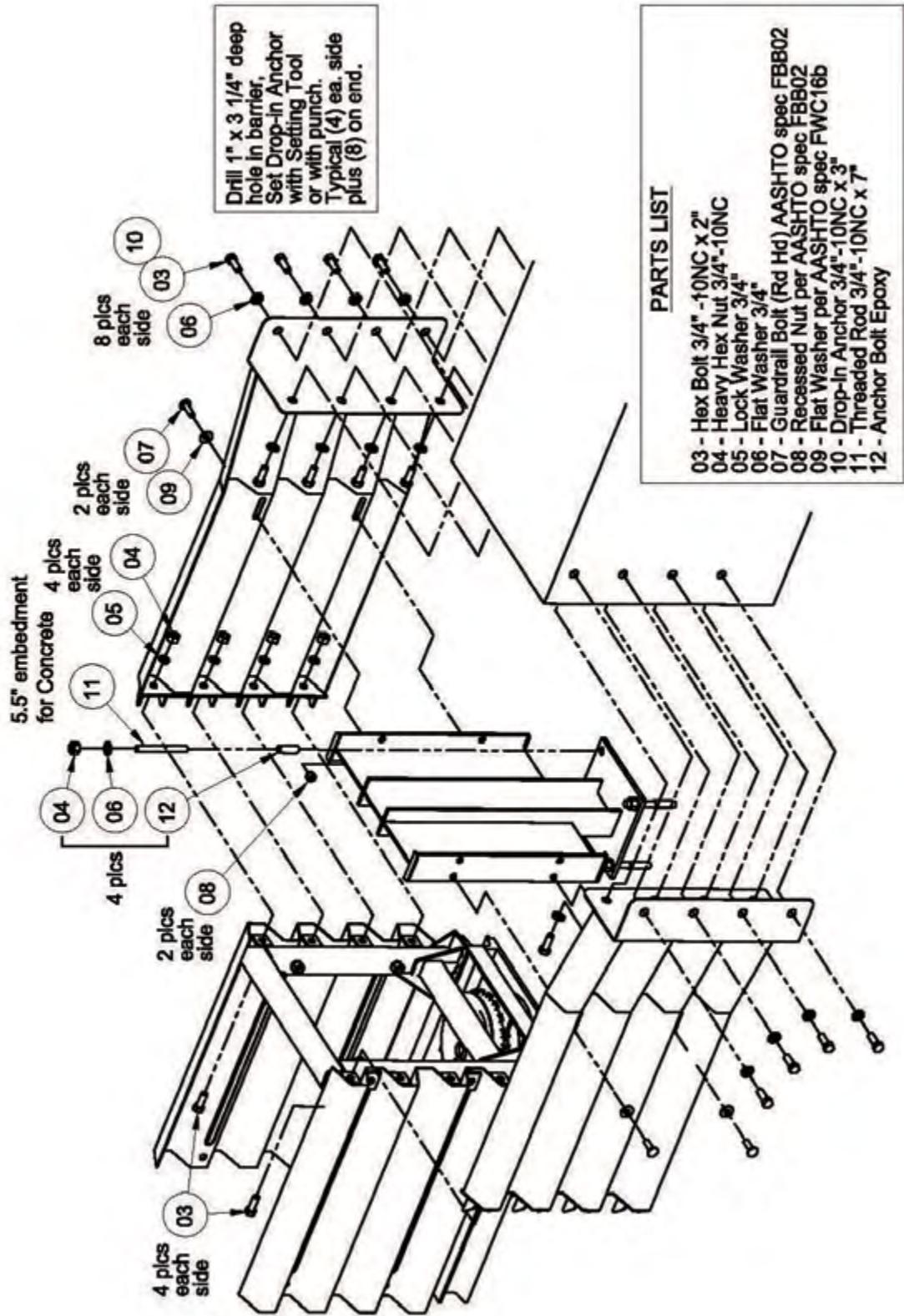


SIDE VIEW





APPENDIX M(2) - TRANSITION, CONCRETE BLOCK, 38-44 INCH (965-1118mm)

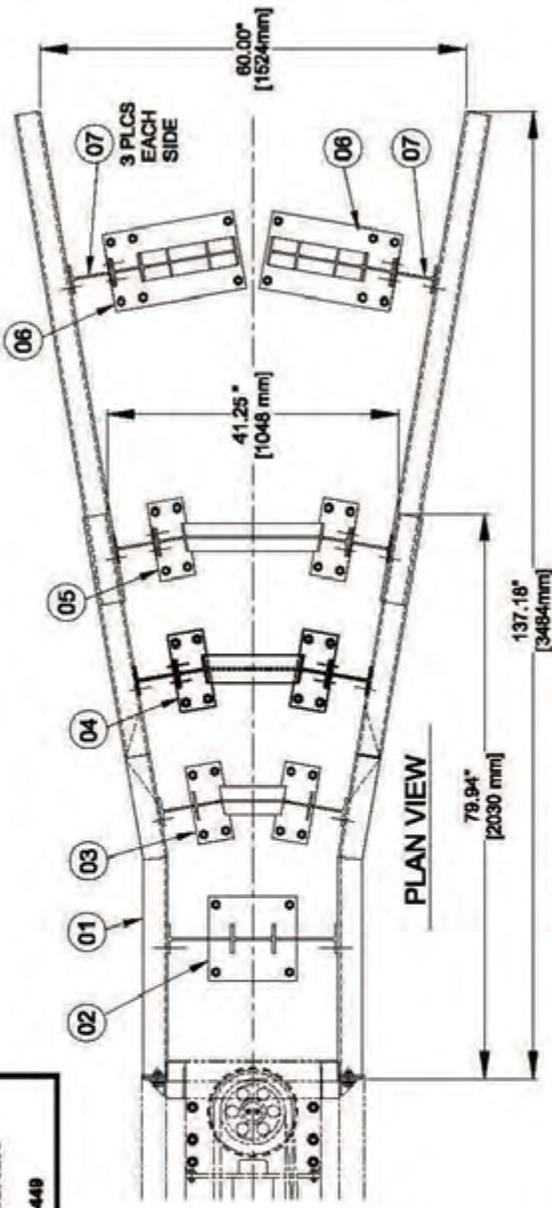




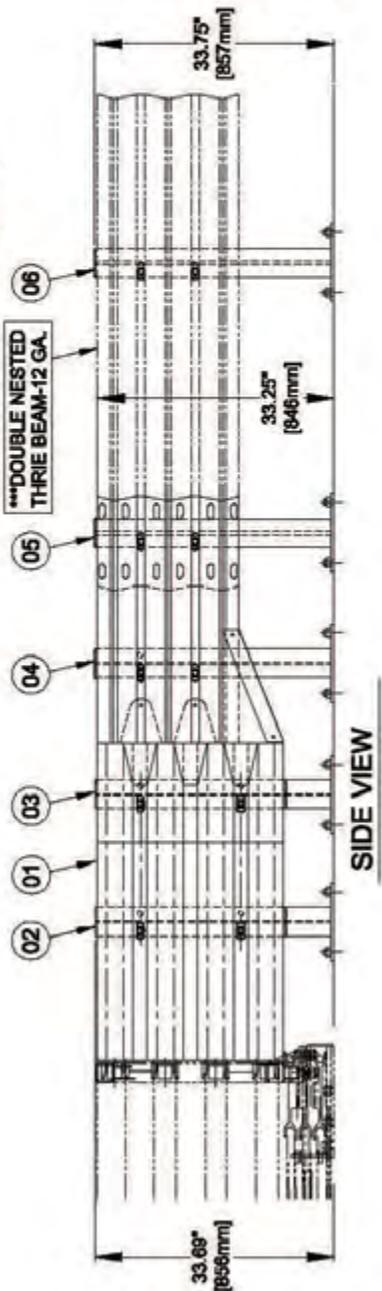
APPENDIX N - TRANSITION, THRIE BEAM WIDE TAPER

Parts List:
 Gore Assembly Complete to Braces #6 - #276288
 01-Transition Thrie 10 Degree Flare Right #276304
 01-Transition Thrie 10 Degree Flare Left #276306
 02-Transition Concrete Spanner Braces #276291
 03-Transition Concrete #1 Tapered Spanner Braces # 276280
 04-Transition Gore Tapered #1 Spanner Braces #276292
 05-Transition Gore Tapered #2 Spanner Braces #276293
 06-Thrie Beam Concrete Leg Braces #270785
 07-Thrie Beam Blockout AA-SHTO PWB02 #233449

*****SPICE BOLTS AND GUARDRAILS BY OTHERS*****



NOTES:
 1) DIMENSIONS SHOWN ARE FOR 60" WIDTH
 2) FOR EACH 1" OF WIDTH CHANGE, ADD OR SUBTRACT THE FOLLOWING:
 2.88" [73.15mm] TO LENGTH OF GUARDRAIL
 2.84" [72.13mm] TO OVERALL LENGTH
 3) ADD OR SUBTRACT ADDITIONAL POST ON EACH SIDE FOR EACH 13" [330mm] CHANGE IN WIDTH.
 4) GUARDRAIL TERMINATION - YOU MUST ADD THE GUARDRAIL OVERLAP LENGTH AND TERMINATE PER STATE REGULATIONS.

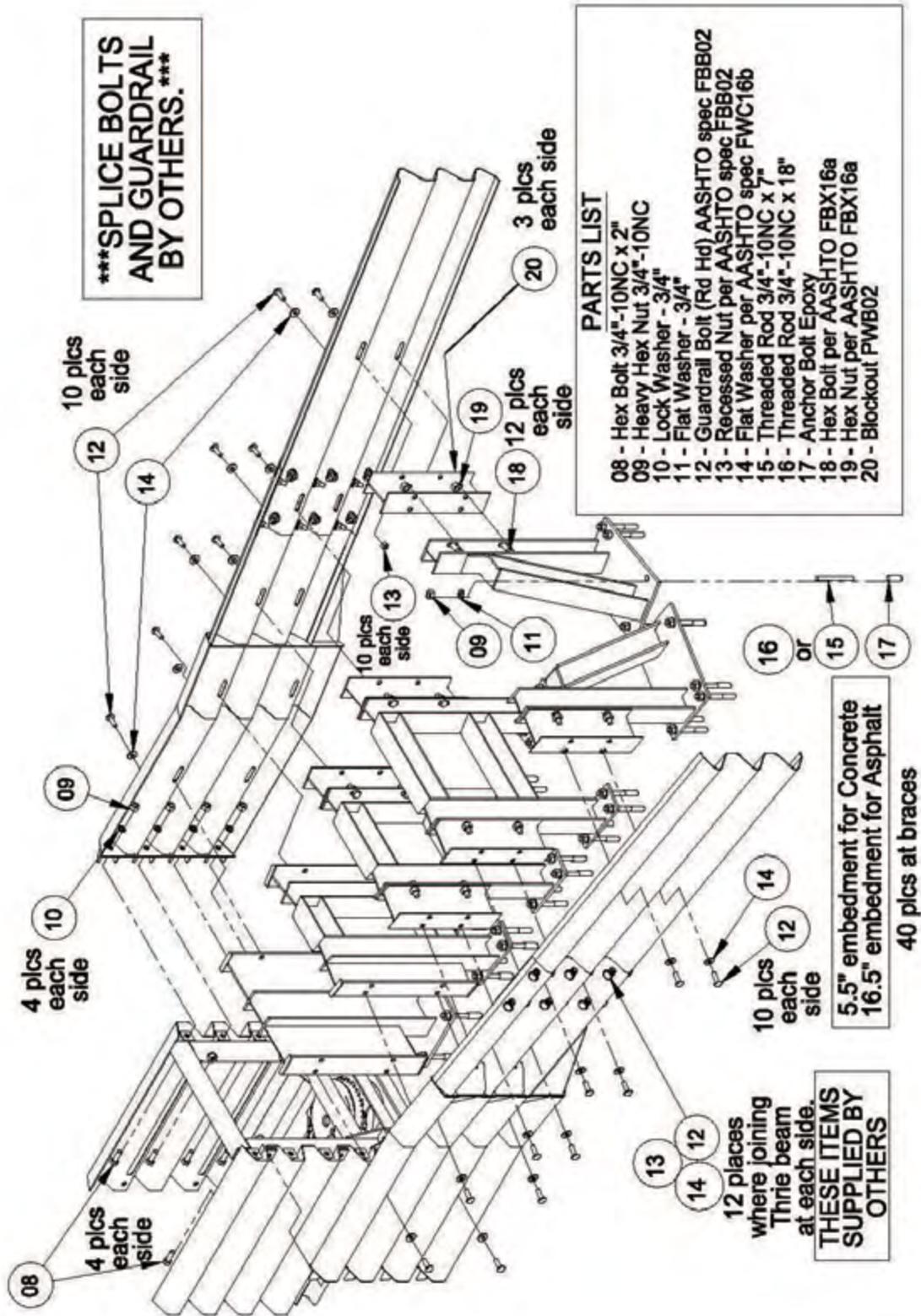


The use of the last brace will be determined by whether the Thrie Beam can be attached to the obstruction or not. If the Thrie Beam distance from the last brace is 40 inches or less and can be attached, you will not need a brace at the obstruction. If you cannot attach to the obstruction, you may need a brace and drill holes in the Thrie Beam at the furthest rearward location.



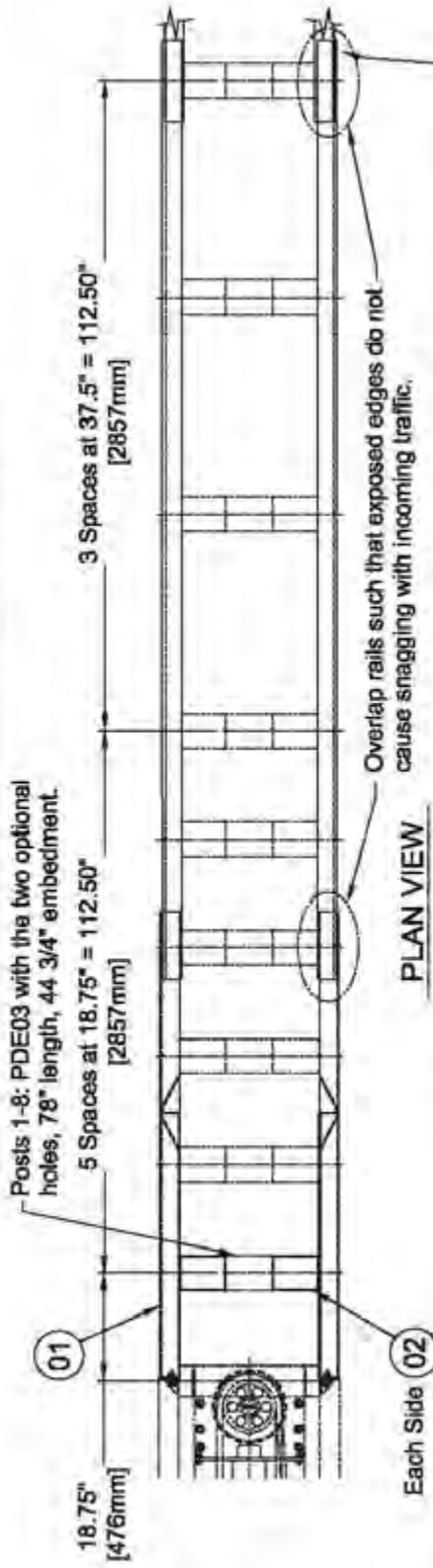


APPENDIX N(2) - TRANSITION, THRIE BEAM WIDE TAPER





**APPENDIX O - TRANSITION TO THRIE BEAM
FOR USE WITH BIDIRECTIONAL TRAFFIC**

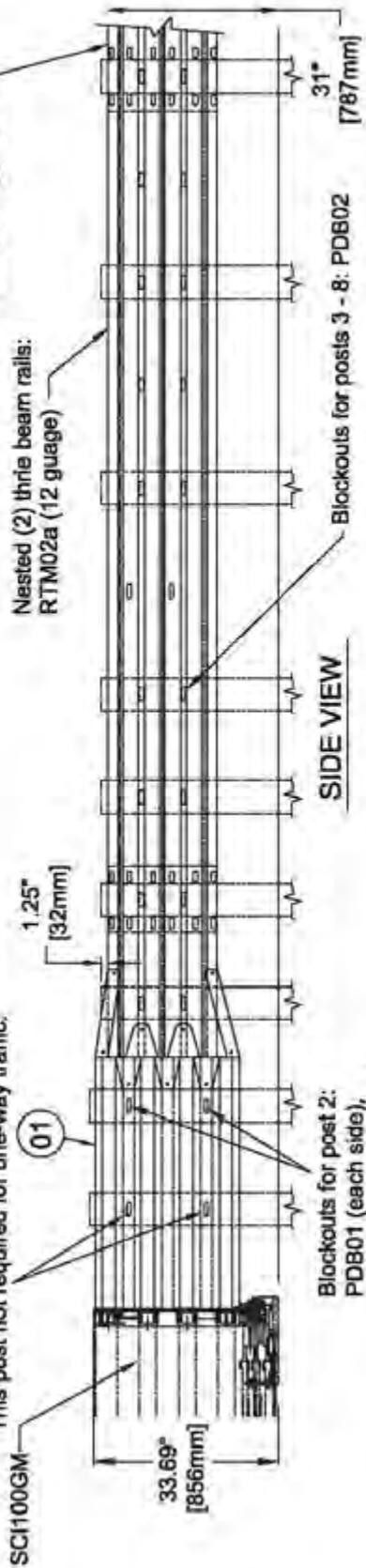


******THIS DESIGN IS FOR BIDIRECTIONAL TRAFFIC
POST SPACING AND NESTED GUARDRAIL PER SPEC.*****

*****GUARDRAILS, POSTS, BLOCKOUTS
AND CONNECTION BOLTS BY OTHERS.*****

- Parts List:**
 01 - Transition Thrie & W Beam - Right #275298
 01 - Transition Thrie & W Beam - Left #232971
 02 - Rectangular Tube Blockout #265560

Blockouts for post 1: these bolt heads must not interfere with panel collapse. If guardrail bolts can be used with a standard blockout, that is acceptable. Otherwise use tube blockout with guardrail bolts. This post not required for one-way traffic.



Blockouts for post 2: PDB01 (each side), or use similar to Part 15 (figure 7) in original design.



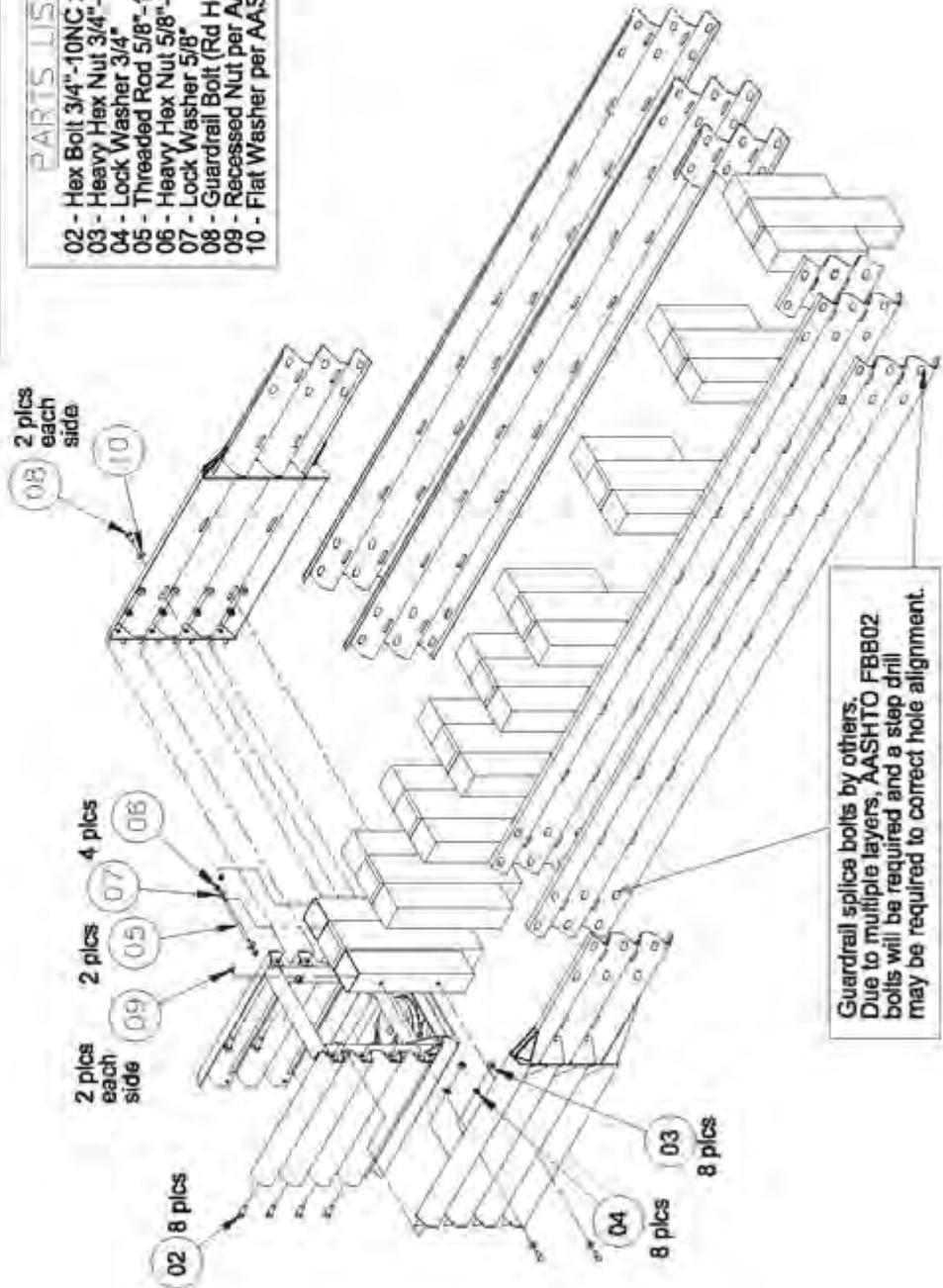


**APPENDIX O(2) - TRANSITION TO THRIE BEAM
*** FOR USE WITH BIDIRECTIONAL TRAFFIC*****

*****THIS DESIGN IS FOR BIDIRECTIONAL TRAFFIC.
POST SPACING AND NESTED GUARDRAIL PER SPEC.**

*****GUARDRAILS, POSTS, BLOCKOUTS AND
CONNECTION BOLTS BY OTHERS.*****

- PARTS LIST**
- 02 - Hex Bolt 3/4"-10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lock Washer 3/4"
 - 05 - Threaded Rod 5/8"-11NC x 11"
 - 06 - Heavy Hex Nut 5/8"-11NC
 - 07 - Lock Washer 5/8"
 - 08 - Guardrail Bolt (Rd Hd)AASHTO spec FBB02
 - 09 - Recessed Nut per AASHTO spec FBB02
 - 10 - Flat Washer per AASHTO spec FWC16b

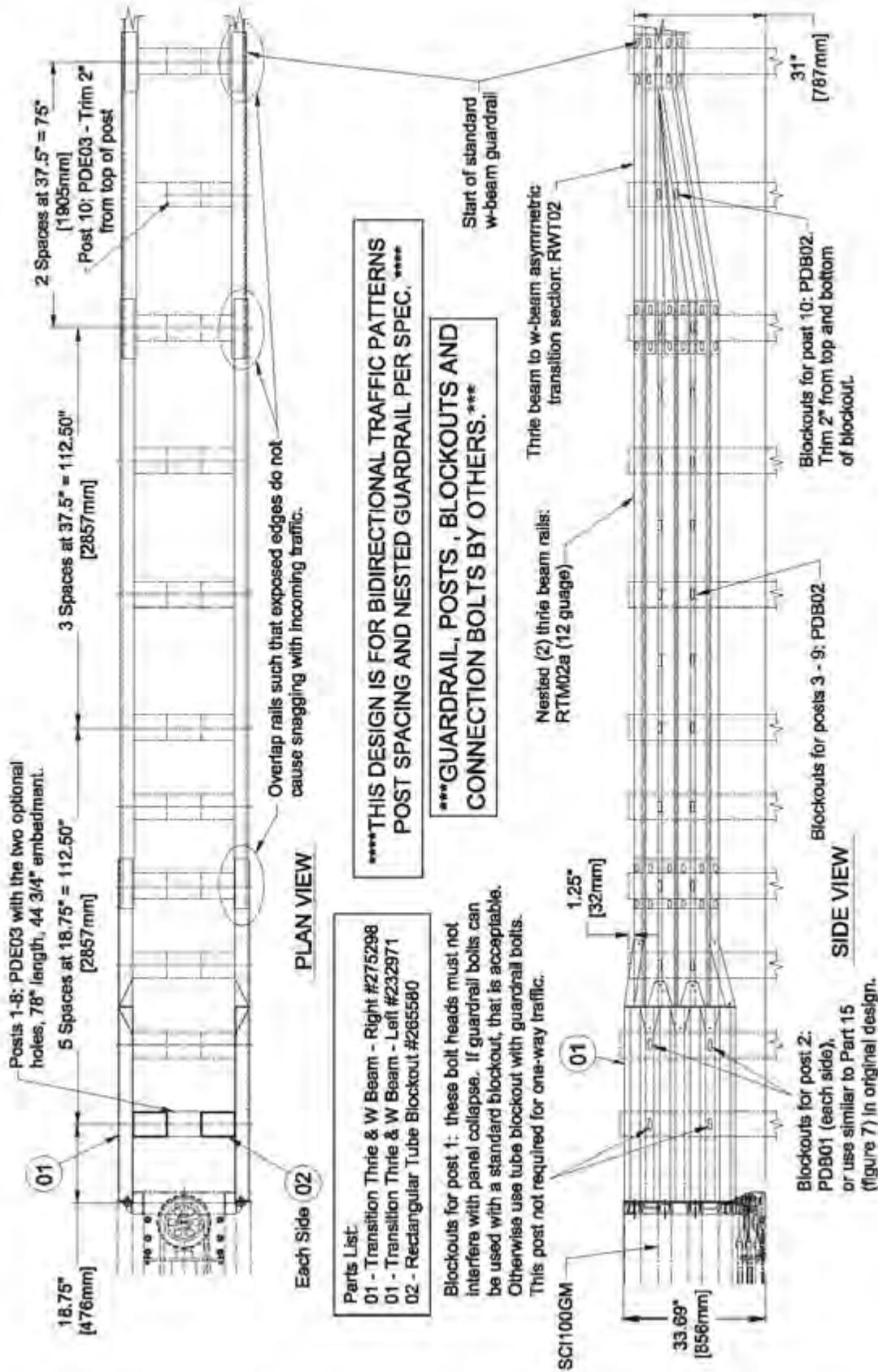


**Guardrail splice bolts by others.
Due to multiple layers, AASHTO FBB02
bolts will be required and a step drill
may be required to correct hole alignment.**





APPENDIX P - TRANSITION TO W BEAM
****FOR USE WITH BIDIRECTIONAL TRAFFIC****



PLAN VIEW

SIDE VIEW

****THIS DESIGN IS FOR BIDIRECTIONAL TRAFFIC PATTERNS
 POST SPACING AND NESTED GUARDRAIL PER SPEC. ****

***GUARDRAIL, POSTS, BLOCKOUTS AND
 CONNECTION BOLTS BY OTHERS.***

- Parts List:
- 01 - Transition Thrie & W Beam - Right #275298
 - 01 - Transition Thrie & W Beam - Left #232971
 - 02 - Rectangular Tube Blockout #265580

Blockouts for post 1: these bolt heads must not interfere with panel collapse. If guardrail bolts can be used with a standard blockout, that is acceptable. Otherwise use tube blockout with guardrail bolts. This post not required for one-way traffic.

Blockouts for post 2:
 PDB01 (each side),
 or use similar to Part 15
 (figure 7) in original design.



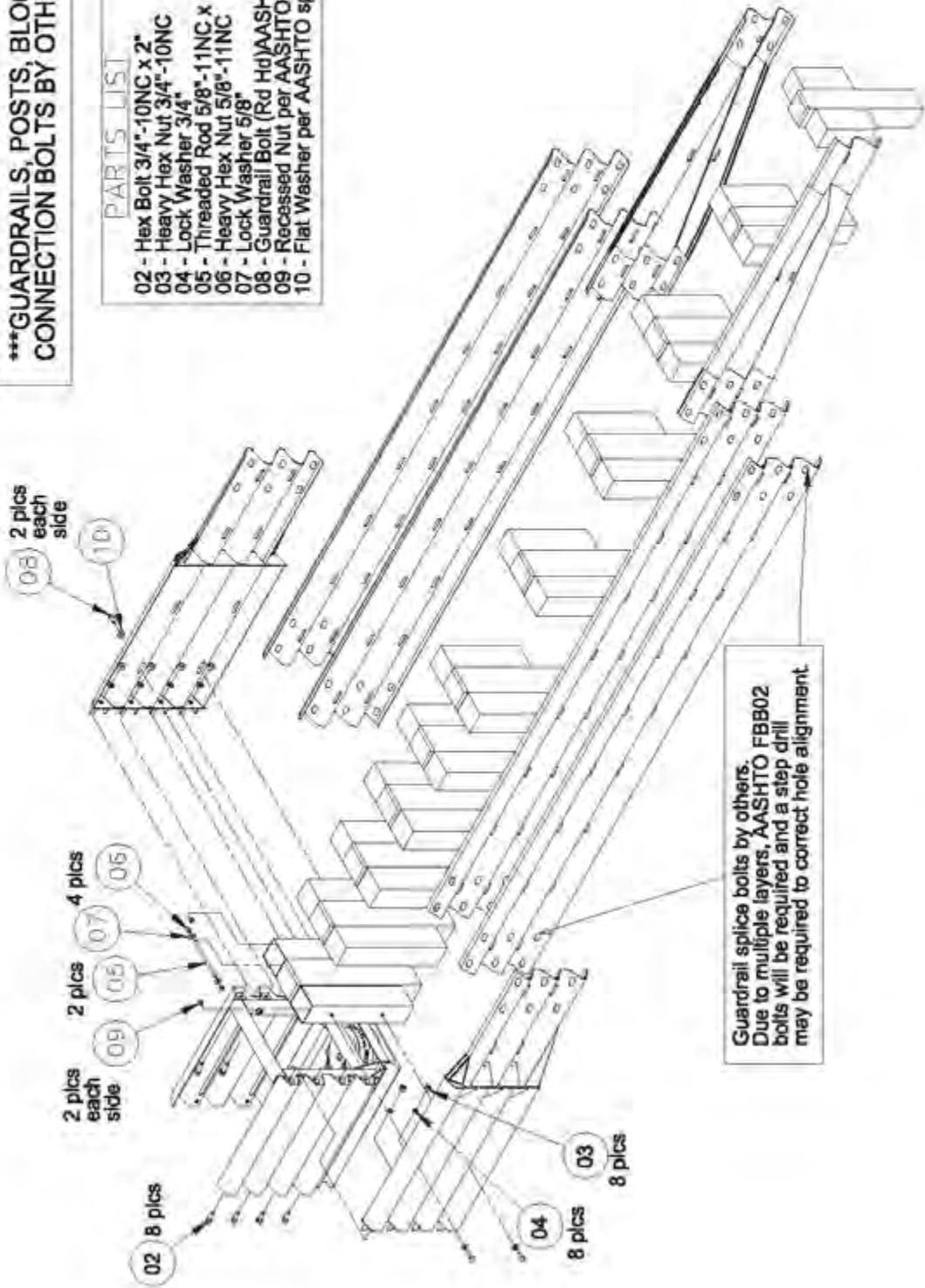


**APPENDIX P(2) - TRANSITION TO W BEAM
** FOR USE WITH BIDIRECTIONAL TRAFFIC****

*****THIS DESIGN IS FOR BIDIRECTIONAL TRAFFIC.
POST SPACING AND NESTED GUARDRAIL PER SPEC.**

*****GUARDRAILS, POSTS, BLOCKOUTS AND
CONNECTION BOLTS BY OTHERS.*****

- PARTS LIST**
- 02 - Hex Bolt 3/4"-10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lock Washer 3/4"
 - 05 - Threaded Rod 5/8"-11NC, x 11"
 - 06 - Heavy Hex Nut 5/8"-11NC
 - 07 - Lock Washer 5/8"
 - 08 - Guardrail Bolt (Rd Hd)AASHTO spec FBB02
 - 09 - Recessed Nut per AASHTO spec FBB02
 - 10 - Flat Washer per AASHTO spec FWC16b



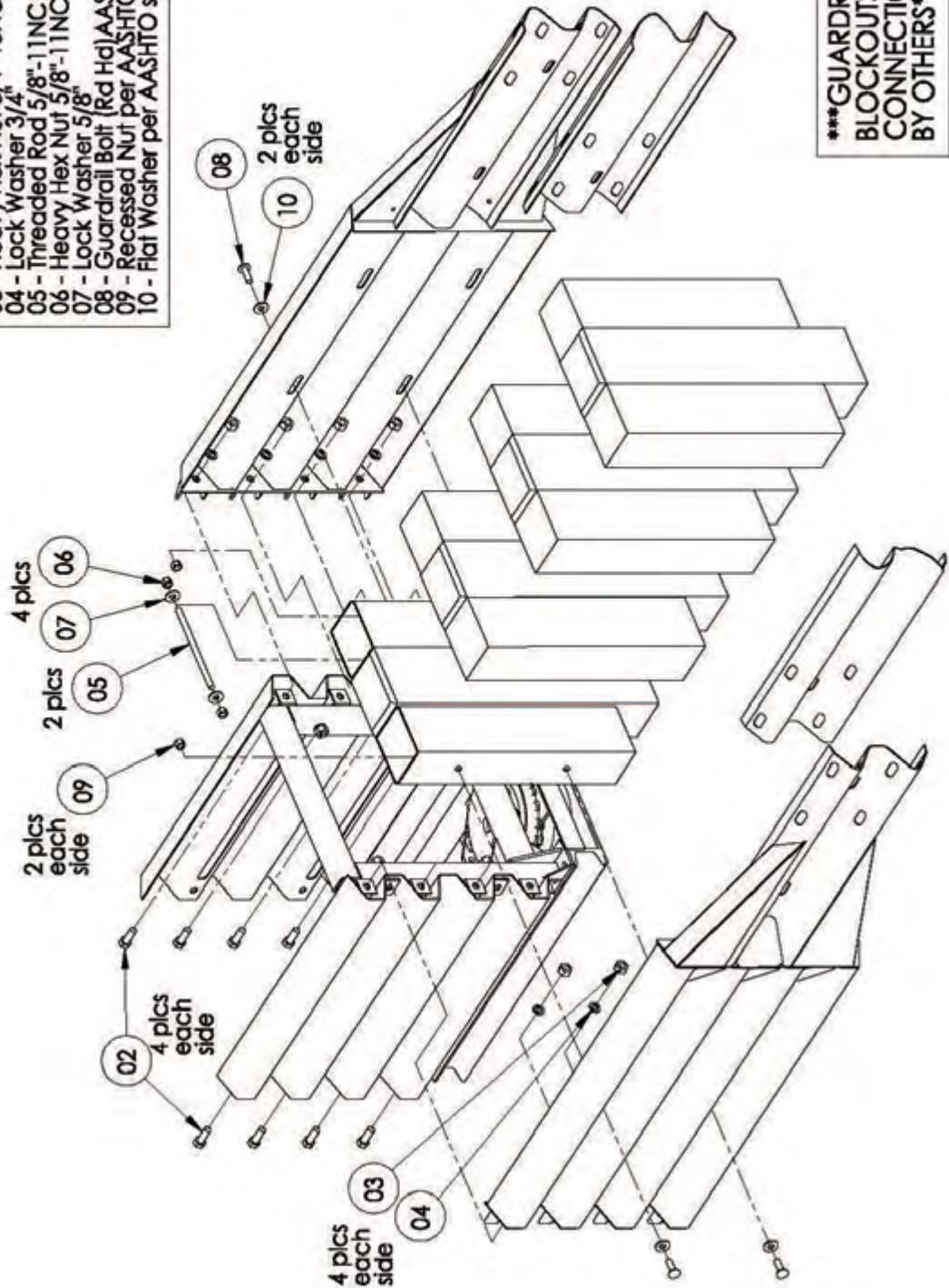
**Guardrail splice bolts by others.
Due to multiple layers, AASHTO FBB02
bolts will be required and a step drill
may be required to correct hole alignment.**





**APPENDIX Q(2) & R(2) - TRANSITION, W BEAM 28" & 31"
HIGH**

- PARTS LIST**
- 02 - Hex Bolt 3/4"-10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lock Washer 3/4"
 - 05 - Threaded Rod 5/8"-11NC x 11"
 - 06 - Heavy Hex Nut 5/8"-11NC
 - 07 - Lock Washer 5/8"
 - 08 - Guardrail Bolt (Rd Hd) AASHTO spec F8802
 - 09 - Recessed Nut per AASHTO spec F8802
 - 10 - Flat Washer per AASHTO spec FWC16b

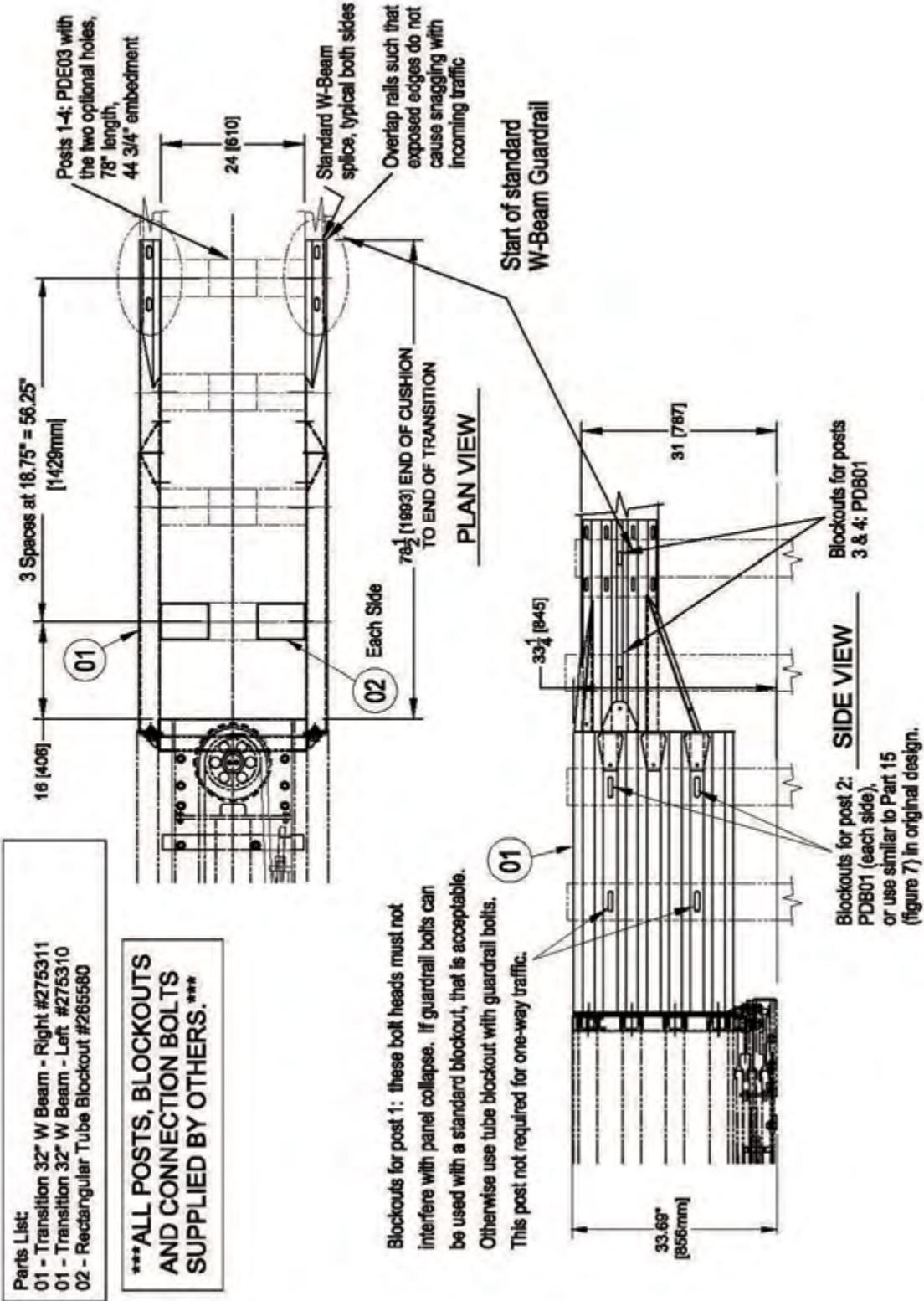


*****GUARDRAILS, POSTS,
BLOCKOUTS AND
CONNECTION BOLTS
BY OTHERS*****





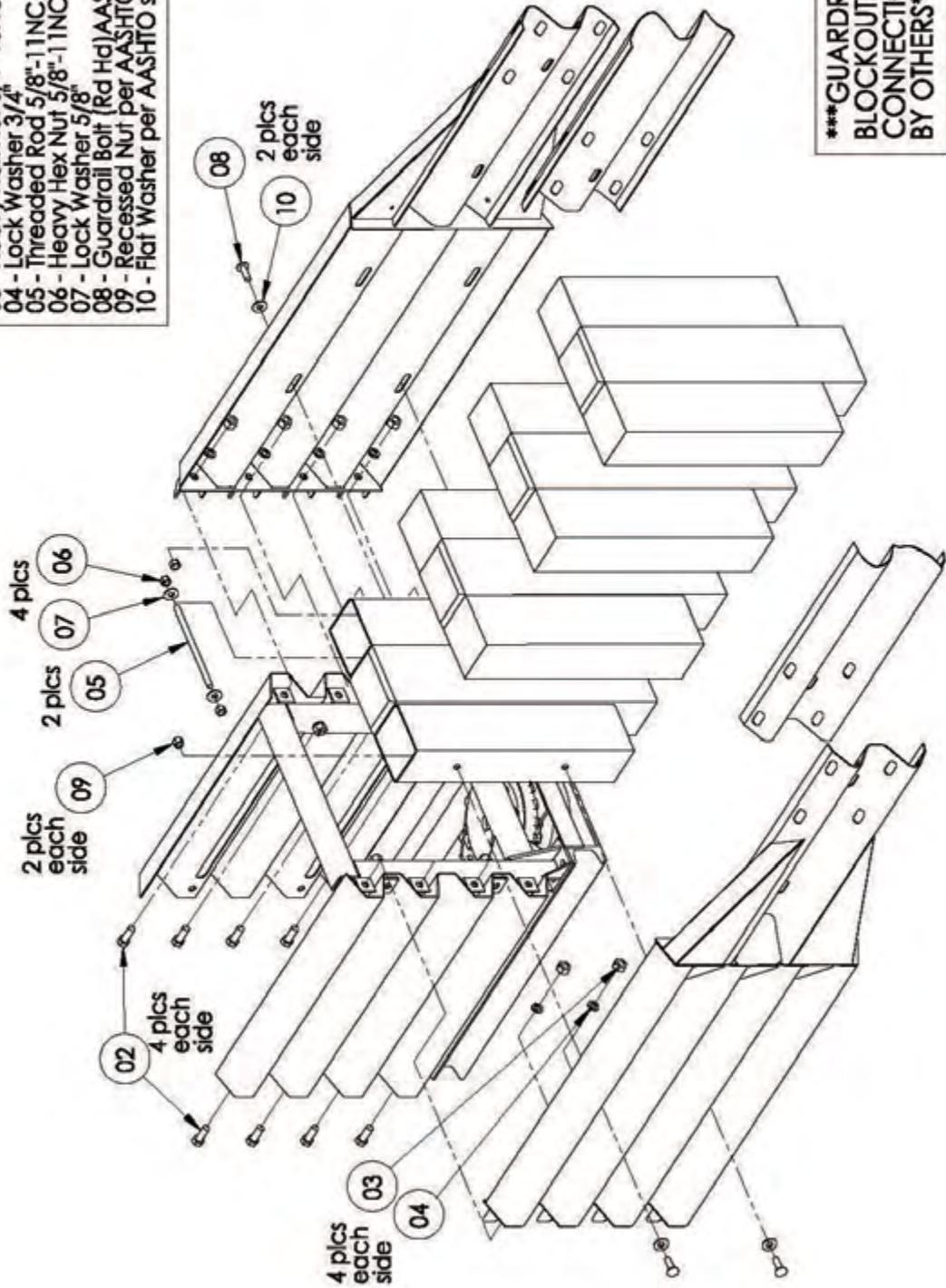
APPENDIX R - TRANSITION, W BEAM 31" HIGH
**** Unidirectional Traffic Only**





APPENDIX Q(2) & R(2) - TRANSITION, W BEAM 28" & 31"
HIGH

- PARTS LIST**
- 02 - Hex Bolt 3/4"-10NC x 2"
 - 03 - Heavy Hex Nut 3/4"-10NC
 - 04 - Lock Washer 3/4"
 - 05 - Threaded Rod 5/8"-11NC x 11"
 - 06 - Heavy Hex Nut 5/8"-11NC
 - 07 - Lock Washer 5/8"
 - 08 - Guardrail Bolt (Rd Hd) AASHTO spec FB802
 - 09 - Recessed Nut per AASHTO spec FB802
 - 10 - Flat Washer per AASHTO spec FWC16b

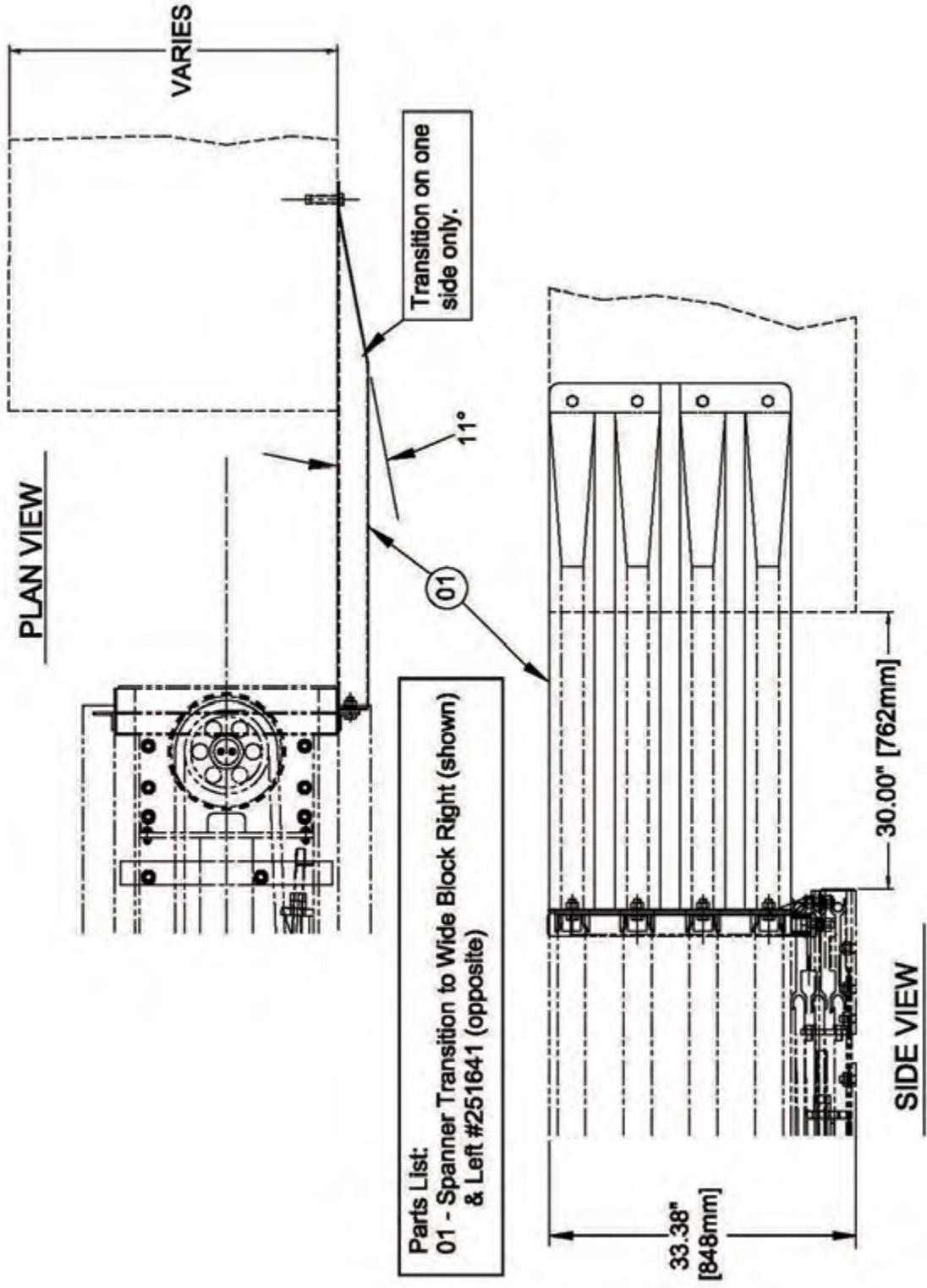


***GUARDRAILS, POSTS,
BLOCKOUTS AND
CONNECTION BOLTS
BY OTHERS***



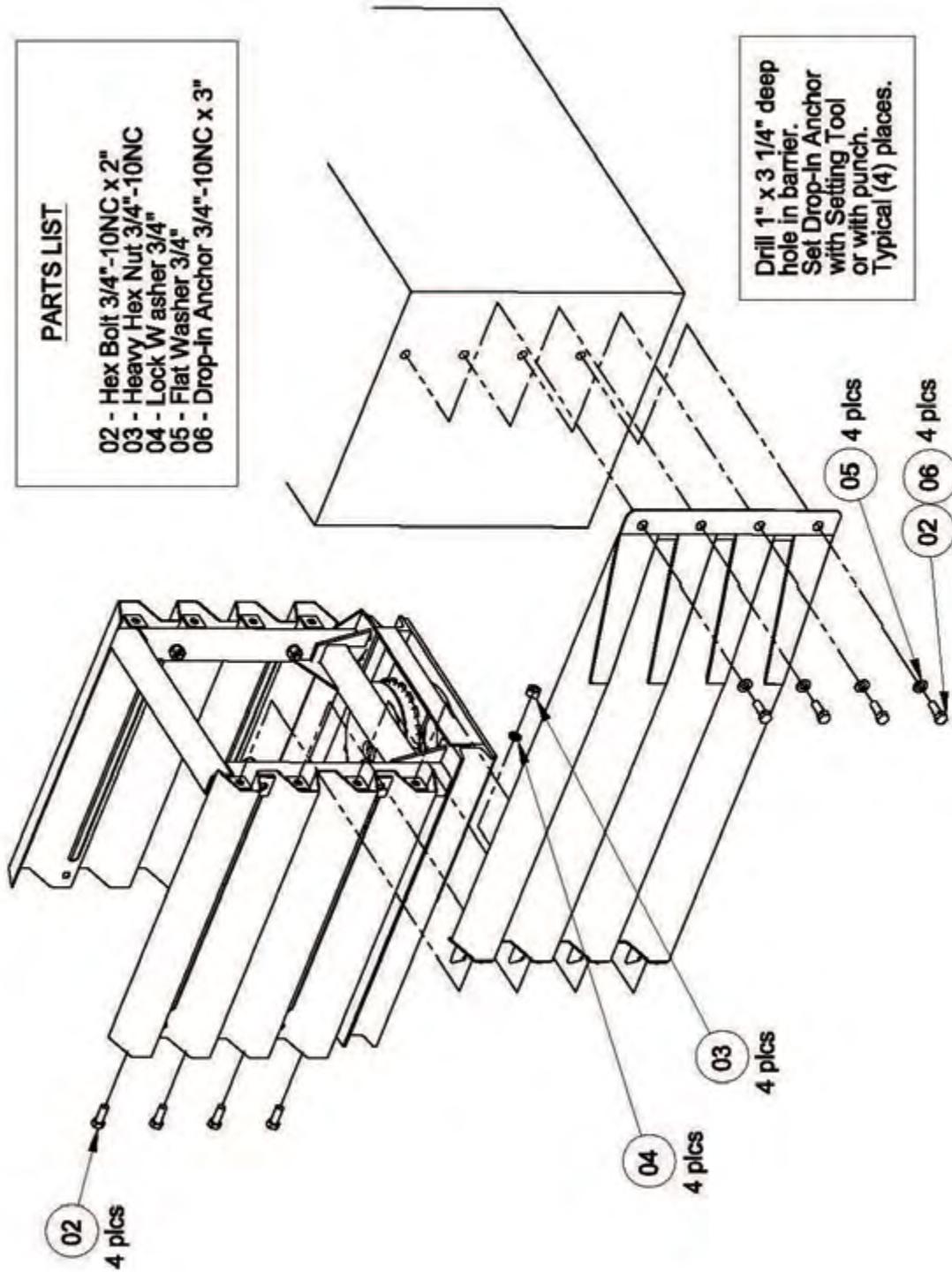


APPENDIX S - TRANSITION, SPANNER FOR CONCRETE BLOCK



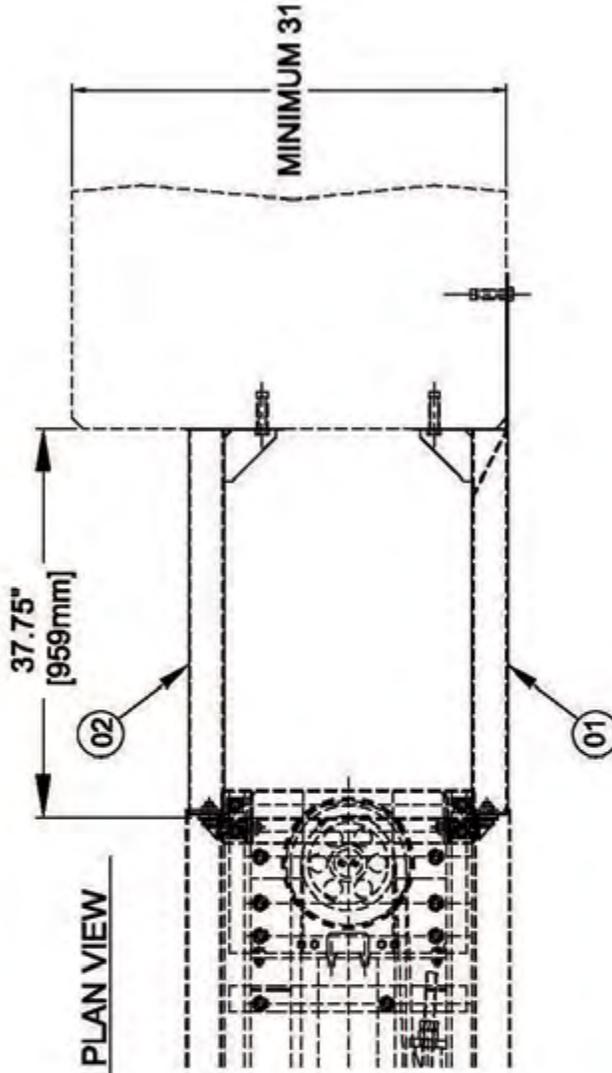


APPENDIX S(2) - TRANSITION, SPANNER FOR CONCRETE BLOCK

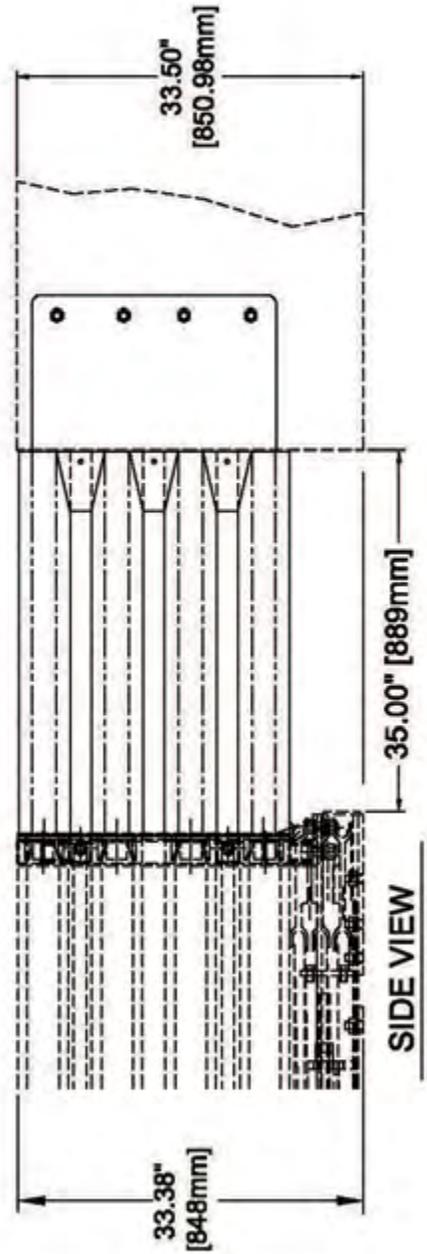




APPENDIX T - TRANSITION, OFFSET CONCRETE BLOCK

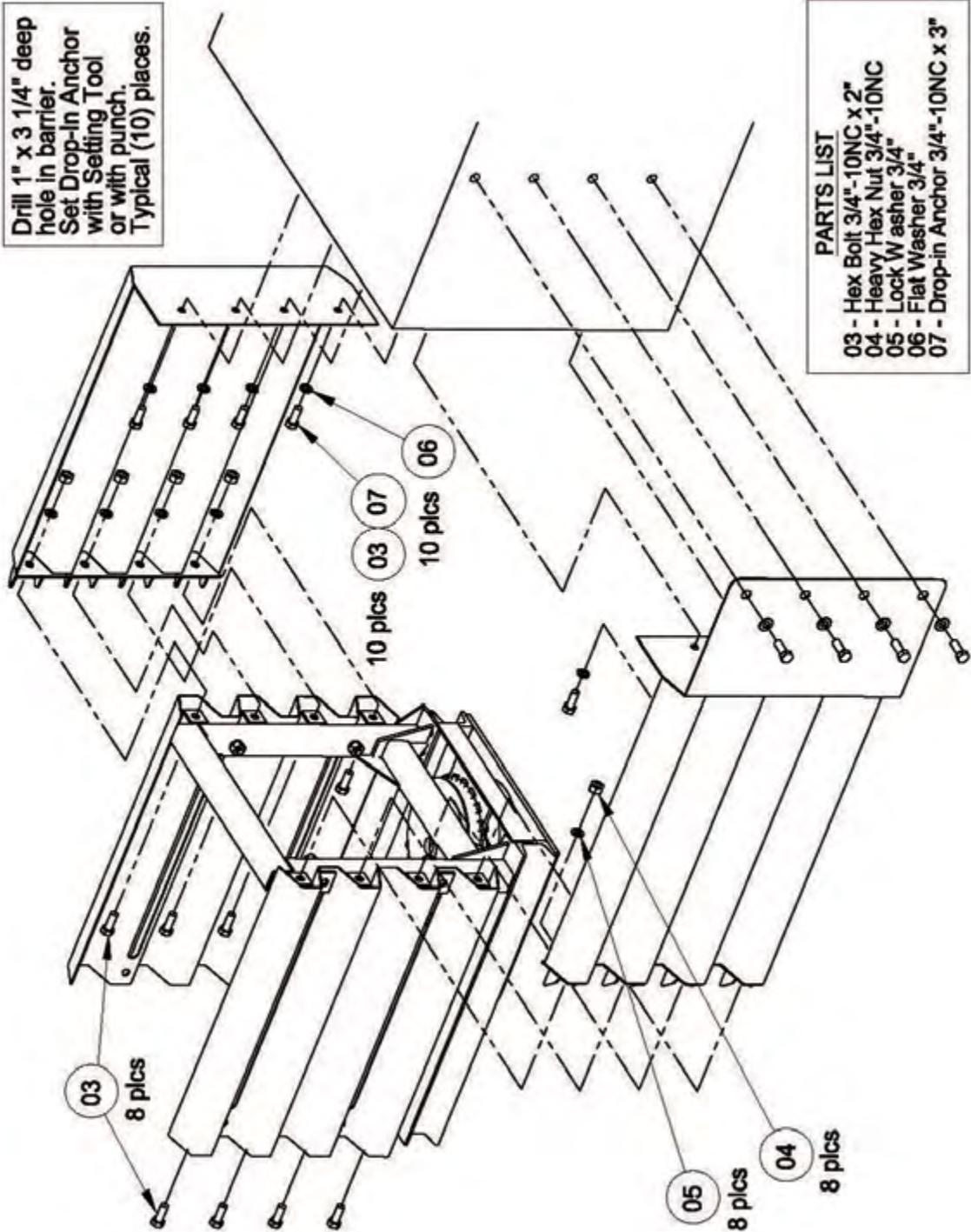


- Parts List:
01 - Straight Panel #275265
02 - Offset Panel #255878





APPENDIX T(2) - TRANSITION, OFFSET CONCRETE BLOCK



SCI70/100GM CRASH CUSHION COMMERCIAL 1-YEAR WARRANTY

Hill and Smith Inc. warrants this product to be free from defects in material and workmanship under normal use and service for a period of one (1) year beginning on the date of installation. Hill and Smith Inc. will repair or replace without charge to the original customer any defective component. This is the sole and exclusive remedy.

This warranty is contingent upon proper use of the System and does not cover Systems that have been modified (including the addition of parts) without the approval of Hill and Smith Inc. or which are in need of repair due to damage from external cause, including accident, collision, improper handling, improper transporting, failure to properly maintain the System as recommended by Hill and Smith Inc. abuse, misuse or which have been damaged by outside parties not employed by Hill and Smith Inc., whether in installation or otherwise.

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THE BUYER AGREES TO INSPECT THE PRODUCT ON RECEIPT AS FULLY AS THE BUYER DESIRES AND TO NOTIFY HSI PRODUCTS INC. OF ANY REVEALED DEFECT.





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