SUPERSEDED BY EB 15-031 EFFECTIVE 9/28/15		*New York State Department of Transportation* **ENGINEERING INSTRUCTION**	**EI** **10-010**

Title: **STANDARD SPECIFICATION SECTION 654 - IMPACT ATTENUATORS - PERMANENT**

Distribution:
- ☒ Manufacturers (18)
- ☒ Local Govt. (31)
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- ☒ Consultants (34)
- ☒ Contractors (39)
- ☐ _____( )

Approved:

Daniel D'Angelo, P.E.
Deputy Chief Engineer, Design

4/14/10
Date

ADMINISTRATIVE INFORMATION:

- This Engineering Instruction (EI) is effective beginning with projects submitted for the letting of January 6, 2011.
- No issuances are superseded by this EI.
- The specification changes transmitted will be incorporated into a future revision of the Standard Specifications.

PURPOSE: The purpose of this EI is to:

- Revise Section 654 *Impact Attenuators*.
- Issue new §712-06 *Expendable Impact Attenuators* and §712-08 *Reusable Impact Attenuators*.
- Eliminate §712-18 through §712-22.

TECHNICAL INFORMATION:

- This EI is being issued concurrently with EI 10-011 *Design Guidance for Section 654 Impact Attenuators-Permanent*.
- §712-18 through §712-22 are eliminated.
- Section 654 *Impact Attenuators* has been renamed "Impact Attenuators - Permanent" and has been revised to provide three generic categories of impact attenuators:
  1. Inertial Barrier Modules: a sand barrel system set in an array for site hazard protection. The only change to this subsection is a reflectorization requirement which is found in §654-3.01 General.
  2. Expendable Impact Attenuators: an impact attenuator unit which requires extensive repair, in parts and/or labor, to return the unit to its full operating capacity, following a moderate to significant impact.
  3. Reusable Impact Attenuators: an impact attenuator unit which requires a very low average cost for replacement parts and labor per incident, including significant impacts.
- Impact attenuators are categorized as either TL2 45 mph (70 km/h) or TL3 62 mph (100 km/h). Within each category, the impact attenuators are defined by the obstruction width effectively shielded. A contract pay item number is assigned to each width range for each category. The ranges are:
  1. 2 ft (610 mm) or less,
  2. greater than 2 ft (610 mm) up to and including 5 ft (1525 mm), and
  3. greater than 5 ft (1525 mm)
- When the contract documents indicate that an attenuator must handle two-way traffic, rather than diverging traffic, the Contractor shall supply an attenuator that is approved for two-way traffic.
- Multiple items in previous impact attenuator specifications have been replaced by a single pay item for each of the following:

- constructing a new foundation,
- drilling and grouting an existing foundation,
- relocating impact attenuators,
- removing and storing impact attenuators, and
- removing and disposing of impact attenuators.

- The contract pay item for refurbishing impact attenuators has been eliminated.
- The contract pay item for relocating existing impact attenuators covers three situations;
  1. Relocating to a new foundation (paid for separately).
  2. Relocating to an existing foundation of same type and configuration.
  3. Relocating to an existing foundation requiring retrofit. This scenario would require the addition of pay item 654.06 Drill and Grout Anchoring System into Existing Foundation
- The following products will be included on the new §712-06 Expendable Impact Attenuator approved list, based on prior approval as proprietary items.

  Expendable Impact Attenuator Approved List:
  - Quadguard (Energy Absorption Systems Inc.)
  - Universal TAU II (Barrier Systems Inc.)
  - React 350 (Energy Absorption Systems Inc.)
  - React 350 Wide (Energy Absorption Systems Inc.)
  - SCI (Smart Cushion Innovations)
  - TRACC (Trinity Highway Products)
- Vendors wishing to have their product(s) appear on the Approved List under the category of "Reusable Impact Attenuators" will be required to submit the certification and information specified in §712-08.
- Repair Parts Cost Basis for Acceptance as a "Reusable" Attenuator: The current threshold for considering an attenuator "reusable" is that none of the NCHRP 350 crash tests cause a repair parts cost to exceed a $750 total for the crash. This figure will be posted on the Approved List will be adjusted periodically by the Design Quality Assurance Bureau to reflect inflation and other factors.
- Cost Impact: It is anticipated that there will be an overall saving with increased competition.

IMPLEMENTATION:

- The Main Office Design Quality Assurance Bureau will insert the standard specification shelf note into contract proposals calling for these contract pay items, beginning with projects submitted for the letting of January 6, 2011.
- The following **new** U.S. Customary contract pay items are approved:

654.05	New Concrete Foundation	Cubic Yard
54.0501	Drill and Grout Anchoring System into Existing Foundation	Each
654.06	Remove and Dispose Impact Attenuator	Each
654.07	Remove and Store Impact Attenuator	Each
654.08	Relocate Impact Attenuator	Each
654.5020	Expendable Impact Attenuator, TL 2, ≤ 2 ft obstruction width	Each
654.5022	Expendable Impact Attenuator , TL 2, 2ft < obstruction width ≤ 5ft	Each
654.5025	Expendable Impact Attenuator , TL 2, > 5 ft obstruction width	Each
654.5030	Expendable Impact Attenuator , TL 3, ≤ 2 ft obstruction width	Each
654.5032	Expendable Impact Attenuator , TL 3, 2ft < obstruction width ≤ 5ft	Each
654.5035	Expendable Impact Attenuator , TL 3, > 5 ft obstruction width	Each
654.5120	Reusable Impact Attenuator , TL 2, ≤ 2 ft obstruction width	Each
654.5122	Reusable Impact Attenuator , TL 2, 2ft < obstruction width ≤ 5ft	Each
654.5125	Reusable Impact Attenuator , TL 2, > 5 ft obstruction width	Each

654.5130	Reusable Impact Attenuator , TL 3, ≤ 2 ft obstruction width	Each
654.5132	Reusable Impact Attenuator , TL 3, 2ft < obstruction width ≤ 5ft	Each
654.5135	Reusable Impact Attenuator , TL 3, > 5 ft obstruction width	Each

- The following U.S. Customary standard contract pay items are disapproved:

654.02xx	Inertial Barrier Module, ___ Pounds, Remove and Dispose
654.03xx	Inertial Barrier Module, ___ Pounds, Remove and Store
654.04xx	Inertial Barrier Module, ___ Pounds, Relocate
654.10xxxx	Impact Attenuator Quad Beam Type
654.11xxxx	Impact Attenuator Quad Beam Type
654.12	Impact Attenuator Quad Beam Type Remove and Dispose
654.13	Impact Attenuator Quad Beam Type Remove and Store
654.14	Impact Attenuator Quad Beam Type Refurbish
654.15xxxx	Impact Attenuator Quad Beam Type Relocate
654.16	Impact Attenuator Quad Beam Type Relocate
654.20xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type
654.21xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type
654.22	Impact Attenuator Reusable HDPE Cylinders & Cable Type Remove and Dispose
654.23	Impact Attenuator Reusable HDPE Cylinders & Cable Type Remove and Store
654.24xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type Relocate
654.25	Impact Attenuator Reusable HDPE Cylinders & Cable Type Relocate
654.26	Impact Attenuator Reusable HDPE Cylinders & Cable Type Refurbish
654.30xx	Impact Attenuator Corrugated Beam Type
654.31xx	Impact Attenuator Corrugated Beam Type
654.32	Impact Attenuator Corrugated Beam Type Remove and Dispose
654.33	Impact Attenuator Corrugated Beam Type Remove and Store
654.34xx	Impact Attenuator Corrugated Beam Type Relocate
654.35	Impact Attenuator Corrugated Beam Type Relocate
654.36xx	Impact Attenuator Corrugated Beam Type Refurbish
654.40xxxx	Impact Attenuator Thrie Beam Type
654.41xxxx	Impact Attenuator Thrie Beam Type
654.42	Impact Attenuator Thrie Beam Type Remove and Dispose
654.43	Impact Attenuator Thrie Beam Type Remove and Store
654.44xxxx	Impact Attenuator Thrie Beam Type Relocate
654.45xxxx	Impact Attenuator Thrie Beam Type Relocate
654.46xxxx	Impact Attenuator Thrie Beam Type Refurbish

- The following U.S. Customary special specification contract pay items are disapproved:

654.48000011	Remove and Dispose Inertial Barrier Modules
654.52000010	Remove Store and Reset Inertial Barrier Modules
654.68990011	Internal Barrier Module
654.70000011	Remove and Store Existing Impact Attenuator

- The following U.S. Customary standard and special specification contract pay items are still approved:

654.01xx	Inertial Barrier Module, ___ Pounds
654.35000091	Concrete Module Safety Terminal

- The following **new** Metric contract pay items are approved:

654.05	New Concrete Foundation	Cubic Meter
654.0501	Drill and Grout Anchoring System into Existing Foundation	Each
654.06	Remove and Dispose Impact Attenuator	Each
654.07	Remove and Store Impact Attenuator	Each
654.08	Relocate Impact Attenuator	Each
654.5020	Expendable Impact Attenuator, TL 2, ≤ 2 ft obstruction width	Each
654.5022	Expendable Impact Attenuator , TL 2, 2ft < obstruction width ≤ 5ft	Each
654.5025	Expendable Impact Attenuator , TL 2, > 5 ft obstruction width	Each
654.5030	Expendable Impact Attenuator , TL 3, ≤ 2 ft obstruction width	Each
654.5032	Expendable Impact Attenuator , TL 3, 2ft < obstruction width ≤ 5ft	Each
654.5035	Expendable Impact Attenuator , TL 3, > 5 ft obstruction width	Each
654.5120	Reusable Impact Attenuator , TL 2, ≤ 2 ft obstruction width	Each
654.5122	Reusable Impact Attenuator , TL 2, 2ft < obstruction width ≤ 5ft	Each
654.5125	Reusable Impact Attenuator , TL 2, > 5 ft obstruction width	Each
654.5130	Reusable Impact Attenuator , TL 3, ≤ 2 ft obstruction width	Each
654.5132	Reusable Impact Attenuator , TL 3, 2ft < obstruction width ≤ 5ft	Each
654.5135	Reusable Impact Attenuator , TL 3, > 5 ft obstruction width	Each

- The following Metric standard contract pay items are disapproved:

654.02xx	Inertial Barrier Module, ___ Pounds, Remove and Dispose
654.03xx	Inertial Barrier Module, ___ Pounds, Remove and Store
654.04xx	Inertial Barrier Module, ___ Pounds, Relocate
654.10xxxx	Impact Attenuator Quad Beam Type
654.11xxxx	Impact Attenuator Quad Beam Type
654.12	Impact Attenuator Quad Beam Type Remove and Dispose
654.13	Impact Attenuator Quad Beam Type Remove and Store
654.14	Impact Attenuator Quad Beam Type Refurbish
654.15xxxx	Impact Attenuator Quad Beam Type Relocate
654.16	Impact Attenuator Quad Beam Type Relocate
654.20xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type
654.21xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type
654.22	Impact Attenuator Reusable HDPE Cylinders & Cable Type Remove and Dispose
654.23	Impact Attenuator Reusable HDPE Cylinders & Cable Type Remove and Store
654.24xx	Impact Attenuator Reusable HDPE Cylinders & Cable Type Relocate
654.25	Impact Attenuator Reusable HDPE Cylinders & Cable Type Relocate
654.26	Impact Attenuator Reusable HDPE Cylinders & Cable Type Refurbish
654.30xx	Impact Attenuator Corrugated Beam Type
654.31xx	Impact Attenuator Corrugated Beam Type
654.32	Impact Attenuator Corrugated Beam Type Remove and Dispose
654.33	Impact Attenuator Corrugated Beam Type Remove and Store
654.34xx	Impact Attenuator Corrugated Beam Type Relocate
654.35	Impact Attenuator Corrugated Beam Type Relocate
654.36xx	Impact Attenuator Corrugated Beam Type Refurbish
654.40xxxx	Impact Attenuator Thrie Beam Type
654.41xxxx	Impact Attenuator Thrie Beam Type
654.42	Impact Attenuator Thrie Beam Type Remove and Dispose
654.43	Impact Attenuator Thrie Beam Type Remove and Store
654.44xxxx	Impact Attenuator Thrie Beam Type Relocate

654.45xxxx	Impact Attenuator Thrie Beam Type Relocate
654.46xxxx	Impact Attenuator Thrie Beam Type Refurbish

- The following Metric. special specification contract pay items are disapproved:

654.0224xx11	SCI-GM Impact Attenuator TL-2
654.0324xx11	SCI-GM Impact Attenuator TL-3
654.22xx--10	Relocate Existing React 350
654.48----01	Remove and Dispose Liquid Cell Impact Attenuators
654.48----11	Remove and Dispose Inertial Barrier Modules
654.52----10	Remove Store and Reset Inertial Barrier Modules
654.5210--10	Remove and Store Inertial Barrier Modules
654.6899--11	Internal Barrier Module (Maintain Only)
654.70----11	Remove and Store Existing Impact Attenuator

- The following Metric standard and special specification contract pay items are still approved:

654.01xx	Inertial Barrier Module, ___ Kilograms
654.35 91	Concrete Module Safety Terminal
654.36 91	Concrete Module Safety Terminal for Single-Slope Concrete Median Barrier

TRANSMITTED MATERIALS:

- Attached are both the USC and Metric standard specification shelf notes for the subject changes.
- The Reusable Impact Attenuator Material Approved List and submitted Material Drawings will be available on the Technical Services Materials Approved List site at https://www.nysdot.gov/divisions/engineering/technical-services/technical-services-repository/alme/.

BACKGROUND: Section 654, *Impact Attenuators*, has evolved over time as new products became available for use. Due to the lack of comparable products, the Standard Specifications have represented proprietary items, instead of generic product selections. There are now a sufficient number of acceptable products to enable Section 654 to be rewritten generically, with contract pay items that are supported by a Materials Approved List.

CONTACT: For further information, contact Bob Lohse of the Design Quality Assurance Bureau rlohse@dot.state.ny.us or by phone at (518) 457-3528.

Make the following changes to the Standard Specifications dated May 4, 2006:

Pages 646 to 653 ***delete*** Section 654 *Impact Attenuators* in its entirety and ***replace*** it with the following:

"SECTION 654 - IMPACT ATTENUATORS - PERMANENT

654-1 DESCRIPTION.

654-1.01 General. The work shall consist of furnishing and installing; removing and disposing; removing and storing; and relocating; impact attenuators, and installing foundations for impact attenuators, in accordance with the contract documents, the working drawings, and as directed by the Engineer.

654-1.02 Inertial Barrier Modules. An impact attenuator consisting of sand-filled modules (barrels) set in an array for site hazard protection.

654-1.03 Expendable Impact Attenuator. An impact attenuator which requires extensive repair, or replacement, to return the unit to its full operating capacity.

654-1.04 Reusable Impact Attenuator. An impact attenuator which requires minimal or no repair to return the unit to its full functional capability.

654-1.05 Concrete Foundation for Impact Attenuator. A new concrete foundation on which an attenuator is placed or, if required, anchored.

654-1.06 Transition Piece(s). Components of the attenuator system that are designed to connect between the attenuator and the shielded object in such a manner as to prevent an impacting vehicle from snagging on the shielded object. Not all installations require a transition piece and some transition pieces must be capable of handling opposite direction impacts.

654-2 MATERIALS. Materials shall conform to the following subsections of Section 700 *Materials and Manufacturing*:

Class A Concrete	501-2
Concrete Grouting Material	701-05
Anchoring Material- Chemically Curing	701-07
Precast Concrete	704-03
Epoxy Coated Bar Reinforcement, Grade 420	709-04
Expendable Impact Attenuator	712-06
Inertial Barrier Modules	712-07
Reusable Impact Attenuator	712-08
Galvanized Coating and Repair Methods	719-01
Anchor Bolts, Nuts and Washers	723-60
Traffic Paint (White)	727-09
Aluminum Sign Panels	730-01
Reflective Sheeting	730-05

654-3 CONSTRUCTION DETAILS.

654-3.01 General.

A. Drawings: Manufacturer's drawings, modified as necessary to reflect site conditions, will be referred to as "working drawings." Working drawings will take precedence over manufacturer's drawings. Working drawings shall show attenuator system: supports, transition pieces, connections, miscellaneous parts, concrete or steel back-up structure, and anchorages not detailed in the plans, but which are necessary to develop the full performance of the impact attenuator. Attenuator mounting surface, or foundation slab, details and limits will be shown in the working drawings. Any component not supplied by the manufacturer will be labeled as "PROVIDED BY OTHERS". A minimum of 7 calendar days prior to beginning work, the Contractor shall submit three (3) copies of working drawings to the Engineer. The submission shall include the manufacturer's certification that modifications made to manufacturer's drawings reflecting site conditions will not impair the satisfactory performance of the impact attenuator as designed and tested under NCHRP requirements. All aspects of the working drawings shall be implemented in the field, including any alterations of the concrete barrier or other obstruction being shielded.

B. Manuals. A minimum of 7 calendar days prior to beginning work, the Contractor shall deliver to the Engineer 3 copies of design manuals, installation manuals, parts lists, and maintenance manuals prepared for each type of impact attenuator being installed.

C. Coordination with Other Work. Coordinate the work under this section with removal and installation of shielded objects, barriers and guide rail in such manner as to limit the exposure of vehicular traffic to potential hazards to no more than 7 calendar days.

D. Excavation. Necessary excavation shall be performed in accordance with Section 203 *Excavation and Embankment.* Where the perimeter of the foundation slab will not be adjacent to pavement, the limit of excavation shall be 600 mm outside of the slab and forming shall be used. Where the perimeter of the foundation slab will be adjacent to pavement that is to remain in place, the limits of excavation shall be the limits of the foundation slab and the existing pavement shall be saw cut full depth prior to removal of the pavement and performance of the excavation work. Sawcutting and excavation shall be included in the cost of the foundation.

E. Anchorages. The impact attenuator shall be anchored to the new foundation slab or existing concrete foundation as shown on the working drawings. Anchor bolts and studs not cast integrally into the new foundation slab shall be anchored with approved concrete expansion anchors, concrete grouting material, or approved chemically curing anchoring material. Such anchor bolts or studs shall be set into holes drilled with rotary impact drills of the size recommended by the manufacturer of the anchor. Core drills will not be acceptable. Care shall be taken that anchor studs projecting from the surface and exposed to foot or wheeled traffic be well marked or protected.

A backup structure, if required by the manufacturer, shall be installed as indicated in the approved Materials Details or working drawings.

F. Transitions. The Contractor shall install the appropriate standard transition piece(s). If a transition is needed, but there is no standard transition design, a manufacturer's approved special transition piece, subject to the Engineer's approval, shall be furnished and installed. Refer to §654-3.01A for submittal requirements.

G. Directionality. When the contract documents indicate that an attenuator must handle two-way traffic, rather than diverging traffic, the Contractor shall supply an attenuator that is approved for the two-way traffic.

H. Reflectorization. ASTM Type III (Class B), Type V (Class C), or Type IX (Class E) sheeting directly applied to plastic or aluminum sheeting, or other lightweight rigid material, shall be affixed to the front cylinder, module, or front face of the impact attenuator. The pattern and color of the reflectorization shall be as indicated in the contract documents.

If no dimensions are provided, the panel shall be approximately square with a minimum of 450 mm on a side (625 mm on Inertial Barrier Modules). Whenever approaching traffic is allowed to pass on both sides of the unit, the pattern shall be upward pointing v-shaped striping, 100 mm wide, alternating between reflectorized yellow and opaque non-reflectorized black stripes, as indicated for Type 3 Object Markers in the MUTCD.

When traffic will be permitted on only one side, the pattern shall be diagonal 100 mm stripes, downward sloping to the side on which traffic is to be permitted.

654-3.02 Inertial Barrier Modules. The Contractor shall install Inertial Barrier Modules of the size and number required at the locations and to the configurations indicated in the contract documents. The Contractor shall also paint and label the layout pattern and weights on paved surfaces using traffic or other durable paint. The metric or U.S. Customary weight as indicated by the engineer shall be marked. When either indicated in the contract documents or when the modules are placed on a bridge deck on any slope exceeding 6%, the 90 kg units shall be restrained from movement and overturning (vandalism) by mechanical means.

654-3.03 Reusable Impact Attenuators. The Contractor shall install Reusable Impact Attenuators on existing or new foundations, in accordance with the contract documents and the working drawings.

654-3.04 Expendable Impact Attenuators. The Contractor shall install Expendable Impact Attenuators on existing or new foundations, as indicated on the contract documents and the working drawings.

654-3.05 Concrete Foundation for Impact Attenuator. When the existing concrete pavement is not sufficient to meet the anchorage requirements or there is not an adequate existing foundation, the Contractor shall remove the existing pavement and construct a reinforced concrete foundation slab and back-up structure to the dimensions indicated in the working drawings. The foundation slab shall be not less than the thickness indicated on the working drawings, or 200 mm, whichever is greatest.

The concrete shall be batched in accordance with Section 501 *Portland Cement Concrete*. If accelerators are needed, the Contractor shall submit the concrete mix design to the Materials Bureau for prior approval. The concrete shall be formed (when necessary), placed, and cured in accordance with Section 502 *Portland Cement Concrete Pavement*. The surface shall be hand finished.

The size, length, and bending details of reinforcement shall be as shown in the foundation slab details in the working drawings. The minimum allowable reinforcing shall be epoxy-coated #16 bars, with longitudinal spacing 400 mm on centers, and cross bar spacing 2 meters on centers. Longitudinal bars shall be placed such that they will not be cut during anchorage installation.

If foundation slab removal is specified, voids resulting from the removal of foundation slabs shall be filled with compacted suitable material or compacted granular material, or other designated material as specified in the contract documents or by the Engineer.

The excavated section of pavement between the new foundation slab and the limits of excavation shall be restored to the full height of the surrounding sound pavement.

654-3.06 Removal and Disposal. The Contractor shall remove impact attenuators of the indicated type, and if required the associated foundation slabs, from their existing locations. Upon removal, the impact attenuators and foundation slabs shall become the property of the Contractor. If foundation slab removal is specified, voids

resulting from the removal of foundation slabs shall be filled with compacted suitable material or compacted granular material, or other designated material as specified in the contract documents or by the Engineer.

If the slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-3.07 Removal and Storage. The Contractor shall remove impact attenuators of the indicated type from their existing locations in a manner that preserves their condition. The impact attenuators shall remain the property of the State, and the Contractor shall store and protect them in a manner that preserves their condition at locations within the contract limits. Parts damaged by the Contractor's activities shall be replaced with like parts in satisfactory condition or repaired at no cost to the State.

If the slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-3.08 Relocate. The Contractor shall remove impact attenuators of the indicated type from their existing locations in a manner that preserves their condition, and reinstall them at the same location or install them at another designated location. The impact attenuators shall remain the property of the State during the course of the work.

If required, the Contractor shall construct a new foundation slab. The cost of the new foundations will be paid for separately. If intermediate storage is required during the relocation, the Contractor shall store and protect impact attenuators. Damaged parts shall be replaced with like parts in satisfactory condition or be repaired at no cost to the State. The cost of replacing or repairing parts having pre-existing damage will be considered Extra Work.

If the original slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-4 METHOD OF MEASUREMENT.

654-4.01 General. (VACANT)

654-4.02 Inertial Barrier Modules. The quantity to be measured for payment will be the number of inertial barrier modules installed.

654-4.03 Expendable Impact Attenuator. The quantity to be measured for payment will be the number of expendable impact attenuators installed.

654-4.04 Reusable Impact Attenuator. The quantity to be measured for payment will be the number of reusable impact attenuators installed.

654-4.05 Concrete Foundation for Impact Attenuator. The quantity to be measured for payment will be in cubic meters of reinforced concrete foundation installed.

654-4.06 Remove and Dispose. The quantity to be measured for payment will be the number of impact attenuators removed.

654-4.07 Remove and Store. The quantity to be measured for payment will be the number of impact attenuators removed.

654-4.08 Relocate. The quantity to be measured for payment will be the number of impact attenuators relocated.

654-5 BASIS OF PAYMENT.

654-5.01 General. The unit prices bid for the work described in this section shall include the cost of all labor, materials, and equipment necessary to satisfactorily perform the work.

Pavement restoration: Pavement restoration will be paid for separately under the contract pay items for Truing and Leveling. If there are no contract pay items for Truing and Leveling, then pavement restoration will be paid under the contract pay item for the top course of hot mix asphalt. If no contract pay items exist in the contract for paving items, then no separate payment for pavement restoration will be made.

Payment will be made under:

Item No.	Item	Pay Unit
654.01xx	Inertial Barrier Module, ___ Kilograms	Each
xx =01 for 90 kg units; 02 for 180 kg units; 03 for 320 kg units;04 for 640 kg units; 05 for 960 kg units		
654.05	Concrete Foundation for Impact Attenuator	Cubic Meter
654.06	Drill and Grout Anchoring System into Existing Foundation	Each
654.0701	Remove and Dispose Impact Attenuator	Each
654.0702	Remove and Store Impact Attenuator	Each
654.08	Relocate Impact Attenuator	Each
654.5010	Expendable Impact Attenuator, TL 2, ≤ 610 mm Obstruction Width	Each
654.5011	Expendable Impact Attenuator, TL 2, > 610 mm up to 1525 mm Obstruction Width	Each
654.5012	Expendable Impact Attenuator, TL 2, >1525 mm Obstruction Width	Each
654.5020	Expendable Impact Attenuator, TL 3, ≤ 610 mm Obstruction Width	Each
654.5021	Expendable Impact Attenuator, TL 3, > 610 mm up to 1525 mm Obstruction Width	Each
654.5022	Expendable Impact Attenuator, TL 3, >1525 mm Obstruction Width	Each
654.5020	Reusable Impact Attenuator, TL 2, ≤ 610 mm Obstruction Width	Each
654.5111	Reusable Impact Attenuator, TL 2, > 610 mm up to 1525 mm Obstruction Width	Each
654.5112	Reusable Impact Attenuator, TL 2, > 1525 mm Obstruction Width	Each
654.5120	Reusable Impact Attenuator, TL 3, ≤ 610 mm Obstruction Width	Each
654.5121	Reusable Impact Attenuator, TL 3, > 610 mm up to 1525 mm Obstruction Width	Each
654.5122	Reusable Impact Attenuator, TL 3, > 1525 mm Obstruction Width	Each"

Page 839, *delete*: "712-06 (VACANT)", previously revised by EI 07-006, and ***replace*** with the following:

"712-06 EXPENDABLE IMPACT ATTENUATOR

SCOPE. This specification covers the material and performance requirements for expendable impact attenuators.

MATERIALS REQUIREMENTS. Expendable Impact Attenuator components shall meet the following requirements:

Impact attenuators that use liquid or other materials as a filler or to provide ballast will be evaluated for potential environmental impacts and/or seasonal limitations.

Covers shall be provided by the manufacturer for all units where ingress of debris from the top will result in deterioration of performance.

Metal parts shall be fabricated from M1020 Merchant Quality or ASTM A36M steel.

All galvanization shall be in accordance with §719-01 *Galvanized Coatings and Repair Methods, Type I.*

Welding shall be in accordance with the Steel Construction Manual, except radiographic inspection shall not be required.

The size and recommended attachment method for reflective marking shall be specified by the vendor.

BASIS OF APPROVAL. Impact attenuator systems shall be NCHRP 350 approved. Impact attenuators meeting the requirements of NCHRP 350 TL-2 are acceptable only as TL-2 devices. TL-3 devices are acceptable for TL-3 and TL-2.

Manufacturers or material suppliers desiring to have impact attenuators approved shall prepare and submit Materials Details Sheets consisting of copies of drawings, specifications, test reports, and Federal acceptance letters, to the Director of the Materials Bureau. The review process requires a minimum of 45 calendar days.

BASIS OF ACCEPTANCE. Expendable Impact Attenuators will be accepted at the contract site on the basis of the manufacturer's name appearing on the Approved List, conformance to the appropriate Materials Details Sheets, and the manufacturer's certification that the product delivered is in conformance with these specifications."

Page 840, *delete*: "712-08 THRU 712-11 (VACANT)" and *replace* with the following:

"712-08 REUSEABLE IMPACT ATTENUATOR

SCOPE. This specification covers the material and performance requirements for reusable impact attenuators.

MATERIALS REQUIREMENTS. Reusable Impact Attenuator components shall meet the following requirements:

Impact attenuators that use liquid or other materials as a filler or to provide ballast will be evaluated for potential environmental impacts and/or seasonal limitations.

Covers shall be provided by the manufacturer for all units where ingress of debris from the top will result in deterioration of performance.

Metal parts shall be fabricated from M1020 Merchant Quality or ASTM A36M steel.

All galvanization shall be in accordance with §719-01 *Galvanized Coatings and Repair Methods, Type I.*

Welding shall be in accordance with the Steel Construction Manual, except radiographic inspection shall not be required.

BASIS OF APPROVAL. Impact attenuator systems shall be NCHRP 350 approved. Impact attenuators meeting the requirements of NCHRP 350 TL-2 are acceptable only as TL-2 devices. TL-3 devices are acceptable for TL-3 and TL-2.

Manufacturers or material suppliers desiring to have impact attenuators approved shall prepare and submit Materials Details Sheets consisting of copies of drawings; specifications, test reports, and Federal acceptance letters, to the Director of the Materials Bureau. The review process requires a minimum of 45 calendar days.

As a condition for approval as a reusable attenuator, Manufacturer shall certify and provide factual data showing that the maximum (materials only) present-day cost for the repair needs incurred, during any one of the

NCHRP 350 crash tests that were considered necessary for the approval, will not exceed the maximum material cost per incident as stipulated by the Director of the Design Quality Assurance Bureau and posted on the Department's web site. The time required for the average repair shall not exceed 4 person-hours. In some circumstances, the Director may accept an In-Service Evaluation Report conforming to the guidelines of NCHRP350 Chapter 7 in lieu of the standard crash test costs. Such a report shall include contact information for the originating agency(ies).

The Department reserves the right to withdraw approval of an item as "reusable" if the in-service repair costs regularly exceed the posted maximum.

BASIS OF ACCEPTANCE. Reusable Impact Attenuators will be accepted at the contract site on the basis of the manufacturer's name appearing on the Approved List, conformance to the appropriate Materials Details Sheets, and the manufacturer's certification that the product delivered is in conformance with these specifications.

712-09 THRU 712-11 (VACANT)"

Pages 846 to 852, ***delete*** Sections 712-18, 712-19, 712-20, 712-21, 712-22, in their entirety, and ***replace*** with: **"712-18 THRU 712-22 (VACANT)".**

Make the following changes to the Standard Specifications dated May 1, 2008:

Pages 681 to 688 ***delete*** Section 654 *Impact Attenuators* in its entirety and ***replace*** it with the following:

"SECTION 654 - IMPACT ATTENUATORS - PERMANENT

654-1 DESCRIPTION.

654-1.01 General. The work shall consist of furnishing and installing; removing and disposing; removing and storing; and relocating; impact attenuators, and installing foundations for impact attenuators, in accordance with the contract documents, the working drawings, and as directed by the Engineer.

654-1.02 Inertial Barrier Modules. An impact attenuator consisting of sand-filled modules (barrels) set in an array for site hazard protection.

654-1.03 Expendable Impact Attenuator. Impact attenuator which requires extensive repair, or replacement, to return the unit to its full operating capacity.

654-1.04 Reusable Impact Attenuator. Impact attenuator which requires minimal or no repair to return the unit to its full functional capability.

654-1.05 Concrete Foundation for Impact Attenuator. A new concrete foundation on which an attenuator is placed or, if required, anchored.

654-1.06 Transition Piece(s). Components of the attenuator system that are designed to connect between the attenuator and the shielded object in such a manner as to prevent an impacting vehicle from snagging on the shielded object. Not all installations require a transition piece and some transition pieces must be capable of handling opposite direction impacts.

654-2 MATERIALS. Materials shall conform to the following subsections of Section 700 *Materials and Manufacturing*:

Class A Concrete	501-2
Concrete Grouting Material	701-05
Anchoring Material- Chemically Curing	701-07
Precast Concrete	704-03
Epoxy Coated Bar Reinforcement, Grade 420	709-04
Expendable Impact Attenuator	712-06
Inertial Barrier Modules	712-07
Reusable Impact Attenuator	712-08
Galvanized Coating and Repair Methods	719-01
Anchor Bolts, Nuts and Washers	723-60
Traffic Paint (White)	727-09
Aluminum Sign Panels	730-01
Reflective Sheeting	730-05

654-3 CONSTRUCTION DETAILS.

654-3.01 General.

A. Drawings: Manufacturer's drawings, modified as necessary to reflect site conditions, will be referred to as "working drawings." Working drawings will take precedence over manufacturer's drawings. Working drawings shall show attenuator system: supports, transition pieces, connections, miscellaneous parts, concrete or steel back-up structure, and anchorages not detailed in the plans, but which are necessary to develop the full performance of the impact attenuator. Attenuator mounting surface or foundation slab details and limits, will be shown in the working drawings. Any component not supplied by the manufacturer will be labeled as "PROVIDED BY OTHERS". A minimum of 7 calendar days prior to beginning work, the Contractor shall submit three (3) copies of working drawings to the Engineer. The submission shall include the manufacturer's certification that modifications made to manufacturer's drawings reflecting site conditions will not impair the satisfactory performance of the impact attenuator as designed and tested under NCHRP requirements. All aspects of the working drawings shall be implemented in the field, including any alterations of the concrete barrier or other obstruction being shielded.

B. Manuals. A minimum of 7 calendar days prior to beginning work, the Contractor shall deliver to the Engineer 3 copies of design manuals, installation manuals, parts lists, and maintenance manuals prepared for each type of impact attenuator being installed.

C. Coordination with Other Work. Coordinate the work under this section with removal and installation of shielded objects, barriers and guide rail in such manner as to limit the exposure of vehicular traffic to potential hazards to no more than 7 calendar days.

D. Excavation. Necessary excavation shall be performed in accordance with Section 203 *Excavation and Embankment*. Where the perimeter of the foundation slab will not be adjacent to pavement, the limit of excavation shall be 2 feet outside of the slab and forming shall be used. Where the perimeter of the foundation slab will be adjacent to pavement that is to remain in place, the limits of excavation shall be the limits of the foundation slab and the existing pavement shall be saw cut full depth prior to removal of the pavement and performance of the excavation work. Sawcutting and excavation shall be included in the cost of the foundation.

E. Anchorages. The impact attenuator shall be anchored to the new foundation slab or existing concrete foundation as shown on the working drawings. Anchor bolts and studs not cast integrally into the new foundation slab shall be anchored with approved concrete expansion anchors, concrete grouting material, or approved chemically curing anchoring material. Such anchor bolts or studs shall be set into holes drilled with rotary impact drills of the size recommended by the manufacturer of the anchor. Core drills will not be acceptable. Care shall be taken that anchor studs projecting from the surface and exposed to foot or wheeled traffic be well marked or protected.

A backup structure, if required by the manufacturer, shall be installed as indicated in the approved Materials Details or working drawings.

F. Transitions. The Contractor shall install the appropriate standard transition piece(s). If a transition is needed, but there is no standard transition design, a manufacturer's approved special transition piece, subject to the Engineer's approval, shall be furnished and installed. Refer to §654-3.01A for submittal requirements.

G. Directionality. When the contract documents indicate that an attenuator must handle two-way traffic, rather than diverging traffic, the Contractor shall supply an attenuator that is approved for the two-way traffic.

H. Reflectorization. ASTM Type III (Class B), Type V (Class C), or Type IX (Class E) sheeting directly applied to plastic or aluminum sheeting, or other lightweight rigid material, shall be affixed to the front cylinder, module, or front face of the impact attenuator. The pattern and color of the reflectorization shall be as indicated in the contract documents.

If no dimensions are provided, the panel shall be approximately square with a minimum of 18 inches on a side (24 inches on Inertial Barrier Modules). Whenever approaching traffic is allowed to pass on both sides of the unit, the pattern shall be upward pointing v-shaped striping, 4 inches wide, alternating between reflectorized yellow and opaque non-reflectorized black stripes, as indicated for Type 3 Object Markers in the MUTCD.

When traffic will be permitted on only one side, the pattern shall be diagonal 4 inch stripes, downward sloping to the side on which traffic is to be permitted.

654-3.02 Inertial Barrier Modules. The Contractor shall install Inertial Barrier Modules of the size and number required at the locations, and to the configurations, indicated in the contract documents. The Contractor shall also paint and label the layout pattern and weights on paved surfaces using traffic or other durable paint. The weight shall be marked. When either indicated in the contract documents or when the modules are placed on a bridge deck on any slope exceeding 6%, the 200 lb units shall be restrained from movement and overturning (vandalism) by mechanical means.

654-3.03 Reusable Impact Attenuators. The Contractor shall install Reusable Impact Attenuators on existing or new foundations, in accordance with the contract documents and the working drawings.

654-3.04 Expendable Impact Attenuators. The Contractor shall install Expendable Impact Attenuators on existing or new foundations, as indicated on the contract documents and the working drawings.

654-3.05 Concrete Foundation. When the existing concrete pavement is not sufficient to meet the anchorage requirements or there is not an adequate existing foundation, the Contractor shall remove the existing pavement and construct a reinforced concrete foundation slab and back-up structure to the dimensions indicated in the working drawings. The foundation slab shall be not less than the thickness indicated on the working drawings, or 8 inches, whichever is greatest.

The concrete shall be batched in accordance with Section 501 *Portland Cement Concrete*. If accelerators are needed, the Contractor shall submit the concrete mix design to the Materials Bureau for prior approval. The concrete shall be formed (when necessary), placed, and cured in accordance with Section 502 *Portland Cement Concrete Pavement*. The surface shall be hand finished.

The size, length, and bending details of reinforcement shall be as shown in the foundation slab details in the working drawings. The minimum allowable reinforcing shall be epoxy-coated #5 bars, with longitudinal spacing 16 inches on centers, and cross bar spacing 6 feet on centers. Longitudinal bars shall be placed such that they will not be cut during anchorage installation.

If foundation slab removal is specified, voids resulting from the removal of foundation slabs shall be filled with compacted suitable material or compacted granular material, or other designated material as specified in the contract documents or by the Engineer.

The excavated section of pavement between the new foundation slab and the limits of excavation shall be restored to the full height of the surrounding sound pavement.

654-3.06 Removal and Disposal. The Contractor shall remove impact attenuators of the indicated type, and if required the associated foundation slabs, from their existing locations. Upon removal, the impact attenuators and foundation slabs shall become the property of the Contractor. If foundation slab removal is specified, voids resulting from the removal of foundation slabs shall be filled with compacted suitable material or compacted granular material, or other designated material as specified in the contract documents or by the Engineer.

If the slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-3.07 Removal and Storage. The Contractor shall remove impact attenuators of the indicated type from their existing locations in a manner that preserves their condition. The impact attenuators shall remain the

property of the State, and the Contractor shall store and protect them in a manner that preserves their condition at locations within the contract limits. Parts damaged by the Contractor's activities shall be replaced with like parts in satisfactory condition or repaired at no cost to the State.

If the slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-3.08 Relocate. The Contractor shall remove impact attenuators of the indicated type from their existing locations in a manner that preserves their condition, and reinstall them at the same location or install them at another designated location. The impact attenuators shall remain the property of the State during the course of the work.

If required, the Contractor shall construct a new foundation slab. The cost of the new foundations will be paid for separately. If intermediate storage is required during the relocation, the Contractor shall store and protect impact attenuators. Damaged parts shall be replaced with like parts in satisfactory condition or be repaired at no cost to the State. The cost of replacing or repairing parts having pre-existing damage will be considered Extra Work.

If the original slab is to remain in place, holes in and other damage to the surfaces underlying the impact attenuator shall be repaired. Anchor bolts or studs that are no longer required or usable shall be removed or cut off flush with the surface.

654-4 METHOD OF MEASUREMENT.

654-4.01 General. (VACANT)

654-4.02 Inertial Barrier Modules. The quantity to be measured for payment will be the number of inertial barrier modules installed.

654-4.03 Expendable Impact Attenuator. The quantity to be measured for payment will be the number of expendable impact attenuators installed.

654-4.04 Reusable Impact Attenuator. The quantity to be measured for payment will be the number of reusable impact attenuators installed.

654-4.05 Concrete Foundation for Impact Attenuator. The quantity to be measured for payment will be in cubic yards of reinforced concrete foundation installed.

654-4.06 Remove and Dispose. The quantity to be measured for payment will be the number of impact attenuators removed.

654-4.07 Remove and Store. The quantity to be measured for payment will be the number of impact attenuators removed.

654-4.08 Relocate. The quantity to be measured for payment will be the number of impact attenuators relocated.

654-5 BASIS OF PAYMENT.

654-5.01 General. The unit prices bid for the work described in this section shall include the cost of all labor, materials, and equipment necessary to satisfactorily perform the work.

Pavement restoration: Pavement restoration will be paid for separately under the contract pay items for Truing and Leveling. If there are no contract pay items for Truing and Leveling, then pavement restoration will be paid under the contract pay item for the top course of hot mix asphalt. If no contract pay items exist in the contract for paving items, then no separate payment for pavement restoration will be made.

Payment will be made under:

Item No.	Item	Pay Unit
654.01xx	Inertial Barrier Module, ___ Pounds	Each

xx =01 for 200 lb units; 02 for 400 lb units; 03 for 700 lb units; 04 for 1400 lb units; 05 for 2000 lb units.

654.05	Concrete Foundation for Impact Attenuators	Cubic Yards
654.06	Drill and Grout Anchoring System into Existing Foundation	Each
654.0701	Remove and Dispose Impact Attenuator	Each
654.0702	Remove and Store Impact Attenuator	Each
654.08	Relocate Impact Attenuator	Each
654.5010	Expendable Impact Attenuator , TL 2, ≤ 2 ft Obstruction Width	Each
654.5011	Expendable Impact Attenuator , TL 2, > 2 ft up to 5 ft Obstruction Width	Each
654.5012	Expendable Impact Attenuator , TL 2, > 5 ft Obstruction Width	Each
654.5020	Expendable Impact Attenuator , TL 3, ≤ 2 ft Obstruction Width	Each
654.5021	Expendable Impact Attenuator , TL 3, > 2 ft up to 5 ft Obstruction Width	Each
654.5022	Expendable Impact Attenuator , TL 3, > 5 ft Obstruction Width	Each
654.5010	Reusable Impact Attenuator , TL 2, ≤ 2 ft Obstruction Width	Each
654.5111	Reusable Impact Attenuator , TL 2, > 2 ft up to 5 ft Obstruction Width	Each
654.5112	Reusable Impact Attenuator , TL 2, > 5 ft Obstruction Width	Each
654.5120	Reusable Impact Attenuator , TL 3, ≤ 2 ft Obstruction Width	Each
654.5121	Reusable Impact Attenuator , TL 3, > 2 ft up to 5 ft Obstruction Width	Each
654.5122	Reusable Impact Attenuator , TL 3, > 5 ft Obstruction Width	Each"

Page 880, *delete*: "712-06 (VACANT)" and *replace* with the following:

"712-06 EXPENDABLE IMPACT ATTENUATOR

SCOPE. This specification covers the material and performance requirements for expendable impact attenuators.

MATERIALS REQUIREMENTS. Expendable Impact Attenuator components shall meet the following requirements:

Impact attenuators that use liquid or other materials as a filler or to provide ballast will be evaluated for potential environmental impacts and/or seasonal limitations. Impact attenuators will be approved for use in shielding an object of a maximum width as specified in the Approved List, and specific configurations may be approved for maximum speeds.

Covers shall be provided by the manufacturer for all units where ingress of debris from the top will result in deterioration of performance.

Metal parts shall be fabricated from M1020 Merchant Quality or ASTM A36M steel.

All galvanization shall be in accordance with §719-01 *Galvanized Coatings and Repair Methods, Type I.*

Welding shall be in accordance with the Steel Construction Manual, except radiographic inspection shall not be required.

The size and recommended attachment method for reflective marking shall be specified.

BASIS OF APPROVAL. Impact attenuator systems shall be NCHRP 350 approved. Impact attenuators meeting the requirements of NCHRP 350 TL-2 are acceptable only as TL-2 devices. TL-3 devices are acceptable for TL-3 and TL-2.

Manufacturers or material suppliers desiring to have impact attenuators approved shall prepare and submit Materials Details Sheets consisting of copies of drawings, specifications, test reports, and Federal acceptance letters, to the Director of the Materials Bureau. The review process requires a minimum of 45 calendar days.

BASIS OF ACCEPTANCE. Expendable Impact Attenuators will be accepted at the contract site on the basis of the manufacturer's name appearing on the Approved List, conformance to the appropriate Materials Details Sheets, and the manufacturer's certification that the product delivered is in conformance with these specifications."

Page 881, *delete*: "712-08 THRU 712-11 (VACANT)" and *replace* with the following:

"712-08 REUSEABLE IMPACT ATTENUATOR

SCOPE. This specification covers the material and performance requirements for reusable impact attenuators.

MATERIALS REQUIREMENTS. Reusable Impact Attenuator components shall meet the following requirements:

Impact attenuators that use liquid or other materials as a filler or to provide ballast will be evaluated for potential environmental impacts and/or seasonal limitations. Impact attenuators will be approved for use in shielding an object of a maximum width as specified in the Approved List, and specific configurations may be approved for maximum speeds.

Covers shall be provided by the manufacturer for all units where ingress of debris from the top will result in deterioration of performance.

Metal parts shall be fabricated from M1020 Merchant Quality or ASTM A36M steel.

All Galvanization shall be in accordance with §719-01 *Galvanized Coatings and Repair Methods, Type I.*

Welding shall be in accordance with the Steel Construction Manual except radiographic inspection shall not be required.

BASIS OF APPROVAL. Impact attenuator systems shall be NCHRP 350 approved. Impact attenuators meeting the requirements of NCHRP 350 TL-2 are acceptable only as TL-2 devices. TL-3 devices are acceptable for TL-3 and TL-2.

Manufacturers or material suppliers desiring to have impact attenuators approved shall prepare and submit Materials Details Sheets consisting of copies of drawings, specifications, test reports, and Federal acceptance letters, to the Director of the Materials Bureau. The review process requires a minimum of 45 calendar days.

As a condition for approval as a reusable attenuator, Manufacturer shall certify and provide factual data showing that the maximum (materials only) present-day cost for the repair needs incurred, during any one of the NCHRP 350 crash tests that were considered necessary for the approval, will not exceed the maximum material cost per incident as stipulated by the Director of the Design Quality Assurance Bureau and posted on the Department's web site. The time required for the average repair shall not exceed 4 person-hours. In some circumstances, the Director may accept an In-Service Evaluation Report conforming to the guidelines of NCHRP350 Chapter 7 in lieu of the standard crash test costs. Such a report shall include contact information from the originating agency(ies).

The Department reserves the right to withdraw approval of an item as "reusable" if the in-service repair costs regularly exceed the posted maximum.

BASIS OF ACCEPTANCE. Reusable Impact Attenuators will be accepted at the contract site on the basis of the manufacturer's name appearing on the Approved List, conformance to the appropriate Materials Details Sheets, and the manufacturer's certification that the product delivered is in conformance with these specifications.

712-09 THRU 712-11 (VACANT)"

Pages 887 to 893, ***delete*** Sections 712-18, 712-19, 712-20, 712-21, 712-22 in their entirety and ***replace*** with: **"712-18 THRU 712-22 (VACANT)"**