

and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
605X005	Permanent (<i>color</i>) Pavement Markers - Mono-Directional, 4" x 4"	Each
605X010	Permanent (<i>color</i>) Pavement Markers - Mono-Directional, 5" x 2"	Each
6051100	Permanent Yellow Pavement Markers - Bi-Directional, 4" x 4"	Each
6051110	Permanent Yellow Pavement Markers - Bi-Directional, 5" x 2"	Each

SECTION 606

(RESERVED)

SECTION 607

PERMANENT TERMINAL IMPACT ATTENUATOR

607.01 Description. This work shall consist of furnishing, assembling, and installing, permanent terminal impact attenuators on or adjacent to the roadways in the state of South Carolina to protect the ends of concrete barrier walls and other hazards.

Each impact attenuator shall control the deceleration of impacting vehicles and dissipation of the vehicles' kinetic energy. When struck from the front, the unit shall bring the errant vehicle to a safe and controlled stop. When impacted from the

side, the unit shall redirect the errant vehicle. Each impact attenuator shall function within the requirements as detailed by these specifications and the manufacturer's specifications.

MATERIAL

607.02 Impact Attenuating Device. The impact attenuator shall be a QuadGuard System manufactured by Energy Absorption Systems, Incorporated, of Chicago, Illinois, or an approved equal and accepted by the Engineer.

Alternative impact attenuating devices shall meet all standards and requirements as specified under this specification to be considered an approved equal. Failure to meet these requirements in their entirety shall disqualify an alternative impact attenuating device as an approved equal.

The attenuator shall be 24, 30, 36, 69, or 90 inches wide and shall contain the number of bays as specified by the plans and/or the special provisions.

The Contractor shall make all corresponding shop drawings and detailed specifications from the manufacturer available for the Engineer's inspection before installation of the attenuator. The shop drawings and specifications shall include performance criteria, installation drawings, and instructions that completely describe the attenuator system. Shop drawings submittals shall conform to the requirements of Subsection **725.02**.

607.03 Crushable Cartridges. Crushable cartridges shall be Type I and Type II as necessary.

Each cartridge shall be new. Cartridges exhibiting pulled staples, wrinkles in the plastic container package, exposed internal material, shall be considered defective and shall not be installed.

All nose assemblies shall be yellow. Supplement the nose

assembly of each attenuator with road signs, either W18-2-24, W18-2R-24, or W18-2L-24, for delineation of the approach end of the unit. The Contractor shall request the necessary sign drawings from the Engineer.

607.04 Performance Requirements. Impact attenuators shall meet the following performance requirements:

1. Each impact attenuator shall meet the test requirements for the National Cooperative Highway Research Program (NCHRP), *Report 350*, 1993, for re-directive, non-gating terminals and crash cushions as directed by the FHWA. Each attenuator shall have approval for use from the FHWA.
2. Design, selection, and placement of terminal impact attenuators shall conform to and utilize devices described in:
 - a. The American Association of State Highway and Transportation Officials (AASHTO) publication, *Roadside Design Guide*, latest edition.
 - b. U.S. Department of Transportation, Federal Highway Administration (FHWA) *Report N5040.16, Crash Cushions, Selection Criteria, and Design*.
3. The impact attenuator shall decelerate and stop vehicles weighing 1800 to 4400 pounds during head-on impacts. The attenuator shall meet the occupant risk and vehicle trajectory criteria required by the NCHRP, *Report 350*, Tests 30, 31, 32, and 33. Test 31 shall also evaluate the capacity of the attenuator to absorb the energy of the standard 3/4 ton pickup truck.
4. The impact attenuator shall redirect vehicles weighing 4400 pounds that impact the unit along the sides at speeds up to 62 MPH at angles of 20 degrees or less for both right-way and wrong-way impacts. The attenuator shall redirect

vehicles weighing 1800 pounds that impact the unit along the sides at speeds up to 62 MPH at angles of 15 degrees. Measure all angles from the longitudinal centerline of the unit. The attenuator shall meet the requirements of the NCHRP, *Report 350*, Tests 36, 37, 38, and 39. These tests shall evaluate the occupant risk and vehicle trajectory criteria, re-directional capability, the structural adequacy of the attenuator, the potential for snagging, and performance during a reverse hit

5. All test result data for 4400 pounds vehicles shall include the standard 3/4 ton pickup truck.

6. The impact attenuator shall remain intact without debris during all impacts within design parameters. After side impacts within design parameters, the unit must remain capable of sustaining an additional side impact or a head-on impact at full design velocity.

7. The impact attenuator shall prevent lateral penetration at or near the “coffin corner” with a subsequent impact against the stationary hazard. The “coffin corner” is the term for the last four feet of the attenuator in front of the hazard. The impact attenuator shall prevent penetration of the “coffin corner” in all impacts from 0 MPH up to the maximum design speeds of the unit for vehicles in the weight range of 1800 to 4400 pounds.

CONSTRUCTION REQUIREMENTS

607.05 Assembly and Installation. The impact attenuator shall be assembled and installed in conformance with these specifications, the manufacturer’s specifications, the special provisions, the plans, and as directed by the Engineer.

The Engineer will inspect each impact attenuator, including all parts and materials, before and immediately after installation to ensure conformance with all specifications.

All obstructions shall be cleared from the immediate site location. The immediate surrounding area and the approach area 50 feet long in advance of the system of curbs, islands, elevated objects, and depressions shall be dressed and cleared where possible. All approach areas in advance of the site location shall be reasonably smooth and flat for no less than 100 feet. Unpaved approach areas shall be graded where necessary to provide smooth and flat surfaces.

Each site location may require preparations such as grading, slope flattening, and excavation and construction of a concrete pad. The immediate site location of the attenuator shall be at the same grade elevation, including adjustments necessary for superelevation, as the adjacent travel lane or paved shoulder. Any location that exceeds a cross slope of 8% or has a variance in excess of 2% shall require one or more of the above site preparations.

A site location within a two-way traffic situation shall require utilization of an approved transition panel. The attenuator shall be placed on the site location to minimize exposure of the rear of the unit to opposing traffic and the possibility of a vehicle snagging the rear of the unit. Each transition panel shall be drilled to permit attachment to the hazard or existing guardrail and to the attenuator. The panel shall be attached to the unit beneath the adjacent fender panel to permit the adjacent forward set of fender panels the ability to move over the transition panel during an impact from the front. The panel shall be installed flat and securely against the side of the hazard to prevent snagging of vehicles as required by these specifications and as directed by the manufacturer's specifications.

The attenuator shall be anchored onto a concrete foundation constructed in accordance with the manufacturer's specifications. The top of each foundation shall be at the same grade elevation as the adjacent travel lane and/or paved shoulder. The foundation shall be constructed to be compatible with the anchor system.

The anchor system shall conform to the requirements of these specifications and the manufacturer's specifications.

The grout used for attenuator anchor systems shall be a two-part polyester epoxy. The grout shall be either the MP-3 Polyester Anchoring System manufactured by Energy Absorption Systems, Inc. or an approved equal.

607.06 Method of Measurement. Impact attenuators shall be measured by each permanent terminal impact attenuator furnished, assembled, installed and accepted.

607.07 Basis of Payment. The number of permanent impact attenuators accepted will be paid for at the contract unit price for the permanent terminal impact attenuator, which price and payment shall be full compensation for furnishing, assembling and installing each attenuator and all labor, equipment, tools and incidentals necessary to satisfactorily complete the work.

Included in the price and payment shall be the preparation of the site location, grading, slope flattening, excavation, concrete pad for attenuator, anchoring system, grout for the anchors if required, connection of the attenuator to the guardrail or concrete barrier where required, furnishing and installing transition panel if necessary, and all structural backing systems and concrete pads.

Payment for this item includes all direct and indirect costs and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
6070000	Permanent Terminal Impact Attenuator	Each