To:		New York State Department of Transportation ENGINEERING INSTRUCTION	EI 01-026
SUPERSEDED BY EI 02-042 EFFECTIVE 9/11/03			

Title: **Section 654 Impact Attenuators**

Distribution:		Approved:
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☒ Regions/Agencies (32)	☐ _____( )	Philip J. Clark, Deputy Chief Engineer, Design Division — Date

ADMINISTRATIVE INFORMATION. This Engineering Instruction (EI) is effective with projects submitted for the letting of July 11, 2002, coinciding with the planned effective date for the proposed *2002 Standard Specifications*. It disapproves a number of specifications issued with EIs 98-028, 98-014, and 01-003, and supersedes these engineering instructions. The superseded engineering instructions contain valid design and layout information, which is included herein. The information will ultimately be incorporated in the *2002 Standard Specifications* and Chapter 10 of the *Highway Design Manual*. A portion of EI 01-003 will be replaced with another engineering instruction.

PURPOSE. To authorize the issuance of Section 654 Impact Attenuators under the *2002 Standard Specifications*; to authorize new Materials Subsections 712-18, 712-19, and 712-20; and to disapprove a number of existing special specifications indicated below. Because of the limited number of manufacturer's for these impact attenuators, the specifications are proprietary. If used in accordance with this engineering instruction, however, no proprietary item justification needs to be submitted.

TRANSMITTED MATERIALS. To save printing expense, nothing is transmitted under this instruction. Full text of the proposed Section 654 and referenced material specifications in the 700 Section will be contained in advance copies of the *2002 Standard Specifications* to be made available to designers. Full text is also available on the IntraDOT site in the Design Quality Assurance Bureau's Specifications and Standards page and with the electronic version of this EI on our web site at www.dot.state.ny.us, "Site Index", "E", Engineering Directives...", "EI Index", "EIs Issued in 2001".

SPECIFICATIONS TO BE DISAPPROVED FOR EFFECTIVE DATE AND BEYOND.

- Items 15654.04xxyy, where xx = 24, 30, 36, 69, and 90; and yy = 03, 04, 05, 06, 09. Not all combinations were entered. These items were for QuadGuard Terminal Impact Attenuators, and were issued under EI 98-028. The name for these used in Section 654 is Quad Beam Type with Expendable Modules.
- Items 15654.2001- 15654.2003 and Items 15654.2101-15654.2103. These are the pay items for the Reusable Energy Absorbing Crash Terminal known as the REACT 350 on new and existing foundations. They were issued under EI 98-014. Items 15654.2004 and 15654.2104 have already been disapproved by EB 00-068. The name used for these impact attenuators in Section 654 is Reusable HDPE Cylinder and Cable Type.
- Items 15654.26, 15654.27, 15654.28, and 15654.29. These are the pay items for six and nine bay TRACCs on existing and new foundations. They were issued under EI 01-003. The name used for these impact attenuators in Section 654 is Corrugated Beam with Metal Tearing Strip Type.
- Items 15654.6801 - 15654.6805. These are the pay items for Inertial Barrier Modules (Sand Barrels) which were issued under EI 85-40 and EI 86-31. The name for these impact attenuators in Section 654 remains the same.
- Items 11654.48, 10654.52, 10654.5210, and 11654.70. These are specifications for the removal and storage and removal and disposal of inertial barrier modules.

UNCHANGED INFORMATION FROM SUPERSEDED ENGINEERING INSTRUCTIONS.

Intact portions of EI 98-014 on the REACT 350 (Cable and HDPE Cylinder Type) These reusable self-restoring devices were originally developed in conformance with NCHRP Report 350 by Roadway Safety Service, Inc., on Long Island. That company has been purchased by the Quixote Corporation, represented in New York State by Transpo Safety of New Rochelle, New York. Objects that can be shielded by the REACT 350 (Cable and HDPE Cylinder Type) include, but are not limited to, ends of concrete barrier, ends of narrow walls, ends of narrow parapets and heavy post blocked median barriers. Other safety articles that also may be used for some or all of these purposes include the GREAT, the QuadGuard (Quad Beam Type with Expendable Modules), the CAT, the BRAKEMASTER; and for one way applications, where room exists, sand barrel arrays. These other articles will be, or have been, separately discussed in the Highway Design Manual or in separate Engineering Instructions.

The NCHRP 350 tests that this device has passed include: test 3-30 - 820C vehicle at 113 km/hr and 0 degrees; test 3-31 - 2000P pickup truck impacting the nose at 113 km/hr and 0 degrees; test 3-38 - 2000P pickup truck impacting the device at 100 km/hr and 20 degrees; and test 3-39 - 820C car impacting the device at the interface of the backup structure and the last cylinder at 100 km/hr and 20 degrees. Based upon the results of these tests, FHWA has classified the REACT 350 (Cable and HDPE Cylinder Type) "experimental," which means states may use it on the NHS if they wish, but no in-service evaluation has been performed.

The reusability property[1] is based upon the self-restoring nature of the high molecular weight polyethylene (ASTM D3350, cell class 345434C) cylinders and the wall thicknesses specified in the manufacturer's drawings for the anticipated impact speeds. Selected layout dimensions are included in the table below. The approved manufacturer's drawings will include complete dimensioning and layout details.

Dimensional and Cost Data for REACT 350

SPEED km/h	NO. BARRELS	PAY ITEMS (new slab / exist foundation)	OVERALL LENGTH UNIT	COST OF UNIT	COST OF SLAB (includes excavation)
70	4	654.2004 (M) 654.2104 (M)	4.64 m	$14,500	$1000
90	6	654.2006 (M) 654.2106 (M)	6.47 m	$17,200	$1250
100	9	654.2009 (M) 654.2109 (M)	9.21 m	$20,800	$1750

Slab dimensions, if slab is required, are 0.2 m longer than the overall length of the units and 1.27 m wide. Costs of unit are based on quote from the manufacturer. The quoted prices include rear support assembly, base rails, stabilizer bars, cables/hardware, anchors, cylinders, cover/reflectors, documentation, and shipping to the jobsite. An allowance of $2,000 per unit has been added for the Contractor installation and markup. The nine (9) cylinder High Speed model disapproved by EB 00-068.

If a new foundation slab is required under the item, concrete shall be 200 mm thick Class A concrete conforming to §501-2. Reinforcing steel shall conform to §709-04 Epoxy Coated Bar Reinforcement, Grade 420 and shall be located and sized as detailed in the approved manufacturer's drawings.

[1]Although much depends on the speed of impact, these crash terminals have successfully taken hits and been easily restored six times so far. The manufacturer claims that a terminal could take hits up to nine times before there is a need for complete replacement.

These units may be installed on existing concrete foundations free of cracking or deterioration that may impair anchorage or the integrity of the foundation. Working cracks or working joints should not be bridged by these units. Existing hot mix asphalt concrete foundations or HMA overlay over concrete foundation may be used for temporary applications, but are not recommended by the manufacturer or the department for permanent applications.

Intact portions of EI 98-028 QuadGuard (Quad Beam Type with Expendable Modules) The Guard Rail Energy Absorbing Terminal (GREAT), predecessor of the QuadGuard (Quad Beam Type with Expendable Modules), has been used for some time in Department projects to shield narrow objects at locations where guide rails are not practical. In some cases, they have also been used for median barrier end terminals. The GREAT is mentioned in the *Highway Design Manual* in §10.2.6 and §10.2.6.4. It is an energy absorbing device fabricated from thrie beam guide rail beams and hex foam cartridges that crush on impact, thereby absorbing the energy of the impacting vehicle.

The Hex Foam Sandwich System has also been used for some time in Department work to protect objects up to 2.29 meters wide. This system is discussed in §10.2.6.3 of the Highway Design Manual.

The manufacturer of these devices (the GREAT and the Hex Foam Sandwich System) has developed an alternative system. It is the manufacturer's intent that this system, the QuadGuard (Quad Beam Type with Expendable Modules), replace the earlier GREAT system as their standard narrow redirective impact attenuator, and also replace the Hex Foam Sandwich System as their standard wide redirective impact attenuator for objects up to 2.29 meters wide.

The QuadGuard (Quad Beam Type with Expendable Modules) is available in five widths and up to 12 different lengths[2]. With six or more bays, the QuadGuard (Quad Beam Type with Expendable Modules) is rated as a NCHRP 350 "Test Level 3" device.

QuadGuards (Quad Beam Type with Expendable Modules) with widths of 610mm, 760mm, or 915 mm have the same "footprint" as the GREATs of those widths, and may be substituted for GREATs of these widths on contracts by order-on-contract at no additional cost and without rebate.

The QuadGuards (Quad Beam Type with Expendable Modules) with 1750 mm or 2285 mm widths may be substituted for Hex Foam Sandwich System of those widths by O.O.C. at no additional cost to the State & without rebate. *Note, however, that the thicknesses of the reinforced concrete slabs used with the QuadGuards (Quad Beam Type with Expendable Modules) are a minimum of 150 mm thick versus the minimum 100 mm thick concrete slab used with the Hex Foam Sandwich System. Reinforcement details are different as well.*

QuadGuards (Quad Beam Type with Expendable Modules) may be used to protect one way approaching traffic and, with the appropriate transition piece, may also be used in two-way traffic situations. Five of these transition pieces are available. These are for: 1) Concrete Jersey Barrier, 2) Corrugated W-rail, 3) Thrie Beam, 4) Vertical Surfaces, and 5) Single Slope Barrier.

The table below contains the number of QuadGuard (Quad Beam Type with Expendable Modules) bays required for the various speeds, physical dimensions, and cost information. This information has been taken from the QuadGuard (Quad Beam Type with Expendable Modules) Design Manual and communications with the vendor.

QuadGuards (Quad Beam Type with Expendable Modules) may be included in contracts or considered as substitutes for the GREATs or for the Hex Foam Sandwich System[3] by order-on-contract, without rebate or additional cost to the State, if requested by the Contractor. QuadGuards (Quad Beam Type with Expendable Modules) shall be included in the PS & Es, instead of the GREATs or Hex Foam Sandwich Systems, when these type devices are desired. The number of bays shall be selected from the table below, based on impact speed. The width of the unit, measured at the back of the unit near the protected object, shall be not less than the width of the protected object.

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2 Several of the available lengths are rated by the manufacturer as performing satisfactorily in the same speed ranges as shorter, and presumably, less expensive units. We have not coded pay items for these less efficient lengths.

3 Provided proper pad is provided or available.

Number of bay, various physical dimensions, and estimated costs of unit.							
IMPACT SPEED (km/h)	NO. OF BAYS	UNIT LENGTH METERS	EFFECT. LENGTH METERS	PAD LENGTH METERS	COST OF UNIT .61,76, .92 m	COST OF UNIT 1.76, 2.29 m	COST OF CONC. PAD
70	3	4.00	3.57	3.66	$11,500	$13,000	$750
80	4	4.91	4.49	4.57	14,000	15,500	800
90	5	5.83	5.40	5.49	16,000	17,500	900
100	6	6.74	6.32	6.40	18,000	19,500	1000
110	9	9.49	9.06	9.14	24,000	25,500	1200
Cost of units includes parts and installation costs by subcontractor and $1000 contractor markup for the prime contractor. The nose piece is not considered a bay. Impact speed is preferably the design speed for the highway, but should not be less than the posted speed.							

QuadGuards (Quad Beam Type with Expendable Modules) intended for permanent application[4] shall be installed on reinforced[5] concrete pads 1.22 m wide and 150 mm thick minimum, on existing reinforced concrete that thick and in good condition, or on unreinforced concrete 200 mm minimum thickness. Should such a foundation not be available, one must be built.

Avoid crossing working cracks or joints as special anchoring hardware will be required. If working joints or cracks cannot be avoided, contact either the manufacturer or vendor with joint/crack location and movement information for assistance with design as needed. Either steel tension strut back-up structures or concrete back-up structures are required. The specifications indicate that steel tension strut back-up structures may be used in all applications. The specifications also indicate that, under some conditions, concrete back-up structure may be used at the contractor's option.

Curbs and islands higher than 100 mm should be removed. Mountable curbs and islands 100 mm or lower may be retained if they are needed to collect and control pavement runoff, but otherwise even they should be removed from the back of the unit to a point fifteen meters (15 m) in advance of the nose of the unit. New curbings,of any height, are not to installed within the above described limits.

Cross slopes steeper than 8% and changes in the rate of cross slope (twist) greater than 2% from front to back of slab are to be avoided. If encountered, they should be corrected by means of leveling or grading.

Certain information should be shown on the plans. This information would include a plan view showing the unit, its concrete pad or notes that the existing foundation at the site is to be used for foundation, the locations of any drainage structures, utility information, expansion joints, working cracks, edges of pavements, curbing or islands, and identifying any special transitions required between the QuadGuard (Quad Beam Type with Expendable Modules) and the protected object.

If QuadGuards (Quad Beam Type with Expendable Modules) are to be attached to concrete barrier, the concrete barrier should be embedded and reinforced over the first 2.50 m from the QuadGuard (Quad Beam Type with Expendable Modules). Bar reinforcement, consisting of # 13 epoxy coated bars at 200 mm c/c each-way, is required. Twelve (12) Type A Typical Stirrups from the Standard Sheets, spaced 200 mm on centers, will provide the vertical reinforcement in both faces. Six (6) straight bars 2.50 m long replace the four (4) 600 mm long dowels shown on the standard sheets. These would be spaced at 200 mm to provide the horizontal reinforcement.

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[4] There are temporary QuadGuards (Quad Beam Type with Expendable Modules) for use in the construction work zones. These will be covered separately.

[5] Reinforcement must be equal to or exceed number 16 rebar @ 600 mm c/c.

Intact Information from EI 01-003, TRACC (Corrugated Beam Type with Metal Tearing Strips) The nine bay (TRACC) Corrugated Beam Type with Metal Tearing Strips is rated as a NCHRP 350 "Test Level 3" device. This means the units can be used on all facilities. The six bay Corrugated Beam Type with Metal Tearing Strips (TRACC) is rated as a NCHRP 350 "Test Level 2" device. TL2 devices are to be used on facilities with design speeds of 70 km/h or less.

Corrugated Beam Type with Metal Tearing Strips (TRACC) may be used to protect one way approaching traffic and, with the appropriate metal transition pieces, may also be used in two-way traffic situations. Transition is available for Concrete Jersey Barrier shapes. The metal transition pieces are included in the price of the unit.

The nine bay Corrugated Beam Type with Metal Tearing Strips (TRACC) is 6.4 m long and 810 mm wide. The six bay Corrugated Beam Type with Metal Tearing Strips (TRACC) is 4.33 m long and 810 mm wide. The maximum width of an object that can be shielded by a Corrugated Beam Type with Metal Tearing Strips (TRACC) unit is 610 mm. The unit installs on both new and existing concrete or asphalt pads, but only concrete pads will be allowed for permanent installations.

The Corrugated Beam Type with Metal Tearing Strips (TRACC) is reusable to a *limited extent*. During end-on impacts, if the stroke (movement of the front face of the sled assembly) is not more than 1.35 m, then field repairs can be made; otherwise the entire system must be replaced. Similarly, during redirecting side impacts, if the cross ties do not bend more than 19 mm (vertically) then field repairs can be made; otherwise the entire system must be replaced.

Details on the anchorage of the units and reinforcements of concrete pads and transitions will be provided in the manufacturer's drawings. For permanent installations Corrugated Beam Type with Metal Tearing Strips (TRACC) can be installed on minimum 150 mm thick reinforced concrete pad (new or existing) using 190 mm anchor studs. Upon severe redirecting side impacts, the anchor studs may come loose from the concrete foundation. Then the damaged anchors would have to be reset before replacing the Corrugated Beam Type with Metal Tearing Strips (TRACC) unit.

Anchorage to asphalt concrete is not permitted in permanent applications because of concerns that the Department would not be able to repair a damaged asphalt foundation quickly enough following impact.

VENDOR INFORMATION. The Corrugated Beam Type with Metal Tearing Strips (TRACC) is manufactured and vended by Trinity Industries, Inc. - (800) 321-2755. The QuadGuard (Quad Beam Type with Expendable Modules) and REACT 350 (Cable and HDPE Cylinder Type) are vended in New York State by Transpo Industries. (914) 636-1000. Inertial Barrier Modules are available from Transpo Industries and Traffix Corporation.

OTHER INFORMATION. The proposed Section 654 Impact Attenuators requires the addition of products to the Department's approved list. Copies of manufacturer's drawings can be obtained through the IntraDOT Design Quality Assurance Bureau Specifications and Standards Section's page for DOT employees who have Internet privileges.

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