
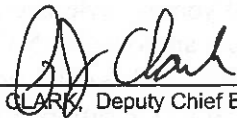


To: SUPERSEDED ^{BY} <i>EB05-001</i> EFFECTIVE 1/3/05		New York State Department of Transportation ENGINEERING INSTRUCTION	EI 01-025
Title: BOX-BEAM BURSTING ENERGY ABSORBING TERMINAL (BEAT)			
Distribution: <input checked="" type="checkbox"/> Manufacturers (18) <input checked="" type="checkbox"/> Surveyors (33) <input checked="" type="checkbox"/> Main Office (30) <input checked="" type="checkbox"/> Consultants (34) <input checked="" type="checkbox"/> Local Govt. (31) <input checked="" type="checkbox"/> Contractors (39) <input checked="" type="checkbox"/> Regions/Agencies (32) <input type="checkbox"/> _____ ()		Approved:  P.J. CLARK, Deputy Chief Engineer Design 10/24/01 _____ Date	

ADMINISTRATIVE INFORMATION. This Engineering Instruction (EI) does not modify or supersede any issuances. It becomes effective with projects submitted for the letting of 05/09/02. This Instruction supplements the information in EB 01-052. The contents of this instruction will ultimately be incorporated into the Highway Design Manual and the next printing of the *Standard Specifications*.

PURPOSES. The purposes of this EI are to:

- ◆ Issue guidelines and revised materials section 710-24 for use of a new safety device, the Box-Beam Bursting Energy Absorbing Terminal (BEAT) for permanent installation to Shield roadside hazards.
- ◆ Issue revised standard specifications for the pay items listed below. These revised specifications provide for optional use of either *Wyoming Style*¹ or *BEAT* end assemblies for use with the box beam guide rail barrier systems.

606.1203 (M) Box Beam Guide Rail End Assembly Type III
606.1253 (M) Box Beam Guide Rail End Assembly Type III (Rustic)

TRANSMITTED MATERIALS. This EI transmits information for the Box-Beam Bursting Energy Absorbing Terminal (BEAT) and the revised standard specifications mentioned above. These are proprietary specifications, but, if they are used in accordance with this instruction, no justification need be made for their use. Similar information on the alternate Wyoming style end assembly is found in EI 98-005, Box Beam Guide Rail End Assembly, Types I, II and III. This Instruction also transmits a shelf note that includes modifications/additions to 710-24, Box Beam End Assembly, Type III; and Box Beam Median Barrier End Assembly, Type C and 606-3, Construction Details.

IMPLEMENTATION. DQAB will insert the specifications into the proposals that call for its use. EICs should provide the extra two copies of the manufacturer's drawings and literature to the Maintenance Group for use by that group and the Residency.

LAYOUT AND GRADING INFORMATION. Since BEAT is relatively short, i.e., approximately 4.3 m long, the pay limits are extended another 10.68 m for a total of 14.98 m. This is to make it consistent with WYBET which is 14.98 m in length. BEAT shall be installed in line with the guiderail within the pay limits. Beyond the pay limits, the guiderail and BEAT combination may have upto 50:1 flare rate w.r.t the guiderail downstream of it, and upto 15:1 w.r.t the roadway as recommended by the AASHTO Roadside Design Guide.

Slopes between the road and the face of the BEAT should be 1:10 or flatter. This slope should be carried underneath the BEAT to a slope break point that is a minimum of 1.0 m distance behind the posts. Please refer to Standard Sheet M606-5R1, or its latest revision for further details.

¹ Wyoming Style is described in detail in EI 98-005.

EI 01-025 Page 2 of 4

ESTIMATED COST. The installed cost of Wyoming Box-Beam End Terminal (WYBET) in recent past has been between \$3800 to \$4000. The BEAT system is expected to cost about the same as the WYBET. The introduction of BEAT is expected to stabilize or decrease the price based on competition. This estimate is based on an installation cost of \$700 per BEAT system installed by an experienced guide rail installation crew. Grading costs are not included in these estimates, and would vary based on location and region. Rustic versions are expected to cost \$500 more than their regular versions.

BACKGROUND. Presently, the Wyoming style *Box Beam Guide Rail Type III End Assembly* is the only NCHRP 350 Test Level 3 box beam end assembly approved by NYSDOT. Road Systems, Incorporated, however, in cooperation with the Midwest Roadside Safety Facility has obtained federal approval for another Test Level 3 end assembly for use with box beam guide rail. This is called the Box-Beam Burster Energy Absorbing Terminal (BEAT).

USAGE. The BEAT system gates upto the third post i.e., 4.8 m downstream from the nose of the BEAT, thereafter it redirects. The BEAT is currently approved for use on guiderail systems ONLY ; it may not be used on median barriers² until FHWA and NYSDOT approval is obtained at a future date.

FUNCTIONAL DESCRIPTION OF THE SYSTEM. Upon head-on impact from a vehicle, the tapered mandrel penetrates the standard box beam section, splitting it into four strips as the impact head is pushed backwards, and causing the impact energy to be absorbed by the force needed to split the box beam section.

STRUCTURAL DESCRIPTION OF THE SYSTEM (See the drawing attached.) The box-beam bursting energy absorbing assembly is approximately 4.3 m in length from the nose of the impact head to the end of the assembly. The first steel post is approximately 3 m long of which 2.54 m is embedded in the ground. The second post is a 1.6 m long standard steel post with the soil plate used with weakpost guiderail systems. The post spacing between posts 1 and 2 is 2.6 m. The post spacing between post 2 and 3 is the standard 1.8 m used with box beam guiderail. The major components of the BEAT type end assembly are as follows:

- ◆ An impact head assembly,
- ◆ A 3.7 m long section of standard box beam rail a.k.a. Stage 1,
- ◆ A steel breakaway end post,
- ◆ A cable anchorage system,
- ◆ A post-breaker attached to the end post, and
- ◆ A second 1.6 m long steel post with soil plate.

The impact head assembly consists of: a front impact plate, a mandrel tube that inserts into the energy absorbing tube, and a tapered mandrel.

- i. The front impact plate has a dimension of 510 mm x 510 mm with 50 mm wide protruded edges to provide a mechanical interlock with the impacting vehicle and to distribute the impact load.
- ii. The mandrel tube is a 1.2 m long section of tube welded to the back of the impact plate on one end. The other end of the mandrel tube is inserted into the stage 1 energy absorbing tube for a distance of approximately 560 mm. A tapered end is added by welding 9.5 mm thick bent plates to this end of the mandrel tube. The tapered end acts like a plunger to shear off bolts at connections to the posts, and (at splices) and to assure that the end of the mandrel tube will span the small gap between the rail elements. Straps are welded around the mandrel tube approximately 560 mm from the plunger end (i.e., where mandrel tube is inserted into the energy absorbing tube) to control the clearance of the mandrel tube within the energy absorbing tube.
- iii. A tapered mandrel fabricated from 9.5 mm thick plates, is welded to the tube 305 mm upstream of the straps. The cross sectional dimension of the mandrel increases from 114 mm to a max of 168 mm. The inside dimensions of the energy absorbing tube is 146 mm.

² Testing has been completed in spring of 2001.

The steel breakaway end post, approximately 3 m long, consists of an upper and a lower post. The upper post consists of a 546 mm long section of W150 x 13 steel post. The lower post consists of a 2.4 m long section of W150 x 37 steel post with a U-shaped collar welded to the top of the post. The upper post is bolted to the collar of the lower post using a 16 mm diameter bolt. A slot is cut through the web of the upper post at the bottom to allow attachment of one end of the cable anchor. The box beam rail is attached to the end post using a special angle support bracket with a single bolt.

The stage 1 energy absorbing tube is a 3.7 m long section of standard box beam rail. A cable anchor bracket to receive one end of the anchor cable is welded to the bottom of the rail in the middle. The cable anchor bracket consists of a thick plate with a hole for a cable anchor and is reinforced with gussets. The other end of the cable is anchored to the end post.

A cable anchorage system provides anchorage to the terminal. The end anchorage system consists of a steel breakaway end post and a Breakaway Cable Terminal (BCT) cable anchor assembly. A BCT cable anchor assembly is used to transmit the force from the box-beam rail element to the end post. The cable is anchored to the end post through a slot bored in the base of the upper section of the end post, and attached with a cable anchor bearing plate, washer, and nut. The other end of the cable is attached to the cable anchor bracket on the bottom of the box-beam rail with washer and nut. Unlike many existing energy absorbing terminals, there is no need for a mechanism to release the cable anchor assembly from the rail since the rail is bursted into four strips.

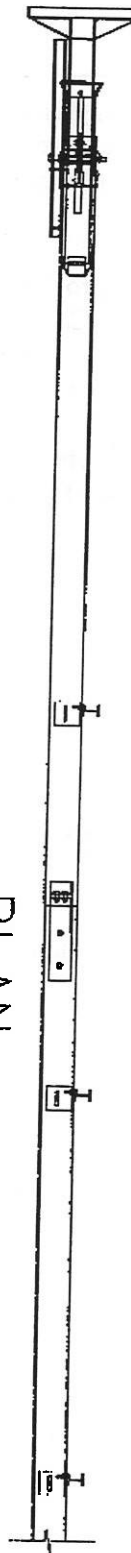
A post breaker is fabricated from 52 mm x 52 mm x 6.4 mm steel tubes. The post breaker is attached to the end post using a bolt. A second bolt is also used to keep the post breaker from rotating. The post breaker is designed to facilitate the separation of the upper section from the lower section of the end post by either shearing the attachment bolt or tearing the metal above the attachment bolt in the collar. The post breaker is designed to function for both head-on impacts and reverse direction impacts into the side of the terminal. In head-on impacts, the impacting vehicle would push the impact head into the upstream end of the post breaker. For side impacts into the terminal in the reverse direction, the impacting vehicle would directly contact the post breaker at its downstream end.

VENDOR INFORMATION. Road Systems, Inc. 1507 East 4th Street, Big Spring, TX. 79720. Phone - (915) 263-2435.

CONTACT PERSON. Arvind Salgam, Design Quality Assurance Bureau, M.O. Bldg 5, Room 410, (518) 457-5855.

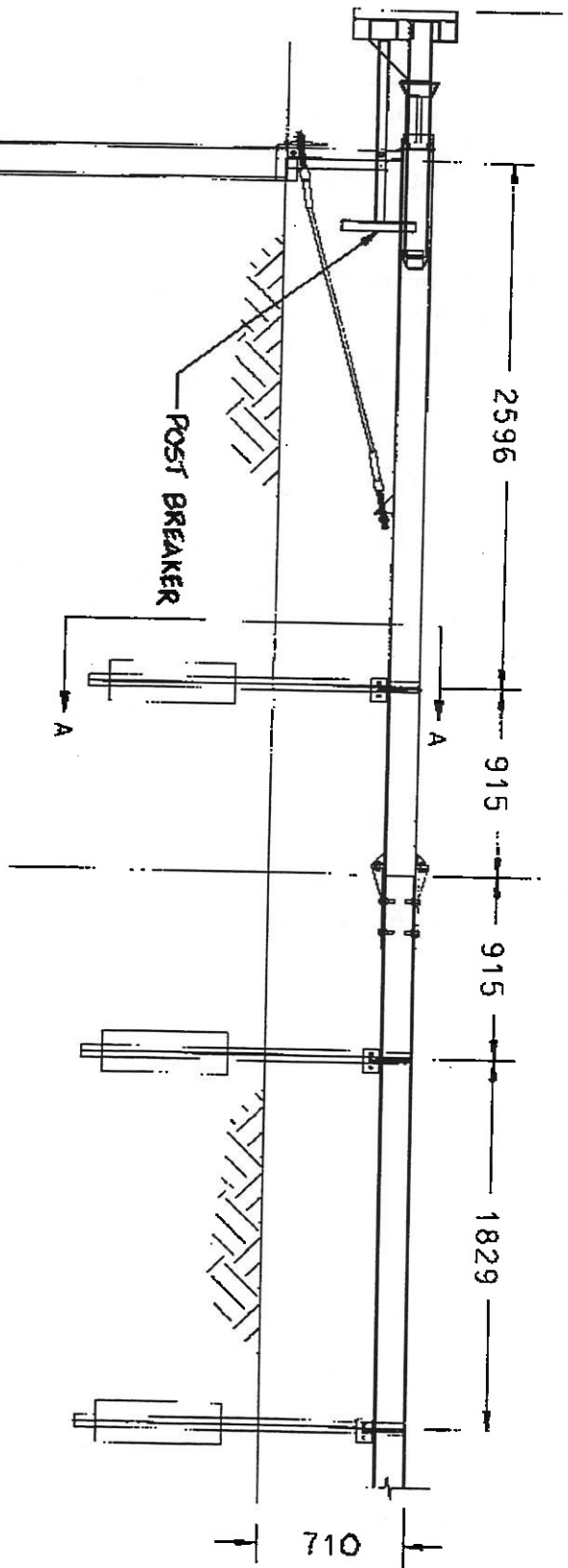
BOX-BEAM BURSTING ENERGY ABSORBING TERMINAL (BEAT)

LAYOUT



ACTUAL LENGTH OF BEAT
4272

PLAN



ELEVATION

Note : The payment limits for the BEAT will be 14 980 mm, measured from the front of the Nose Assembly.

**BOX BEAM GUIDE RAIL END ASSEMBLY, TYPE III ;
and BOX BEAM MEDIAN BARRIER END ASSEMBLY, TYPE C**

Make the following changes to the *Standard Specifications of January 2, 1995*:

Page 6-24, *After Line 2*, Add the following,

"F. End Terminals and Assemblies. The following shall apply to end terminals or assemblies to be installed under this section.

1. Drawings. For end terminals and end assemblies not shown on standard sheets or detailed in the plans, the Contractor shall submit two copies of the manufacturer's drawings, modified as necessary to reflect site conditions, to the Engineer for approval prior to ordering any materials required under this section. Drawings of parts not detailed on the plans, but which are necessary to develop the full performance of the end assemblies or terminals shall also be provided. The Contractor shall commence work of installation of end assemblies or terminals only after approval of the above mentioned drawings and authorization from the Engineer to do so.

2. Manuals. In addition to the drawings mentioned above, the Contractor shall deliver to the Engineer two (2) copies of design manuals, installation manuals, parts lists, and maintenance manuals prepared for each type end terminal or assembly being installed but not shown on the standard sheet.

3. Coordination with Other Work. The work of furnishing and installing all types of end assemblies shall be coordinated with the removal of existing impact attenuators or end assemblies, the installation of guide railing or median barrier, or the installation of the object to be shielded, so as to minimize the time that motorists are exposed to the possibility of collision with the shielded object, unprotected ends of barriers, or incomplete end terminals or assemblies. Also, the contractor shall minimize exposure of approaching vehicular traffic to the possibility of impact on the back of the end assembly. Unless modified in the Contract Documents, minimization shall mean seven (7) or fewer calendar days.

4. Traffic Protection. Traffic protection devices, such as cones, drums, lights, signs, barricades, or other articles directed by the Engineer, shall be provided and maintained under their respective pay items. These devices shall not be removed until the end assembly, including required transition pieces, is fully operational. If the end assembly is to be installed in lighted areas, or in areas to be lighted, the mentioned traffic protection articles shall also be maintained until the lighting system is operational."

Make the following changes to *Addendum #2* to the *Standard Specifications of January 2, 1995*:

Page VI-8, Line 26, **delete** 'materials details' and **replace** with 'manufacturer's drawings'.

Page VI-8, Line 33, **delete** 'materials details' and **replace** with 'manufacturer's drawings'.

Page VI-9, Line 5, **delete** 'materials details' and **replace** with 'manufacturer's drawings'.

Page VI-10, Line 19, **delete** 'materials details' and **replace** with 'manufacturer's drawings'.

Page VI-10, Lines 21 thru 25, **delete** and **replace** with the following:

" The payment limits for the Box Beam Guide Rail End Assembly Type III will be 14 980 mm, measured from the front of the Nose Assembly. These payment limits apply regardless of whether the end assembly type III employs crushable fiberglass elements or beam bursting type mandrels. The payment limits for the Box Beam Median Barrier End Assembly, Type C will be the entire length of the unit, which is 15 065 mm, measured from the front of the Nose Assembly to the splice at the far end of the telescoping section."

**BOX BEAM GUIDE RAIL END ASSEMBLY, TYPE III ;
and BOX BEAM MEDIAN BARRIER END ASSEMBLY, TYPE C**

Page VII-25, Line 43 thru Page VII-27, Line 7 *delete* and *replace* with the following:

**"710-24 Box Beam Guide Rail End Assembly, Type III;
and Box Beam Median Barrier End assembly, Type C**

SCOPE. These specifications cover the material and quality requirements for Box Beam Guide Rail End Assembly Type III and Box Beam Median Barrier End Assembly, Type C. These end assemblies are manufactured articles, and function by absorbing energy either through crushing of fiberglass elements or by splitting the beam element at the corners of the box beam. When specified, these end assemblies are used to terminate the ends of box beam guide rails and box beam median barriers. Box Beam Guide Rail End Assembly Type III and Box Beam Median Barrier End Assembly, Type C are fabricated in accordance with these specifications, the manufacturer's instructions, and the manufacturer's drawings. Box Beam End Assembly Type III are available in two styles. These are Wyoming style and another style that uses a Box Beam Splitting Mandrel. Box Beam Median Barrier Type C is available only in the Wyoming style which uses crushable fiberglass tubing

MATERIALS REQUIREMENTS.

A. End Assemblies Using Crushable Fiberglass Elements (Wyoming Style)¹ : Materials used in the fabrication of the Box Beam Guide Rail End Assemblies Type III and Box Beam Median Barrier End Assembly, Type C (Wyoming style) shall conform with the following requirements:

Foundation Tubes, Nose Assembly, Outer Tube, Telescoping Section and Intermediate Spacer Block	ASTM A500, Gr. B
Wood and Timber Post Posts and Timber Blockouts	§710-13
Fasteners, except shear bolts on posts 6,7, & 8	ASTM A307
Shear bolts on posts 6, 7, & 8	SAE Grade 0
Rubber Pad	Hard Rubber Division II Sect18.2
Steel Posts, Shelf Angles, and other metal parts	ASTM A36M
Galvanized Coatings and Repair Methods	§719-01

The Cable Assembly shall consist of galvanized steel cable, 6 X 19 mm, with 19 mm threaded rod swaged to both ends.

The composite tube shall be MMFG Extren series 500 pulltruded fiberglass structural tubes and shall exhibit the following properties:

1. Tubing shall be manufactured using the pulltrusion process. Tubing shall be manufactured of glass fiber reinforced resin with a glass resin ratio of 50%. The resin shall be isophthallic polyester. Glass reinforcement shall include the following three varieties:
 - A. Surface mat shall be used on all exterior surfaces.
 - B. Continuous glass strand rovings shall be used internally.
 - C. Continuous strand mats shall be used internally.
2. The composite material shall exhibit the following minimum mechanical properties:
 - A. Ultimate Tensile Strength: Ultimate Tensile strength shall be longitudinally 207 000 kPa and transversely 48 300 kPa measured from coupons. Bending strength of the full section shall be 138 000 kPa.
 - B. Ultimate Compressive Strength shall be as given above except Transversely shall be 105 500 kPa.

¹ These end assemblies may be used with either box beam guide rail or with box beam median barrier.

**BOX BEAM GUIDE RAIL END ASSEMBLY, TYPE III ;
and BOX BEAM MEDIAN BARRIER END ASSEMBLY, TYPE C**

- C. Ultimate Shear Strength shall be 31 050 kPa.
- D. Modulus of Elasticity shall be 17 300 000 kPa
- E. Barcol Hardness shall be 50.

3. The energy dissipation properties of the alternate fiberglass epoxy composite tube shall be evaluated using static compressive testing. Each test specimen shall be 610 mm long with a 102 mm long tulip shape cut into one end of the test specimen. The test specimen shall be crushed statically at a rate of 50 mm per minute and the total crush length shall be not less than 305 mm . A minimum of three static compressive tests shall be conducted. The results of each test shall meet the following static energy dissipation properties:

First Stage Energy Absorber	
Average Crush Force	80 kN ± 9kN
Maximum Compressive Force	115 kN
Allowable Compressive Force Variation	± 11 kN
Second Stage Energy Absorber	
Average Crush Force	182 ±13 kN
Maximum Compressive Force	245 kN
Allowable Compressive Force Variation	± 22.3 kN

B. END ASSEMBLIES USING BOX BEAM SPLITTING MANDREL : BEAT²

MATERIALS

Materials used in the fabrication of the Box Beam Guide Rail End Assemblies Type III (BEAT) shall conform with the following requirements:

The Mandrel Tube, Box Beam rail	ASTM A500, Grade B
Impact Head and it components including face plate, top and bottom plates, lower and upper support boxes, Gussets	10 Ga. ASTM A36M
Steel post, guide plates and mandrel support block, gusset plate, guide support, bent and front guide plates and all metal parts	ASTM A36M
Mandrel Plate	ASTM AR 250

Steel Foundation Tubes shall meet the requirements of §710-21 Box Beam Guide Railing and Median Barrier. Soil plates, struts, bearing plates shall meet the requirements of ASTM A36 or ASTM A36 M. All metal components designated to be galvanized shall be hot dip galvanized in accordance with §719-01, Galvanized Coatings and Repair Methods.

Reflective sheeting mounted on a frangible material shall be provided by the manufacturer for the free end of the end assembly. The reflectorization shall consist of alternating reflectorized 100 mm yellow and non-reflectorized 115 mm black stripes oriented at a 45 degree angle, with the lower edge of the stripes near the traveled way. The reflective material shall meet the requirements of §730-05, Reflective Sheeting, Class B.

Rustic versions of BEAT system shall comply with the above requirements except the metal parts exposed to view shall be painted in accordance with §740-03 Painting Galvanized Surfaces. Normal box beam guide rail included within the pay limits for the BEAT shall conform to the same specifications as box beam guide rail to which the BEAT is attached.

² End assemblies using box beam splitting mandrel to be used only for guiderail. They are not to be used on median barrier.

**BOX BEAM GUIDE RAIL END ASSEMBLY, TYPE III ;
and BOX BEAM MEDIAN BARRIER END ASSEMBLY, TYPE C**

BASIS OF ACCEPTANCE. Box Beam Guide Rail End Assembly Type III and Box Beam Median Barrier End Assembly, Type C will be accepted at the site of the work by the Engineer on the basis of conformance of the delivered articles with the manufacturer's drawings, and upon the manufacturer's certificate of compliance with these specifications."