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<p>Title: BOX BEAM GUIDE RAIL END ASSEMBLY, TYPEs I, II and III</p>			
<p>Distribution:</p> <p><input type="checkbox"/> Manufacturers (18) <input type="checkbox"/> Surveyors (33)</p> <p><input checked="" type="checkbox"/> Main Office (30) <input checked="" type="checkbox"/> Consultants (34)</p> <p><input type="checkbox"/> Local Govt. (31) <input type="checkbox"/> Contractors/AGC(39)</p> <p><input checked="" type="checkbox"/> Regions/Agencies (32) ()</p>	<p>Approved:</p> <p></p> <p>P. J. Clark/Deputy Chief Engineer, Design Division <u>02/03/98</u> Date</p>		

ADMINISTRATIVE INFORMATION. This instruction modifies §10.2.5.3 of the *Highway Design Manual*. Its contents eventually will be incorporated into that reference. It takes effect with the letting of 6/25/98. No Engineering Instructions are superseded hereby.

PURPOSES. The purposes of this instruction are to:

- 1 Disapprove the pay items 606.12 M, 606.1250 M, 606.13 M, and 606.1350 M and their English unit counterparts
- 2 Issue standard specifications as follows:

606.1201 (M)	Box Beam Guide Rail End Assembly	Type I	each
606.1202 (M)	Box Beam Guide Rail End Assembly	Type II	each
606.1203 (M)	Box Beam Guide Rail End Assembly	Type III	each
606.1251 (M)	Box Beam Guide Rail End Assembly	Type I (Rustic)	each
606.1252 (M)	Box Beam Guide Rail End Assembly	Type II (Rustic)	each
606.1253 (M)	Box Beam Guide Rail End Assembly	Type III (Rustic)	each
- 3 Issue a usage and selection policy for these end assemblies.

TRANSMITTED MATERIALS. Standard specifications described above. Approved Materials Details and a standard sheet showing grading and point-of-need details will be transmitted under separate cover.

BACKGROUND. There have been recent engineering instructions on the subjects of weak post and heavy post blocked out corrugated beam barriers. These were EI 97-014 and 97-016 and discussed that after July 1998¹, the Federal Highway Administration (FHWA) policy will permit only those safety articles to be installed on the National Highway System (NHS) that have passed, or are judged to be able to pass, *National Cooperative Highway Research Program Report 350 (NCHRP 350)* crash tests. These engineering instructions communicated that federal policy, extended it to the non-NHS, and further extended it to cover reconstruction and certain rehabilitation activities.

The box beam system is widely used in New York State. There are presently two standard end assemblies for box beam guide rail shown on the standard sheets and used in accordance with the *HDM*. These end assemblies are designated Type I and Type II End Assemblies. They are specified under pay items 606.12 M and 606.13 M for the galvanized finish and under 606.1250 M and 606.1350 M for the rustic versions. Pay items in the U.S. customary unit are also available.

The box beam guide rail itself passed the *NCHRP 350* 100 km/h 25° crash testing with the 2000 kg pickup truck and therefore may be used on all type facilities. None of the end assemblies for box beam barrier has been qualified with the 2000 kg pickup truck, however the Type II and Type III box beam guide rail end assemblies have qualified to *NCHRP 230* test criteria and the Type III is scheduled to be tested this year.

Box Beam Guide Rail End Assemblies Type I. The Box Beam Guide Rail End Assembly Type I was the

1. This date has since been changed to 9-30-98 and the prohibition applies on the NHS to contracts advertised after that date and to NHS force account work performed after that date.

initial end assembly for box beam guide rail. It was indicated by Engineering Instruction 89-007 to be the preferred end assembly at the approach ends of box beam guide rail when the standard four (4) meter flare back from the line of barrier could be attained. End Assemblies Type I were, and continue to be, permitted at the departure end on one-way roadways with or without flare.

Box Beam Guide Rail End Assemblies Type II. Standard Box Beam Guide Rail End Assemblies Type II have been tested in accordance with *NCHRP 230* criteria with small cars, which would be the critical vehicle for this article. They passed at speeds as high as 52 miles per hour. The Box Beam Guide Rail End Assembly Type II was judged to perform better in end on and near end on impacts than the Box Beam Guide Rail End Assembly Type I but there were concerns at the time that motorist reaction would be more erratic in the presence of a Box Beam Guide Rail End Assembly Type II introduced near the road than with the Box Beam Guide Rail End Assembly Type I properly flared back away from the road. Therefore, the policy for the use of the Box Beam Guide Rail End Assembly Type II, established by Engineering Instruction 89-007, was that they should be used at driveway openings and at other breaks in the run of barrier where the line of guide rail had already been established. In addition to those applications, because of their superior impact performance, and despite the possibility of erratic motorist reaction, the Box Beam Guide Rail End Assembly Type II was also to be used where flaring the end of the barrier back the standard amount to accommodate the Box Beam Guide Rail End Assembly Type I was not possible.

Box Beam Guide Rail End Assemblies Type III (WYBETs). The State of Wyoming and Texas Transportation Institute have developed an end assembly for box beam guide rail and median barrier. This end assembly is now built and marketed by Syro Steel Company, a subsidiary of Trinity Industries. At present, this end assembly has also been tested to just the *NCHRP 230* criteria. Nationally this unit is known as the WYBET, however, to be consistent with other terminology in New York State, we have decided to call this article the Box Beam Guide Rail End Assembly Type III.

There are four working parts to the Box Beam Guide Rail End Assembly Type III. The first three are two 152 X 152 mm structural steel tubes and a 178 X 178 mm structural steel tube. The fourth part is an assembly consisting of two fiberglass composite pipe sections² separated by a steel spacer block. This assembly is contained and collapsed by the first three parts when the front of the assembled Box Beam Guide Rail End Assembly Type III is hit. If hit on the side at, or beyond, the third post, Box Beam Guide Rail End Assembly Type IIIs redirect.

End assemblies are safety articles covered by the above federal and state policies. Unfortunately, there are not yet any end assemblies for box beam systems which have been crash tested to the *NCHRP 350* standards, including the Box Beam Guide Rail End Assembly Type III. Technically, therefore, the introduction of the Box Beam Guide Rail End Assembly Type III and the continued use of the Box Beam Guide Rail End Assembly Type II would not satisfy the letter of the federal policy after the 1998 date unless the FHWA agrees they would pass *NCHRP 350* tests if tested. Since, however, these articles have demonstrated crashworthiness under *NCHRP 230* criteria, and are the most crashworthy end terminals available for box beam, and since they would likely pass the requisite crash testing, if so tested, we believe their use conforms to the intent of the policy.

POLICY. Box Beam Guide Rail End Assembly Type I. There are no plans to test the Box Beam Guide Rail End Assembly Type I. *Therefore, installations of the Box Beam Guide Rail End Assembly Type I are hereby disapproved within the design clear zone at locations where they would be subject to end on or near end on impacts.* Sometimes design clear zones are substantially narrower than the 9.1 m historically used in making guiderail decisions. In these cases, end assemblies installed just outside the clear zone could still be fairly close to the road where they would be subject to near end on impacts. Even though Type I End Assemblies are acceptable in these locations, the designer should consider providing higher type end assemblies.

On the left side of two-way roadways with adequate shoulders, there will almost always be enough lateral distance to a normally installed Box Beam Guide Rail End Assembly Type I to carry it across the clear zone. The

2. These pipes are 150 mm diameter. The longer of the two is 3810 mm and the shorter 1830 mm. There is also a 760 mm "air space" that can close up on frontal impact so the maximum "stroke" of these on high speed frontal impact is 6400 mm; 4570 mm max observed.

preponderance of impacts on an end terminal in such a location will be at blunt angles. Terminals impacted at blunt angles function by gating. Since Type I End Assemblies “gate” well, they may continue to be installed, re-installed or retained on the left side of two-way roads when they can be installed with the standard 4 m flare back. Also, they may continue to be installed, re-installed, and retained at the departure end of runs of barrier on one-way roadways, regardless of offset from the traveled way.

Box Beam Guide Rail End Assembly Type II. Box Beam Guide Rail End Assemblies Type II have passed NCHRP 230 crash tests at speeds of 52 mph. *Until further notice, Box Beam Guide Rail End Assemblies Type II may therefore continue to be installed, reinstalled, and retained on approach terminal sections of barriers within the design clear zones of highways with operating speed of 80 km/h (50 mph) or less. They may also be installed at driveway openings on facilities signed for 55 mph.*

Box Beam Guide Rail End Assembly Type III. This end assembly has also been successfully crash tested in accordance with NCHRP 230 with heavy and light passenger cars at sixty miles per hour. It is therefore currently regarded by the FHWA and the Department as a crashworthy end assembly on all highway. It could lose this status if it were to fail NCHRP 350 crash testing. *At speeds in excess of 80 km/h (50 mph), except at driveway openings with a pair of end assemblies, it is the only one of our end assemblies for box beam guide rail that can be installed within the design clear zone at locations where they are subject to end-on, or near end-on impact. End Assemblies, Type II may be installed at driveway openings having two installed end assemblies.*

OTHER METHODS OF TERMINATING GUIDE RAIL. There has been considerable discussion of the various kinds of Box Beam Guide Rail End assemblies. Do not infer from the length of this discussion that these are the only acceptable means of treating the approach ends of guide rail. Other acceptable methods of treating these ends includes fitting them with Type I End Assemblies and carrying them outside the clear zone; shielding them behind another barrier; burying them in a nearby back slope; constructing a berm and burying them in that; and on one way facilities, protecting them with sand barrel arrays. Details and design information on these treatments are found in Chapter 10 of the *Highway Design Manual* and/or in the *AASHTO Roadside Design Guide*. *These other acceptable methods should be considered before deciding to install the Type III End Assembly because many times these methods will be preferable to using an End Assembly Type III. In addition to investigating the above alternatives, check to see if the condition for which the barrier was initially considered cannot itself be eliminated or otherwise remedied.*

APPLICABILITY. This usage policy included in this instruction is applicable to new installations of end terminals whether on new construction projects, reconstruction projects, or on 3R projects. It also requires replacements of non-conforming end terminals on reconstruction projects. This instruction does not require replacements of non-conforming end terminals on 3R projects. That matter will be separately addressed.

LAYOUT INFORMATION. The following is layout information only. Consult the section of this instruction entitled “Policy” before deciding to use any of the Box Beam Guide Rail End Assemblies at a given location.

Box Beam Guide Rail End Assembly Type I. The Box Beam Guide Rail End Assembly Type I is 2.20 m long. In use, it is attached to a 21.95 m length of curved box beam. These two lengths sum to 24.15 m all of which is usually installed beyond the point-of-need. Point-of-need in this case is to be determined in the manner described in the *Highway Design Manual*, §10.2.2.1. Detailed layout data is contained on the standard sheets for box beam guide rail. In accordance with the *HDM* in actuality, however, only approximately 18 m of the 21.95 m length of curved guiderail is required and the guide rail may be laid out accordingly, if desired.

Box Beam Guide Rail End Assembly Type II. Type II End Assemblies will function when installed in line with the run of guide rail or with moderate flare. The standard sheets for box beam guide rail include layout data for these end assemblies.

Whenever possible, at the approach ends, they should be installed at least 2.5-3 m offset from the traveled way. With narrow shoulders, the end portion of the rail may be flared away from its normal position in order to attain the above offset at the free end.

Once the line of guide rail is established, Type IIs may be installed in the line of guide rail at short breaks in the run of guide rail, such as at driveway breaks, without special offset.

The Box Beam Guide Rail End Assembly Type II will not redirect impacting vehicles within its 8.23 m length but will redirect beginning at its far end where it reaches the standard box beam guide rail mounting height of 685 mm (27 inches). Layout and payment limit information for this end assembly is shown on the standard sheets for box beam guiderail.

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Box Beam Guide Rail End Assembly Type III. (WYBET). The Box Beam Guide Rail End Assembly Type III, telescoping on itself as it does, must be installed without angle or curvature. This is to prevent buckling or binding. It may be installed flared or parallel to the direction of traffic. Flare rates should not exceed 1 on 15. Flare is to be introduced downstream of the Box Beam Guide Rail End Assembly Type III by flaring back individual lengths of rail. Approximately 1° of flare may be achieved at each box beam joint.

To reduce nuisance hits and plowing difficulties, the Type III End Assembly should be installed at least 2.5-3 m beyond the traveled way at the approach ends, if possible. On narrow shoulders, the Type III End Assembly and the necessary lengths of rail may be angled back from the line of guide rail to attain the recommended offset. Once the line of barrier is established, End Assembly Type IIIs may be installed in the line of guide rail. At these breaks the nose assembly shouldn't protrude beyond the established line of guide rail, however.

The overall length and payment limits of the Box Beam Guide Rail End Assembly Type III for guide rail is 14.98 m. 10.06 m of this has redirection capability and may be included within the length-of-need or run-out length thereby reducing the paid length of the box beam barrier.

Points-of-need and run out length for End Assembly Type III should be determined in accordance with Engineering Instruction 98-004 Point-Of-Need Determination and Runout Length Determination for Guide Rail Runs That Use Gating End Terminals. The 4.92 m (16.1') from the free end to post 3 "gates" under certain crash conditions and therefore the area into which a vehicle that has been "gated" should be reasonably free of objects and made as traversable as conditions permit. The 10.06 m portion that does redirect may be used to reduce the paid length of the guide rail item.

The 22.5 m by 6.1 m obstacle free rectangular area mentioned in Engineering Instruction 98-004, Point-Of-Need Determination and Runout Length Determination for Guide Rail Runs That Use Gating End Terminals should be provided as a minimum but additional lengths of guide rail are recommended whenever conditions permit.

GRADING REQUIREMENTS. Slopes between the road and the face of the Box Beam Guide Rail End Assembly Type III should be 1:10 or flatter. This slope should be carried underneath the Box Beam Guide Rail End Assembly Type III to a slope break point rear of the posts. The location of this slope break point is depicted in the Engineering Bulletin "Selection Guidelines for End Terminals for Heavy Post Blocked-out Corrugated Guide Rail, Miscellaneous Federal Requirements," but is verbally described as follows: There are eight posts in the Box Beam Guide Rail End Assembly Type III. Number them from 1 to 8, starting with the post at the free end of the End Assembly as post 1.

Post spacing is as follows: Between post 1 and 2, post spacing is 2800 mm; from posts 2 to 8, post spacing is 1829 mm. From post 8 to the center of the splice joining the Box Beam Guide Rail End Assembly Type III to the run of box beam barrier is 914 mm. From the front impact plate to the center of post 1 is 295 mm. In addition to the posts mentioned, between post 1 and 2, there is a foundation tube driven into the ground and strutted to the foundation tube of post 1, which is 1905 mm removed from this foundation tube. No post is inserted into this foundation tube. Post 1 is a breakaway wooden posts; all other posts are 75 mm by 8.5 kg/m steel posts of the same kind as used with the box beam.

At post 8, the slope break point should be 600 mm minimum behind the back of the post. Between posts 8 and 4, the distance to the slope break increases to 1000 mm. From post 4 to post 2 offset to slope break point continues at 1000 mm. From post 2 to 1, the straight line established from post 4 to 2 is continued to a point opposite the very front nose assembly. At that point, the slope break point transitions back to the normal slope break point over a transition length fifteen times as long as the difference in widths between the grading at the nose assembly of the End Assembly Type III and the normal slope break point established by Table 10-4 of §10.2.3.5, as needed, to provide adequate anchorage for the posts. The slope on the embankment side of the slope break point should be 1:4 preferably with a 1:3 recommended maximum. This grading will appear on a standard sheet.

ESTIMATED COST. End Assembly Type III is estimated to cost \$2250 parts and another \$1000 for installation and profit for an estimated total of \$3250, not including grading.

CONTACT PERSON. Larry Brown of the Design Quality Assurance Bureau, (518) 457-4093.

Box Beam Guide Rail End ASSEMBLY TYPE III

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

Page 6-19, Line 35, *add* the words "materials details, manufacturer's directions" after the words "standard sheets".

Page 6-20, between Lines 20 and 21, *add* "710-24 Box Beam Guide Rail End Assembly Type III."

Page 6-20, Line 32, *add* ", 710-24" after "710-22."

Page 6-21, Line 2, *add* "materials details,"

Page 6-23, Line 4, *add* ", materials details, manufacturer's directions"

Page 6-23, Lines 7, 8,9, 11,13,15, and 16, *add* "and foundation tube(s)" after the word "post(s)"

Page 6-31, Line 22, *add* the words "materials details, manufacturer's directions" after the words "standard sheets"

Line 22, also *add* after this line the following new paragraph

" The payment limits for the Box Beam Guide Rail End Assembly Type III will be the entire length of the unit, which is 14 980 mm, measured from the front of the Nose Assembly to the splice at the far end of the telescoping section."

Page 6-33, Line 5, *add* "reflectorization," after the word "backfill"

Page 6-35,

Line 33, *replace* "606.12 M" with "606.1201 M"

Line 34, *replace* "606.13 M" with "606.1202 M"

Line 34, *add* after this line "606.1203 M Box Beam Guide Rail End Assembly Type III Each"

Line 35, *replace* "606.1250 M" with "606.1251 M"

Line 36, *replace* "606.1350 M" with "606.1252 M"

Line 36, *add* after this line "606.1253 M Box Beam Guide Rail End Assembly Type III (Rustic) Each"

Page 7-112, line 20. Delete this line and replace it with the following:

"710-24 Box Beam Guide Rail End Assembly Type III

SCOPE. These specifications cover the material and quality requirements for Box Beam Guide Rail End Assembly Type III. 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 Assemblies Type III are fabricated in accordance with these specifications, the manufacturer's instructions, and the approved Materials Details.

MATERIALS REQUIREMENTS. Materials used in the fabrication of the Box Beam Guide Rail End Assemblies Type III 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

Box Beam Guide Rail End ASSEMBLY TYPE III

Rubber Pad

Hard Rubber Division II

Sect 18.2

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 pultruded fiberglass structural tubes and shall exhibit the following properties:

1. Tube shall be manufactured using the pultrusion process. Tubing shall be manufactured of glass fiber reinforced resin with a glass resin ratio of 50%. The resin shall be isophthalic 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.
 - 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

The materials and construction requirements of Box Beam Guide Rail End Assemblies, Type III (Rustic) shall be the same as Box Beam Guide Rail End Assemblies, Type III except metal parts shall conform with §710-25 Guide Rail and Median Barrier Systems (Rustic).

BASIS OF ACCEPTANCE. Box Beam Guide Rail End Assembly Type III will be accepted at the site of the work by the Engineer on the basis of their manufacturer's name appearing on the approved list, conformance of the delivered articles with the approved Materials Details, and upon the manufacturer's certificate of compliance with these specifications.