SUPERSEDED BY EB 02-019 EFFECTIVE 9/12/02		New York State Department of Transportation ENGINEERING INSTRUCTION	EI 00-034

Title: **BREAKAWAY STEEL AND WOOD POST END TERMINALS FOR HPBO CORRUGATED BEAM GUIDE RAILING - ET 2000+ & SKT 350**

Distribution:		Approved:
☒ Manufacturers (18)	☒ Surveyors (33)	
☒ Main Office (30)	☒ Consultants (34)	
☒ Local Govt. (31)	☒ Contractors (39)	
☒ Regions/Agencies (32)	☐ _____( )	P. J. Clark, Deputy Chief Engineer, Design — 10/23/00 Date

EFFECTIVE DATE. This Engineering Instruction is effective with projects submitted for the letting of 05/03/01, however, the specifications may be used earlier.

ADMINISTRATIVE INFORMATION. This Engineering Instruction (EI) supersedes EI 99-016, and is related to §10.2.5.2 and §10.2.6.6.C. of the *Highway Design Manual*. The design guidance in this EI will ultimately be incorporated into the *HDM*.

PURPOSE.

- Issue usage and selection guidance and specifications for the use of the ET 2000+ with hinged steel breakaway posts and the SKT 350 end terminals also with steel breakaway posts. These are end terminals for use with Heavy Post Blocked-Out Corrugated Beam Guide Railing (HPBO).
- Re-issue specifications for SKT 350 with wood breakaway posts. These specifications were previously issued by EI 99-016, which is being superseded by the current EI.
- Issue a revised specification for the ET 2000 which incorporates wood breakaway posts and the ET 2000+ extruder head.
- Provide optional specifications under which ET 2000+ or the SKT 350 may be used at the contractor's choice.

TRANSMITTED MATERIALS. This instruction transmits information and specifications for the ET 2000+ and the SKT 350 end terminals and the optional specifications. All of these will be Main Office inserts. All these specifications are proprietary, including the optional specifications, but if they are used in accordance with this instruction, no justification need be made for their use.

The transmitted new specifications are:

ITEM 15606.3401 M	**End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000+, Steel Breakaway Posts**
ITEM 15606.3451 M	**End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000+, Steel Breakaway Posts, (Rustic)**
ITEM 15606.3501 M	**End Terminal for HPBO Corrugated Beam Guide Railing, SKT 350, Steel Breakaway Posts**
ITEM 15606.3551 M	**End Terminal for HPBO Corrugated Beam Guide Railing, SKT 350, Steel Breakaway Posts, (Rustic)**
ITEM 15606.3601 M	**Optional End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000 or SKT 350, Steel Breakaway Posts**
ITEM 15606.3651 M	**Optional End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000 or SKT 350, Steel Breakaway Posts, (Rustic)**

The re-transmitted or revised specifications are:

ITEM 15606.34 M	**End Terminal for HPBO Corrugated Guide Rail, ET 2000+, Wood Posts**
ITEM 15606.3450 M	**End Terminal for HPBO Corrugated Guide Rail, ET 2000+, Wood Posts (Rustic)**
ITEM 15606.35 M	**End Terminal for HPBO Corrugated Guide Rail, SKT 350, Wood Posts**
ITEM 15606.3550 M	**End Terminal for HPBO Corrugated Guide Rail, SKT 350, Wood Posts (Rustic)**
ITEM 15606.36 M	**Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000+ or SKT 350, Wood Posts**
ITEM 15606.3650 M	**Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000+ or SKT 350, Wood Posts (Rustic)**

Revised specifications for ET 2000(+) and re-issued specifications for SKT 350 with Wood Posts retain the same pay item numbers given under the superseded EI 99-016, but have a modified item description. The modification will facilitate the continued use of ET 2000(+) and SKT 350 with wood posts option on facilities like parkways.

BACKGROUND. Subsequent to the issuance of EI 99-016, both Trinity/Syro and Road Systems, Inc. developed designs that use breakaway steel posts. In addition to developing breakaway steel posts for ET 2000, Trinity/Syro, manufacturer of the ET 2000, also modified their guide rail extruder head, making it lighter in weight, narrower, and taller. These modifications to the ET 2000 extruder head, identified as the ET 2000+, result in less expensive fabrication and approximately 100 mm additional offset to the head from the traveled way when compared to the ET 2000. Also, because the bottom of the ET 2000+ extruder head is closer to the ground, it is more likely to engage the frame of a vehicle sliding sideways. It is therefore said by its manufacturer to provide additional safety in side impacts compared to the earlier ET 2000.

In the earlier designs, breakaway timber posts were used. In order to facilitate maintenance of the ET 2000 and the SKT 350 end terminals, they were placed in steel foundation tubes. Breakaway steel posts, however, can be directly embedded in the soil without creating undue maintenance problems because they can be easily extracted, if need be. Therefore, except for the first two posts of the SKT 350, in which the breakaway steel posts must be placed in steel foundation tubes, steel foundation tubes are not necessary for either the SKT 350 or ET 2000 utilizing steel breakaway posts.

The ET 2000+ and the Sequential Kinking Terminal 350 (SKT 350) are both crashworthy end terminals for HPBO guide rail, and these end terminals have passed NCHRP 350 Test Level 3 crash testing. Test Level 3 involves testing at 100 km/h (62 mph). Articles qualified at that test level may be used on all classes of highways and at all speeds.

USAGE. Except for urban roads with 85th percentile operating speeds of 70 km/h (45 mph) or less and rural roads 50 km/h (30 mph) or less, the approach ends of HPBO guide rail that cannot reasonably be carried to the clear zone, shielded by another barrier, buried in the back slope or in a suitable berm, shall be terminated with the appropriate aforementioned end terminals; one of the flared end terminals, such as the SRT 350 or the FLEAT, or an approved crash cushion[1]. On urban roads with 85th percentile operating speeds of 70 km/h (45 mph) or less and rural roads 50 km/h (30 mph) or less, standard turned down end terminals may continue to be used inside or outside the clear zone and the rail shall converge with the highway at the flare rates of 10:1, 8:1 and 7:1 for operating speeds of 70km/h, 60km/h, and 50km/h, respectively. Proper use of the crashworthy end terminals requires that the end of the guide rail be located in accordance the EI 98-004 Point of Need Determination for Guide Rail Runs That Use Gating End Terminals. Point of need for the turned down end terminals, however, may continue to be determined as indicated in §10.2.2.1 Point of Need, given in the *Highway Design Manual*.

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1 Sand Barrel Arrays for approach ends on one-way roads, QUADGUARD, BRAKE MASTER, REACT 350 are among the approved crash cushions. See also latest EIB program.

Steel breakaway or hinged posts are preferred over wood posts. Because of the ease they will provide in future maintenance operations, and because end terminals constructed with steel breakaway or hinged posts will be less expensive to install, designs using steel breakaway or hinged posts are preferred over designs utilizing timber breakaway posts inside steel foundation tubes.

Optional Items Preferred Over Non-Optional Items. The optional items are the preferred items because they will increase competition and lower prices if used. The specifications requiring either the ET 2000+ or the SKT 350, to the exclusion of the other, may be specified by Regions if they desire to use them in order to obtain either device for research purposes; or upon the directions of the Regional Director, with the concurrence of the Deputy Chief Engineer, Design Division. They may also be used during construction as part of the value engineering process or in Orders-on-Contract.

Selection Guidelines. There are several types of end terminals that have passed crash testing and could be used at the approach end of heavy post blocked-out guide rail. The principal advantages of the SKT 350 or the ET 2000+, when compared to the alternative systems, is that reduced grading is possible and lesser amounts of guide rail may be provided, and vehicles that hit the end terminal at flat angles will be brought to a gentle stop within the limits of the roadway.

APPLICABILITY. The 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, but does not require replacement of (i.e., is silent on) non-conforming end terminals on 3R projects. That matter will be separately addressed in a future Engineering Instruction which will be entitled "Replacement of Guide Rail (and Median Barrier) End Terminals on 3R Projects."

DESIGN AND CONSTRUCTION DETAILS.

1) Layout Information. There are nine posts in either the SKT 350 or the ET 2000+ regardless of whether the posts are steel or wood. Number the posts starting with the post at the free end being post 1. Post spacing is 1905 mm (6'-3") throughout the length of either end terminal. Either end terminal may be installed either parallel to the line of guide rail or moderately flared from the theoretical line of the guide rail to 600 mm (2'-0") or less. The term 'moderately flared' is being used since we have a number of flared end terminals that require higher flare than is allowed here. If moderately flared, one of two flaring options must be used: Flaring Option 1-The SKT 350 or ET 2000+ shall be flared over the whole 15.2 m (50'-0") length 1:25, or less, with respect to the line of guide rail; or, Flaring Option 2- they shall be flared over half their 15.2 m (50'-0") length from post 5 back to the free end 1:25 or less with respect to the line of the guide rail. Flare is recommended because flare will reduce the number of nuisance hits on the end, and facilitate snow plowing. The manufacturers do not recommend any other means of attaining flare. These two options are detailed by the manufacturer in their drawings and are shown on Standard Sheet M606-12.

Both of the above end terminals "gate" from their free ends to post 3. From post 3 downstream, both end terminals redirect.

The beginning of the rail at approach ends should be determined as indicated in Engineering Instruction 98-004 on "Point of Need and Runout Length Determination for Guide Rail Runs That Use Gating End Terminals." Ideally, the amount of guide rail indicated by the formulas should be provided. If there is not enough room available to provide this much, then lesser amounts may be provided. The lower bound on the length of guide rail to install in advance of a shielded object is suggested below under "Clear area" and is shown on Standard Sheet M606-12.

2) Clear Area. As indicated above, both of the end terminals discussed herein "gate" upstream of post 3. An area approximately 6 m (20'-0") wide in back of the guide rail and 20 m (65'-6") along the guide rail is recommended by the FHWA to be made clear of obstacles and reasonably traversable. Grading within this area should be as indicated below under "Special Grading Requirements." However, if total clearance is not possible, this area should be cleared to the extent that it is similar to unshielded roadside areas upstream of the end terminal.

3) Special Grading Requirements. Grading should be done in accordance with the following description. Slopes between the road and the ET 2000+ or the SKT 350 should not be steeper than 1:10. Ordinary shoulder slopes, which

are generally not steeper than 1:16, are excellent. These relatively flat slopes should be carried underneath the ET 2000+ or SKT 350 to a slope break point located behind the back of the posts. Slopes may increase outboard of the slope break point to 1:4 slope preferred; 1:3 maximum. At post 8, the distance to the slope break point should be 600 mm (2'-0") minimum behind the back of the post. Between post 8 and post 4, the distance to the slope break increases to 1000 mm (3'-3".) Between post 4 and post 2, the slope break point is 1000 mm (3'-3") behind the back of the posts. This 1000 mm (3'-3") slope break point line is extended in line to a point opposite the front of the guide rail extruder unit. At that point, the slope break point transitions back to the normal slope break point given in the HDM in §10.2.3.5, Post Systems, Table 10-4. Transition length longitudinally should be 15 times the difference in widths between the slope break points opposite the guide rail extruder and the normal width to the slope break point shown on the plans. This distance is usually taken from Table 10-4. These requirements are being shown on Standard Sheet M 606-12 Parallel Type End Terminal for HPBO Corrugated Beam Guide Rail, Grading, Payment, & Layout Details.

The above grading scheme has been proposed by the FHWA. Regions wishing to simplify it may do so. For example, a constant 1 m (3'-3") offset behind all eight of the posts would satisfy the Federal intent, be simpler to layout than the federally proposed scheme, and would provide the same or better stability for the errant vehicle[2].

4) Description of the Steel Breakaway or Hinged Posts. Both the companies offer steel posts that either are breakaway or hinged. These are substitutes for the timber breakaway posts used in earlier versions of these end terminals for heavy post blocked out corrugated beam guide railing. Posts from Trinity/Syro, manufacturer of the ET 2000 and ET 2000+ end terminals, have an upper post and a lower base post. Splice plates are welded to each of the flanges of the lower base post. Two bolts pass through these splice plates. The larger is a 19 mm bolt which acts a pivot point. The smaller is a 9.5 mm bolt which acts as a shear bolt when the ET 2000+ is impacted head on. The result of this pair of bolts is that the Hinged Breakaway Post is very yielding when bent around the web, but retains strength when bent about the neutral axis which is perpendicular to the web.

Posts from Road Systems, Inc., fabricator of the SKT 350, are similar except that hinge and shear bolts are replaced by a single 31 mm plug weld through each of the splice plates to the flange of the upper post. These plug welds provide greater post strength when the post is bent around the neutral axis which is parallel to the flanges than when bent around the neutral axis parallel to the web.

5) Recommended Offset At The First Post. For maintenance purposes, the free end of the ET 2000+ or the SKT 350 should be offset from the traveled way a minimum of approximately 3 m. Larger offsets are preferred.

Where shoulders are narrow, ET 2000+s or SKT 350s should be flared back to the recommended offset or beyond, whenever practical to do so. Up to 600 mm (2'-0") of flare from the theoretical line of guide rail is possible within the SKT 350's or the ET 2000+'s 15.2 m (50'-0") length.

IMPLEMENTATION. DQAB will insert the specifications into the proposals. EIC's should pass along one copy each of manufacturers directions and drawings to the Regional Maintenance Engineer and the Resident Engineer.

ESTIMATED COST. The average weighted price statewide for the 89 ET 2000 end terminals installed in calendar year 1999 projects was $2500. Each of these installations included eight foundation tubes @ $75 each for a total of $600 per installation. The costs of the ET 2000+ with Hinged Breakaway Steel Posts and the SKT 350 with Steel Breakaway Posts should be lower because they do not require those foundation tubes, except for SKT 350 that requires foundation tubes for the first two posts.

CONTACT PERSON. Larry Brown, Design Quality Assurance Bureau, M.O Bldg 5, Room 410, (518)-457-4093, or Arvind Salgam of the Design Quality Assurance Bureau at (518) 457-5855.

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2 Both grading schemes will be shown on the Standard Sheets M606-12 for grading, layout, and payment details.

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ITEM 15606.3501 M - End Terminal for HPBO Corrugated Beam Guide Railing, SKT 350, Steel Breakaway Posts
ITEM 15606.3551 M - End Terminal for HPBO Corrugated Beam Guide Railing, SKT 350, Steel Breakaway Posts, (Rustic)
ITEM 15606.3601 M - Optional End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000+ or SKT 350, Steel Breakaway Posts
ITEM 15606.3651 M - Optional End Terminal for HPBO Corrugated Beam Guide Railing, ET 2000+ or SKT 350, Steel Breakaway Posts, (Rustic)

DESCRIPTION.

Under this work, the Contractor shall furnish and install End Terminals for Heavy Post Blocked-Out Corrugated Beam Guide Railing of the type and locations indicated in the Contract Documents, or where directed by the Engineer, in accordance with these specifications, applicable Standard Sheets, and the manufacturer's directions and drawings. The Engineer will be the sole determiner in the event there are differences between specifications, standard sheets, manufacturer's directions and drawings.

MATERIALS.

Steel foundation tubes shall meet the requirements of §710-21 Box Beam Guide Railing and Median Barrier. The breakaway steel posts shall be of the dimensions indicated on the manufacturer's drawings and Blockouts shall meet the requirements of §710-13, Wood and Timber Posts and Timber Blockouts or §710-26, Plastic and Synthetic Block-Outs for Heavy Post Guiderail Systems. Corrugated Beam Guide Railing shall meet the requirements of §710-20, Corrugated Beam Guide Railing and Median Barrier. Soil plates, breakaway steel posts, struts, bearing plates, and the guide rail extruder shall meet the requirements of ASTM A36 or ASTM A36M. Fasteners shall be as indicated on the manufacturer's drawings. All metal components shall be hot dip galvanized in accordance with §719-01, Galvanized Coatings and Repair Methods.

Reflective sheeting shall be provided by the manufacturer for the free end of the terminal. 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.

End terminals designated as rustic shall comply with the above requirements except metal parts exposed to view shall meet the requirements of §710-25, Guide Railing and Median Barrier Systems (Rustic) except parts to be painted shall be painted in compliance with §740-03, Painting Galvanized Surfaces.

ET 2000+. The End Terminal shall be ET 2000+ with Hinged Steel Breakaway Posts, as fabricated by the Syro Steel Company, Girard, Ohio (800-321-2755).

SKT 350. The SKT 350 shall be the "SKT 350 Assembly for Steel Breakaway Post System 2 Foundation Tube Option" as fabricated by Road Systems, Inc., Big Springs, Texas, (915) 263-2435 or (815) 464-5917.

CONSTRUCTION DETAILS.

§606-3.01 General of the Standard Specifications shall apply. Posts and foundation tubes shall be driven unless otherwise approved by the Engineer. The manufacturer shall provide written installation instructions and three copies of their manufacturers drawings, maintenance manuals, and parts lists prior to installation of the ET 2000+ or SKT 350, (Rustic.)

ET 2000+, SKT 350 and rustic versions shall be installed after grading is completed at the locations indicated in the Plans, or where directed by the Engineer. They shall be installed in accordance with the manufacturer's instructions

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and the directions of the Engineer.

The work, including the necessary grading work, shall be coordinated with the installation of the guide rail or removal of existing anchorage units to minimize the time the traveling public is exposed to unanchored runs of guide rail. During periods when the public is exposed to unanchored guide rail, plastic drums or other devices approved by the Engineer, shall be placed in advance of the unanchored run and in advance of the ends of the rail. In addition, the ends of the rail shall be brought to the ground level, twisted over to lay flat, and be pinned to the ground.

In the event the end terminals become damaged, the units shall be promptly repaired. Unless another period is indicated in the contract documents, promptly repaired shall mean repaired within fourteen (14) calendar days.

METHOD OF MEASUREMENT.

The work will be measured as the number of End Terminals for Heavy Post Blocked-Out Corrugated Beam Guide Railing of the indicated type satisfactorily furnished and installed in accordance with these specifications. The payment limits for these units shall extend from the front of the guide rail extruder to the center of the ninth guide rail post, which is located approximately 15.8 m distant from the front of the guide rail extruder.

BASIS OF PAYMENT.

The unit bid price per End Terminal for Heavy Post Blocked-Out Corrugated Beam Guide Railing of the indicated type shall include the cost of all labor, materials, and equipment necessary to satisfactorily furnish and install the units between the above described payment limits. The cost of earthwork, grading, top soiling, and seeding shall be measured and paid for separately. The cost to repair units damaged by public travel will be borne by the Contractor, or the by State, in accordance with the provisions of §107-09 Damage.

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ITEM 15606.3450 M - End Terminal for HPBO Corrugated Guide Rail, ET 2000+, Wood Posts (Rustic)
ITEM 15606.35 M - End Terminal for HPBO Corrugated Guide Rail, SKT 350, Wood Posts
ITEM 15606.3550 M - End Terminal for HPBO Corrugated Guide Rail, SKT 350, Wood Posts (Rustic)
ITEM 15606.36 M - Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000+ or SKT 350, Wood Posts
ITEM 15606.3650 M - Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000+ or SKT 350, Wood Posts (Rustic)

DESCRIPTION.

Under this work, the Contractor shall furnish and install End Terminals for Heavy Post Blocked-Out Corrugated Guide Rail of the type indicated at the locations indicated in the Contract Documents, or where directed by the Engineer, in accordance with these specifications, applicable Standard Sheets, and the manufacturer's directions and drawings. The Engineer will be sole determiner in the event there are differences between specifications, standard sheets, manufacturers directions and drawings.

MATERIALS.

Steel foundation tubes shall meet the requirements of §710-21, Box Beam Guide Railing and Median Barrier. The break away wooden posts shall be short 1143 mm posts of the dimensions indicated on the manufacturer's drawings and Blockouts shall meet the requirements of §710-13, Wood and Timber Posts and Timber Blockouts or §710-26, Plastic and Synthetic Block-Outs for Heavy Post Guiderail Systems. Corrugated Beam Guide Rail shall meet the requirements of §710-20, Corrugated Beam Guide Railing and Median Barrier. Soil plates, struts, bearing plates, and the guide rail extruder shall meet the requirements of ASTM A36 or ASTM A36M. Fasteners shall be as indicated on the manufacturer's drawings. All metal components shall be hot dip galvanized in accordance with §719-01, Galvanized Coatings and Repair Methods.

Reflective sheeting shall be provided by the manufacturer for the free end of the terminal. 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.

End terminal designated as rustic shall comply with the above requirements except metal parts exposed to view shall meet the requirements of §710-25 Guide Railing and Median Barrier Systems (Rustic) except parts to be painted shall be painted in compliance with §740-03, Painting Galvanized Surfaces.

Silicone Sealant. Silicone sealant shall be commercially available silicone sealant which will adhere to wood and galvanized steel.

ET 2000+. The End Terminal shall be ET 2000+, Option A (8 foundation tubes) as fabricated by the Syro Steel Company, Girard, Ohio (800-321-2755).

SKT 350. The SKT 350 shall be the "SKT 350 Assembly with Eight Foundation Tubes" as fabricated by Road Systems, Inc., Big Springs, Texas, (915) 263-2435 or (815) 464-5917.

CONSTRUCTION DETAILS.

§606-3.01 General of the Standard Specifications shall apply. Foundation tubes shall be driven unless otherwise approved by the Engineer. The manufacturer shall provide written installation instructions and three copies of their manufacturer's drawings, maintenance manuals, and parts lists prior to installation of the ET 2000+ or SKT 350, (Rustic.)

ET 2000+, SKT 350 and rustic versions shall be installed after grading is completed at the locations indicated in the Plans, or where directed by the Engineer. They shall be installed in accordance with the manufacturer's instructions and the directions of the Engineer.

The work, including the necessary grading work, shall be coordinated with the installation of the guide rail or removal of existing anchorage units to minimize the time the traveling public is exposed to unanchored runs of guide rail.

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ITEM 15606.3650 M - Optional End Terminal for HPBO Corrugated Guide Rail, ET 2000+ or SKT 350, Wood Posts (Rustic)

During periods when the public is exposed to unanchored guide rail, plastic drums or other devices approved by the Engineer, shall be placed in advance of the unanchored run and in advance of the ends of the rail. In addition, the ends of the rail shall be brought to the ground level, twisted over to lay flat, and be pinned to the ground.

The space between the wooden post and the top of the foundation tube shall be sealed with commercially available silicone sealant which is compatible with both wood and galvanized steel.

In the event the end terminals become damaged, the units shall be promptly repaired. Unless another period is indicated in the contract documents, promptly repaired shall mean repaired within fourteen (14) calendar days.

METHOD OF MEASUREMENT.

The work will be measured as the number of End Terminals for Heavy Post Blocked-Out Corrugated Beam Guide Rail of the indicated type satisfactorily furnished and installed in accordance with these specifications. The payment limits for these units shall extend from the front of the guide rail extruder to the center of the ninth guide rail post, which is located approximately 15.8 m distant from the front of the guide rail extruder.

BASIS OF PAYMENT.

The unit bid price per End Terminal for Heavy Post Blocked-Out Corrugated Beam Guide Rail of the indicated type shall include the cost of all labor, materials, and equipment necessary to satisfactorily furnish and install the units between the above described payment limits. The cost of earthwork, grading, top soiling, and seeding shall be measured and paid for separately. The cost to repair units damaged by public travel will be borne by the Contractor, or the by State, in accordance with the provisions of §107-09 Damage.