Indiana Department of Transportation

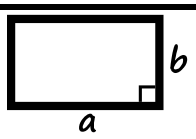
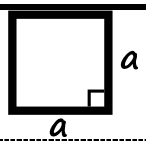
CERTIFIED TECHNICIAN PROGRAM
TRAINING MANUAL FOR

Construction Procedures Part II

2026 Revision

MATH REFERENCES

1 foot = 12 inches	1 square foot = 144 square inches	1 cubic foot = 1728 cubic inches
3 feet = 1 yard	9 square feet = 1 square yard	27 cubic feet = 1 cubic yard
5280 feet = Mile	1760 yards = 1 mile	1 acre = 4840 square yards

Rectangle		Square	
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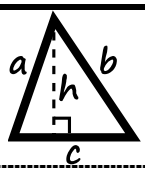
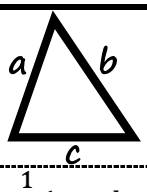
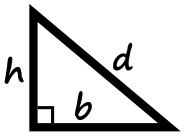
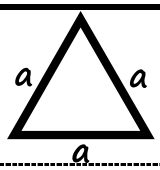
Area	$a \times b$	Area	a^2
Triangle		Triangle (any)	
Perimeter	$a+b+c$	Area by sides (no height)	$s = \frac{1}{2}(a+b+c)$
Area	$\frac{1}{2}(b \times h)$		$A = \sqrt{s(s-a)(s-b)(s-c)}$
Right Triangle		Equilateral Triangle	
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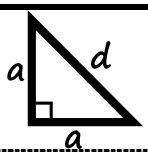
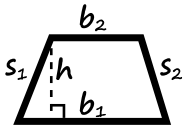
Isosceles Right Triangle		Trapezoid	
Perimeter	$2a+d$	Perimeter	$b_1+b_2+s_1+s_2$
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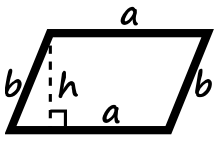
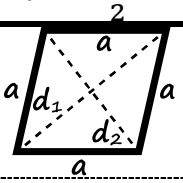
Parallelogram		Rhombus	
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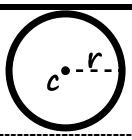
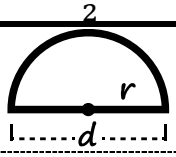
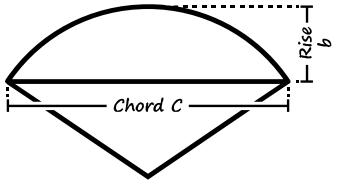
Circle		Semicircle	
Perimeter	$2\pi r$	Perimeter	$\pi r + 2r$
Area	πr^2	Area	$\frac{\pi r^2}{2}$

AREA OF A CIRCULAR SEGMENT

$$\text{Area} = C \times b \times \text{coefficient}$$



Coefficient	$\frac{b}{C}$
0.66667	0.00218
0.66668	0.00436
0.66669	0.00655
0.66671	0.00873
0.66673	0.01091
0.66676	0.01309
0.66679	0.01528
0.66683	0.01746
0.66687	0.01965
0.66692	0.02183
0.66697	0.02402
0.66703	0.02620
0.66710	0.02839
0.66717	0.03058
0.66724	0.03277
0.66732	0.03496
0.66740	0.03716
0.66749	0.03935
0.66759	0.04155
0.66769	0.04374
0.66779	0.04594
0.66790	0.04814
0.66802	0.05035
0.66814	0.05255
0.66826	0.05476
0.66839	0.05697
0.66853	0.05918
0.66867	0.06139
0.66882	0.06361
0.66897	0.06583
0.66913	0.06805
0.66929	0.07027
0.66946	0.07250
0.66964	0.07473
0.66981	0.07696
0.67000	0.07919
0.67019	0.08143
0.67039	0.08367
0.67059	0.08592
0.67079	0.08816
0.67101	0.09041
0.67122	0.09267
0.67145	0.09493
0.67168	0.09719
0.67191	0.09946

Coefficient	$\frac{b}{C}$
0.67215	0.10173
0.67240	0.10400
0.67265	0.10628
0.67291	0.10856
0.67317	0.11085
0.67344	0.11314
0.67372	0.11543
0.67400	0.11773
0.67429	0.12004
0.67458	0.12235
0.67488	0.12466
0.67519	0.12698
0.67550	0.12931
0.67582	0.13164
0.67614	0.13397
0.67647	0.13632
0.67681	0.13866
0.67715	0.14101
0.67750	0.14337
0.67786	0.14574
0.67822	0.14811
0.67859	0.15048
0.67897	0.15287
0.67935	0.15525
0.67974	0.15765
0.68014	0.16005
0.68054	0.16246
0.68095	0.16488
0.68136	0.16730
0.68179	0.16973
0.68222	0.17216
0.68265	0.17461
0.68310	0.17706
0.68355	0.17952
0.68401	0.18199
0.68448	0.18446
0.68495	0.18694
0.68543	0.18943
0.68592	0.19193
0.68642	0.19444
0.68692	0.19696
0.68743	0.19948
0.68795	0.20201
0.68848	0.20456
0.68901	0.20711

Coefficient	$\frac{b}{C}$
0.68956	0.20967
0.69011	0.21224
0.69067	0.21482
0.69123	0.21741
0.69181	0.22001
0.69239	0.22261
0.69299	0.22523
0.69359	0.22786
0.69420	0.23050
0.69482	0.23315
0.69545	0.23582
0.69608	0.23849
0.69673	0.24117
0.69738	0.24387
0.69805	0.24657
0.69872	0.24929
0.69941	0.25202
0.70010	0.25476
0.70080	0.25752
0.70151	0.26028
0.70223	0.26306
0.70297	0.26585
0.70371	0.26866
0.70446	0.27148
0.70522	0.27431
0.70600	0.27715
0.70678	0.28001
0.70758	0.28289
0.70838	0.28577
0.70920	0.28868
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0.71087	0.29452
0.71172	0.29747
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0.71345	0.30341
0.71434	0.30640
0.71524	0.30941
0.71615	0.31243
0.71707	0.31548
0.71800	0.31854
0.71895	0.32161
0.71991	0.32470
0.72088	0.32781
0.72187	0.33094
0.72287	0.33409

Coefficient	$\frac{b}{C}$
0.72388	0.33725
0.72491	0.34044
0.72595	0.34364
0.72701	0.34686
0.72808	0.35010
0.72916	0.35337
0.73026	0.35665
0.73137	0.35995
0.73250	0.36327
0.73364	0.36662
0.73480	0.36998
0.73598	0.37337
0.73717	0.37678
0.73838	0.38021
0.73960	0.38366
0.74084	0.38714
0.74210	0.39064
0.74337	0.39417
0.74466	0.39772
0.74597	0.40129
0.74730	0.40489
0.74865	0.40852
0.75001	0.41217
0.75140	0.41585
0.75280	0.41955
0.75422	0.42328
0.75566	0.42704
0.75713	0.43083
0.75861	0.43464
0.76011	0.43849
0.76164	0.44236
0.76318	0.44627
0.76475	0.45020
0.76634	0.45417
0.76795	0.45817
0.76959	0.46220
0.77125	0.46626
0.77293	0.47035
0.77463	0.47448
0.77636	0.47865
0.77812	0.48284
0.77990	0.48708
0.78171	0.49135
0.78354	0.49566
0.78540	0.50000

MANUAL DISCLAIMER

The references in this manual are reflective of the 2026 INDOT Standard Specifications. The material covered herein is for training purposes only. The Standard Specifications, Contract Information Book, General Instruction to Field Employees, and Construction Memos should be consulted for determining the current inspection procedures for a given contract. On-site procedures, field tests, and other operating procedures may vary from those described within this manual.

TABLE OF CONTENTS

CHAPTER ONE: *TRAFFIC SIGNALS*

In this chapter the construction of a traffic signal system is discussed. Shop drawings for Signing, Signals, and Lighting will be reviewed and approved by the INDOT Office of Traffic Design and Review. These items typically include all overhead sign structures, signal strain poles and cantilevers, high mast lighting, luminaries, and light poles. Plans and calculations should be submitted by the Contractor to the PEMS and forwarded to the Office of Traffic Design Manager at TrafficDesignReview@indot.IN.gov for review and approval.

A technician working on a traffic signal is required to be aware that work activities progress very quickly, and any unresolved problems become the controlling operation for the completion of the work. For this reason, the technician should anticipate problems before they become the controlling operation. The following steps are recommended before any work is started by the Contractor:

1. Review Sections **805** and **922**, Part 4 of the current edition of the Manual of Uniform Traffic Control Devices (MUTCD), and appropriate Standard Drawing Sheets.
2. Closely examine the plans, and field check the planned locations of all structures before the preconstruction conference. These include the controller, poles, detector housings, loops, handholes, and signal head locations.
3. Check the right-of-way,(*R/W)*, distances as shown on the plans. This may usually be accomplished by reviewing old road plans in ERMS, the *Electronic Record Management System.*
4. After the locations of all underground utilities have been determined, again closely examine the structure locations and signal cable quantities for any conflicts. Any significant errors should be brought to the attention of the PEMS, Area Engineer, or District Traffic Department.
5. In urban areas, check with property owners about possible basements extending out under the sidewalk areas.

WOODEN POLES WITH DOWN GUYS

Wooden poles with down guys are generally less expensive to install than steel strain poles and are typically used only for temporary signals. Standard Drawings **E 805-SGSC-01** through **04** provide detailed requirements for wooden pole installations. When laying out and inspecting the locations where wooden poles and anchors are being installed, the following items are required to be considered:

1. Each wooden pole is required to be visually inspected and meet the requirements of Section **911.**
2. The locations of the wooden poles are staked so they may be seen from any of the other pole locations.
3. Placing wooden poles or down guy anchors in the ditch line should be avoided.
4. Wooden poles are set a minimum of 7 ft in the ground and raked back out of plumb 12". The material excavated from the hole should be observed for utility conflicts.
5. For single spans, the pole anchors are located by extending the line of the span back 20 ft from the pole and swung a 7.5 ft arc in either direction.

6. For double spans, the pole anchors are located by extending the line which divides the extension of the two spans back 20 ft and swing a 7.5 ft arc in either direction.
7. Any pole anchor location change which would place the pole anchor closer than 15 ft from the wooden pole should generally not be permitted. The use of a strain pole should be investigated for cases of insufficient anchorage.
8. The line on the drilled hole for the pole anchor is required to be toward the top of the wooden pole.
9. The breaking of the expansion anchor and the proper backfill and compaction of the anchor assembly are critical to the proper functioning of the wooden pole. Initial and continued movement of the anchor assembly is required to be monitored.

STEEL STRAIN POLES

Steel strain poles (***Figure 1-1***) are used primarily on permanent installations. These poles have a higher initial installation cost; however, the service life is much longer than a wooden pole with down guys. Standard Drawings **E 805-SGSC-01** through **04** provide detailed requirements for steel pole installations. When laying out and inspecting the locations where steel strain poles are being installed, the following items are required to be considered:

Figure 1-1 Steel Strain Pole

1. The Basis for Approval for the reinforcement bars and concrete in the foundation and the steel strain pole will be in accordance with the Frequency Manual requirements for each item.
2. The footing dimensions are 3 ft in diameter and 12 ft deep.
3. If bed rock, loose stones, or boulders more than ½ yd^3 in volume are encountered before the 12 ft depth is obtained, the PEMS or Area Engineer should be contacted. Section **206** Class X Excavation covers the procedure to be used if this occurs.
4. The Contractor always has the option of using a foundation casing if unstable soil conditions are anticipated.
5. The exposed portion of the foundation may be 3 ft in diameter or 3 ft square.
6. Adjacent anchor bolts are required to be oriented in the same direction with the span or spans attached to the steel strain pole.
7. A tremie is used until the concrete is within 5 ft of the top of the foundation.
8. The steel strain pole foundation is finished 4 to 6" above the original ground and the top edge is chamfered. In locations where the foundation is located within the sidewalk, the sidewalk elevation is the top of the foundation.
9. Each foundation has a minimum of three conduit entries with grounding bushings.
10. Each steel strain pole is grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the steel strain pole through the conduit grounding bushings and grounding duct to an 8' by ½" ground rod located 1 ft away from the foundation and 1 ft below the finished ground surface.
11. The exposed concrete surface of the foundation is rubbed after forms are removed.
12. If electrical service is on the steel strain pole, all three conduits from the steel strain pole are run to the controller. Consult District Traffic for possible future designs.

13. Metal poles erected on concrete foundations shall be reasonably plumb after installation of signal heads.
14. The handhole side of the pole shall be at right angles to the direction of the signal cantilever arm or span, catenary, and tether.
15. Signal cables shall be brought up inside the poles.
16. Any steel pole not galvanized shall be coated with structural steel coating system in accordance with Section **619.**

SPAN, CATENARY, AND DOWN GUYS

The span and catenary, as shown on the Standard Drawings ***(Figure 1-2***), are one of the first things motorists notice about a signalized intersection. If the span and catenary are sagging or sloppy, the whole job appears so.

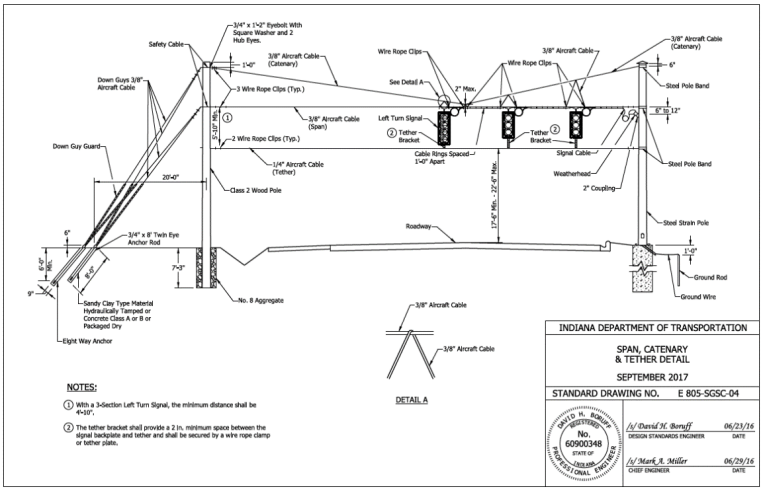


Figure 1-2 Span, Catenary, and Tether (E 805-SGSC-04)

When inspecting the installation of spans, catenaries, and down guys, consider the following items:

1. The Basis For Approval for ⅜" or ¼" stainless steel aircraft cable is per the Frequency Manual.
2. Spans, catenaries, and down guys are ⅜" stainless steel aircraft cable. Tether lines are generally ¼" aircraft cable.
3. Spans are required to be level. Therefore, a leveling mark should be placed on the side of each pole representing the pavement elevation at the lowest signal head.
4. The span is located by measuring 22 or 23 ft from the leveling mark for the location of the drilled hole for the wooden pole or pole band for the steel strain pole.
5. The catenary is located a minimum of 12" for wooden poles and 6" for steel poles. below the top of either a wooden pole of steel strain pole. The catenary connection may have to be lower depending on overhead utility conflicts.
6. Three Crosby clamps are used at each eye bolt or pole band connection and are installed in the same directions. Three bolt clamps are never used on aircraft cable.
7. The aircraft cable is doubled back 54" at each eye bolt or pole band connection. The first Crosby clamp is installed 3" from the eye bolt, the second 18" from the first, and the third 18" from the second.
8. Down guys are required to be in place before any work is conducted on the spans and catenaries of wooden poles.
9. The down guys are tightened until the top of the wooden pole starts to move.
10. Span jacks are used to tighten the spans. For double spans, each span is jacked alternately until very tight.
11. The catenary swinging free is required to be between 18" and 24" above the span at the closest point.

12. The span and catenary are connected at the center of the span. The signal heads are supported and leveled from the catenary by means of "A" wires. Each "A" wire is connected at the bottom by two Crosby clamps spaced 12 to 24" apart. No Crosby clamp is used at the top of the "A" wire. The ends of the A wires are protected by servi-clips. "A" wires may be either ¼" or ⅜" aircraft cable.
13. The National Electrical Code requires 8 ft vertical and 6 ft horizontal clearance from any overhead power line.

SIGNAL HEAD INSTALLATION AND CLEARANCES

The traffic signal heads are often the only part of the whole traffic signal system that the motorist actually notices. When traffic signals are involved, before starting work, the Contractor must provide the names of the Level II Traffic Signal Construction Technicians, the Level II Traffic Signal Field Technicians and Work Zone Traffic Safety Specialists, who have been assigned to perform the signal related work, and a photocopy of each person's certification card granted by the International Municipal Signal Association (or an approved equivalent). Therefore, the vertical and horizontal positioning and the directional orientation are critical to a well-functioning system. Backplates must be provided on all overhead signal heads except for any signal heads installed on existing traffic signal cantilever structures.

When inspecting the installation of traffic signal heads, consider the following:

1. The Basis For Approval for signal heads and accessories is in accordance with the Frequency Manual.
2. Inspect each signal head assembly while still on the ground for the following:
    a. Physical defects
    b. Visor type
    c. Signal indication diameters
    d. Lens orientation
    e. Too much play between the balance adjustor and weatherhead clevis per wiring specifications
    f. Approximate vertical hanging for each signal head
3. Minimum 17.5' and maximum 22.5' roadway clearance is required for signal heads.
4. Signal heads are adjusted vertically to approximate a uniform grade of all like signal heads.
5. If a tether line is specified (***Figure 1-3***), all the signals are required to be aligned vertically. This may have to be done several times if the span or catenary requires adjustment. The tether line is designed to break if hit.
6. Signal heads are located and aimed according to the plans. The minimum spacing between signal heads serving the same direction is 8 ft. The minimum spacing between free swinging signal heads not serving the same direction is 4 ft. The District Traffic Department should approve the layout of signal heads.
7. If a signal head is required to be mounted more than 2 hours before use, then the entire signal head is hooded.
8. Hooded signal heads are not to be left up for more than five days.

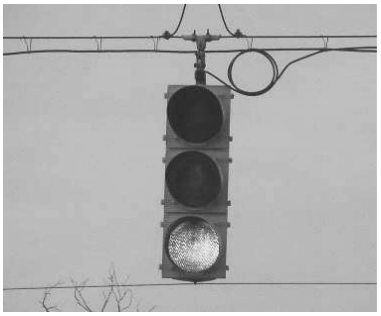


Figure 1-3 Tether Line

DISCONNECT HANGER INSTALLATION

The disconnect hanger (***Figure 1-4***) is an electrical junction box generally suspended at a specified location on the span, and all the wiring connections are conducted while on the span. When inspecting the installation of a disconnect hanger the technician is required to consider the following items:

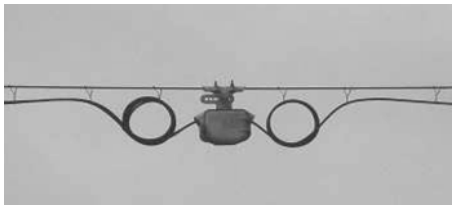


Figure 1-4 Disconnect Hanger

1. Basis for Approval for disconnect hangers is in accordance with the Frequency Manual.
2. Each disconnect hanger is inspected on the ground for physical defects, tightness of door latch and span hanging connections, and an 18-circuit terminal block.

TRAFFIC SIGNAL CABLE INSTALLATION

Traffic signal cable is the multi-conductor cables which carry electrical impulses from the power source to the entrance switch, from the entrance switch to the controller, from the controller to the signal heads, and from the controller to the detection devices. Pay items are designated by the number of conductors in the cable and the gauge of the cable. When inspecting the installation of traffic signal cable, the technician is required to consider the following items:

1. The Basis for Approval for all traffic signal cable is per the Frequency Manual.
2. The color-coding scheme is required to be discussed at the preconstruction conference and should conform to the District policy.
3. Fused and unfused cables are not permitted to occupy the same conduit. 3C/8 (3 conductor 8 gage wire) traffic signal cable is considered unfused.
4. In above ground pole handholes, an acceptable splice is a "standing splice" utilizing wire nuts and electrical tape wrapping.
5. For traffic signal cable hung from a span, cable rings are spaced at 12".
6. Traffic signal cable quantities are required to be verified.
7. All cable runs will be installed in continuous lengths without splices between terminals except as necessary at handholes, junction boxes, pole signal bases, and pedestal bases.
8. Coded cable conductors shall be used throughout the installation. Cable conductors shall be tagged at all detector housings, handholes, signal pole bases, and controller cabinets. At the ends of each cable, the tag shall be placed between 4" and 8" from the end of the wire and on the outer jacket. At all other locations, the tag shall be placed in the middle of the length of cable stored at the location. Tags shall identify the cables by their use, for instance as power, pedestrian signal, signal, detection loop for example.
9. Green wire shall be utilized as the ground wire in all wiring schema. All wire will be color coded and, where possible, will use red wire to connect red lenses, orange wire to connect yellow lenses, and brown wire to connect green lenses.

DRIP LOOP INSTALLATION

The purpose of a drip loop (***Figure 1-5***) is to prevent water from entering the weatherhead at either a signal head, disconnect hanger, or traffic pole. Drip loops are required to be approximately 15" in diameter, contain at least one full turn of traffic signal cable, and be wrapped tightly with several wraps of electrical tape. The drip loop should not rub against the traffic signal head.

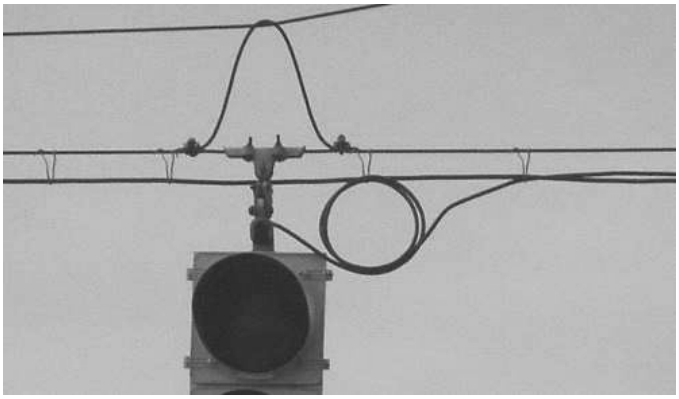


Figure 1-5 Drip Loop

POLE AND MAST ARM INSTALLATION

Pole and mast arm installations ***(Figure 1-6***) are found in urban areas where spans and catenaries are either impractical or not as aesthetically pleasing as poles and mast arms. Standard Drawings E **805-TSCS-01** through **19** provide detailed information on the construction and installation requirements of traffic signal cantilevered structures.

Figure 1-6 Pole and Mast Arm

When inspecting the installation of a pole and mast arm system, the following items are required to be considered:

1. The Basis for Approval for the pole, mast arm, anchor bolts, and accessories is in accordance with the Frequency Manual. The Basis For Approval for the concrete used in the footing is in accordance with the Frequency Manual.
2. Field check each footing location using the planned mast arm length and locate the end span signal head according to the plans. Any apparent errors in the plans are required to be reported to the PEMS immediately.
3. Check the R/W shown in the plans to ensure the footing is entirely within the R/W.
4. After the underground utilities have been located, check to ensure that the footing locations meet the following criteria:
    a. The face of the pole is required to be at least 18" from the face of the curb.
    b. Underground utility clearance requirements are required to be satisfied. Encasement of an underground utility should never be considered without prior consent of the utility company. Unexpected or mismarked underground utilities are one of the largest causes of contract delay.
    c. Do not locate a footing within the confines of a wheelchair ramp or where a wheelchair would have difficulty maneuvering. If the foundation is required to be in the curb ramp area, then move the foundation as far out of the ramp as possible and place the top of the foundation level with the curb ramp grade. If pedestrian signal indications are specified, they are required to be clearly visible from the beginning of the crosswalk to within 10 ft of the opposite side. The footing should be kept as close to the crosswalk lines as possible.

d. Footings are located so signal heads are within 40 to 120 ft from the stop bar.
e. The location of the footing may be moved a maximum of 2 ft perpendicular to flow of traffic, but the mid-mast signal head should still be located at a lane width spacing from the end mast arm signal head. The mid-mast signal head is never located beyond the curb line and the minimum spacing between signal heads is 8 ft.

5. If possible, locate the footing entirely off the sidewalk.
6. Each footing has a minimum of three conduit entries.
7. Each mast arm pole is grounded by a continuous #6 bare copper wire from the grounding lug on the inside of the mast arm pole through the conduit grounding bushings and grounding duct to an 8' by ½" ground rod located 1 ft away from the foundation and 1 ft below the finished surface.
8. If the footing is greater than 5 ft deep, a tremie is required below the 5 ft level.
9. If the footing is located in a sidewalk area, the footing is finished flush with the surrounding sidewalk. If the footing is located in a non-sidewalk area, the footing is finished 4" above the original ground using chamfered edges around the top of the footing.
10. Expansion joint material is used when the footing contacts any other concrete.
11. The pedestrian signal heads are located on the pole in such a manner as to provide protection from truck turning movements.
12. The bottom of the mid-mast mounted signal head is adjusted level with the end of the mast arm signal head.

ELECTRICAL SERVICE AND ENTRANCE SWITCH INSTALLATION

The electric service (***Figure 1-7***) requirements vary with the utility company involved. Generally speaking, if the electric service does not meet any of the requirements, the electricity is not connected.

Figure 1-7 Electrical Service and Entrance Switch

When inspecting the installation of an electric service the following items are required to be considered:

1. The Basis for Approval for the entrance switch, the conduit riser, the weatherhead, the traffic signal cable and all other miscellaneous material is in accordance with the Frequency Manual.
2. 3C/8 stranded traffic signal cable is used for the electrical service from the service weatherhead to the entrance switch, and from the entrance switch to the controller.
3. At least 4 ft of 3C/8 is left rolled up at the weatherhead.
4. An electric meter is placed above the entrance switch if required by the local power company, or if specified by INDOT.
5. Since the controller operates on 120 volts, one conductor of the 3C/8 is terminated at the entrance switch.

6. For an electric service on a steel strain pole, a 1" riser with weatherhead is placed on the outside of the steel strain pole. Conduit hangers are banded to the outside of the steel strain pole and the conduit is installed on the hangers.
7. An oxidation inhibitor is applied to all surfaces that mate with a dissimilar material, such as aluminum to steel.
8. Conduit straps or hangers are placed 1 ft from the weatherhead and at a maximum spacing of 5 ft from there down.
9. Entrance switch enclosures are required to contain a single pole 50 amp breaker.
10. The bottom of the entrance switch is mounted at a height of 4 ft.
11. The entrance switch is grounded by means of a #6 bare solid copper wire encased in a ½" electrical conduit between the entrance switch and the ground rod.
12. The 8' by ½" ground rod is located 1 ft outside the pole or foundation and 1 ft below the ground surface. The grounding connection is required to be an approved type.

CONTROLLER INSTALLATION INCLUDING FOUNDATION

The traffic signal controller ***(Figure 1-8***) is the mechanism which makes the traffic signal system operate the way intended. The technician should never change any of the settings of any of the equipment inside the controller cabinet. Only a trained District Traffic Signal Technician has the authority to set or change any of the various controller timings. The controller cabinet will be installed in accordance with the requirements of Section **805**, additional details on installation are shown on the Standard Drawings **E 805-SGCF-01** through **06** for foundations and on **E 805-SGCO-01** through **08** for signal controllers.

Figure 1-8 Traffic Signal Controller

Three document packets shall be prepared in accordance with Section **922** for each cabinet. Each packet shall be labeled with the name of the contract number, the intersection, the commission number of the signal, and the date of installation. One paper packet shall be placed in the cabinet, one paper packet shall be submitted to the Engineer, and one electronic packet shall be submitted to the Asset Manager in the Department's Traffic Management Division within two days after the signal is turned on. Information in the packets shall include all approved changes to the signal installation. All detector loop lead-in tags and detector rack labels shall reflect all approved changes to the signal installation.

Consider the following when inspecting the installation of a traffic signal controller:

1. The Basis for Approval for the concrete, controller, cabinet, and all accessory items is in accordance with the Frequency Manual.
2. The controller cabinet is in the same direction oriented so that a traffic signal technician standing at the controller with the door open may see the majority of the signal heads.
3. Try to anticipate any future maintenance problems you might be creating.

4. Check the plans and standard sheets for the controller foundation location, type, dimensions, and anchor bolt placement.
5. There will be a minimum of three conduit entries into the controller foundation. There should always be a spare conduit entry. The price of a few extra feet of conduit is small compared to the price of relocating the controller foundation on a future modernization contract.
6. The top edges of the controller foundation are required to have chamfered edges, and the exposed sides of the foundation be rubbed.
7. The top of the controller foundation must be sloped toward the controller drain.
8. A continuous run of #6 bare copper wire connects the grounding lug on the controller back panel, each conduit grounding lug, and the approved grounding connection to the ground rod.
9. An 8' by ½" ground rod is placed 1 ft outside the confines of the controller foundation, and 1 ft below the finished ground level.
10. The controller cabinet door is required to open and close easily when the controller cabinet is properly aligned on the controller foundation. The outside lower edges of the controller are sealed all around with a silicone sealer.
11. All field wiring ***(Figure 1-9***) is required to be neat and easy to follow. The "bird nest" affect is discouraged.
12. All traffic signal cables entering the controller cabinet, signal poles, and handholes are tagged with aluminum tags indicating the signal phase, pedestrian phase, power, pedestrian actuation, or loop phase.
13. On traffic signal modernization contracts, the old and the new systems are kept independent of each other at all times.

Figure 1-9 Controller Cabinet Wiring

14. A District Traffic Signal Technician is required to always be present when a new signal system is turned on for the first time.
15. Newspapers, TV and radio stations, schools, and law enforcement agencies are notified of the new signal turn on dates.
16. A new traffic signal system at an intersection where a traffic signal system did not exist beforehand or where a flashing beacon system is being upgraded to a traffic signal system are required to remain on flash for at least three days prior to placement on normal operation. A new signal is never placed on normal operation on a Friday or just before a holiday.

STEEL CONDUIT INSTALLATION

Steel conduit is used to carry the traffic signal cable between the controller and all points of intended use. When inspecting the installation of conduit, the following items are required to be considered:

1. The Basis For Approval for conduit is in accordance with the Frequency Manual.
2. Steel conduit is required to be 2" nominal diameter. Larger size conduit may be used with no additional payment, but when it is used, it shall be for the entire length of the run from outlet to outlet.

3. Rigid grade and intermediate grade steel conduit are both acceptable. Most Contractors elect to use rigid conduit.
4. PVC, HDPE, and Fiberglass conduit are also acceptable, but the 12" cover of B-borrow is financially unattractive to most Contractors. PVC, HDPE, and Fiberglass conduit also requires 2" of natural sand under the conduit.
5. Steel conduit is installed to a depth of no less than 24" and no more than 5 ft below the finished grade, unless otherwise indicated.
6. The maximum length for a straight run of conduit between handholes is approximately 200 ft. This figure may be considerably less depending on the number of bends in the run of conduit.
7. All conduit inside a foundation is included in the price of the foundation.
8. Pushed or jacked conduit is the most expensive conduit for the Contractor. Pushing or jacking methods are required to not create an excessive void around the conduit, and the jacking pit is kept a minimum of 2 ft from the nearest pavement or shoulder.
9. The edges of all street cuts for detector housings or stopped jacked conduits are required to be sawed.
10. Compacted B borrow is used for the backfill of all street cuts not at a detector housing.
11. Except at detector housings, street patches are required to match the surrounding pavement. 12" of concrete and 1" to 2" of HMA surface mix are acceptable patches for HMA pavement.

HANDHOLE INSTALLATION

Handholes (***Figure 1-10***) are junction points for conduit and pulling points for the traffic signal cables in these conduits. They are placed as near as possible to the locations on the plans.

Figure 1-10 Handhole

When inspecting the installation of handholes, the following items must be considered:

1. The Basis For Approval of the handhole tile and handhole ring and cover is in accordance with the Frequency Manual.
2. Handholes class 1 and class 2 are shown on the Standard Drawings.
3. Handholes are placed in the direct line of the conduit run, if possible.
4. 200 ft is the maximum handhole spacing for a straight run of conduit unless otherwise shown on the plans.
5. A handhole is not placed in a ditch line.
6. A handhole is located to alleviate standing water in a conduit and to prevent water from backing up into the controller cabinet.
7. The grade of the ring and cover must match the existing grade.
8. Coarse aggregate #8 is used below the bottom of the handhole unless the parent material is granular.
9. Concrete for the 5" pad is worked under the handhole tile. Concrete for the 5" pad may be either class A, B, C, or bag mix conforming to **ASTM C 387.**
10. Conduits must extend 3" to 6" beyond the inside wall of the handhole tile and be grouted. Grout mix is required to conform to **ASTM C 387.**

11. All conduits are required to have bushings.
12. All traffic signal cable are required to have approximately 2 ft of slack in a handhole.
13. The cover for a polymer concrete handhole must state the ANSI/SCTE tier rating of the polymer concrete handhole.

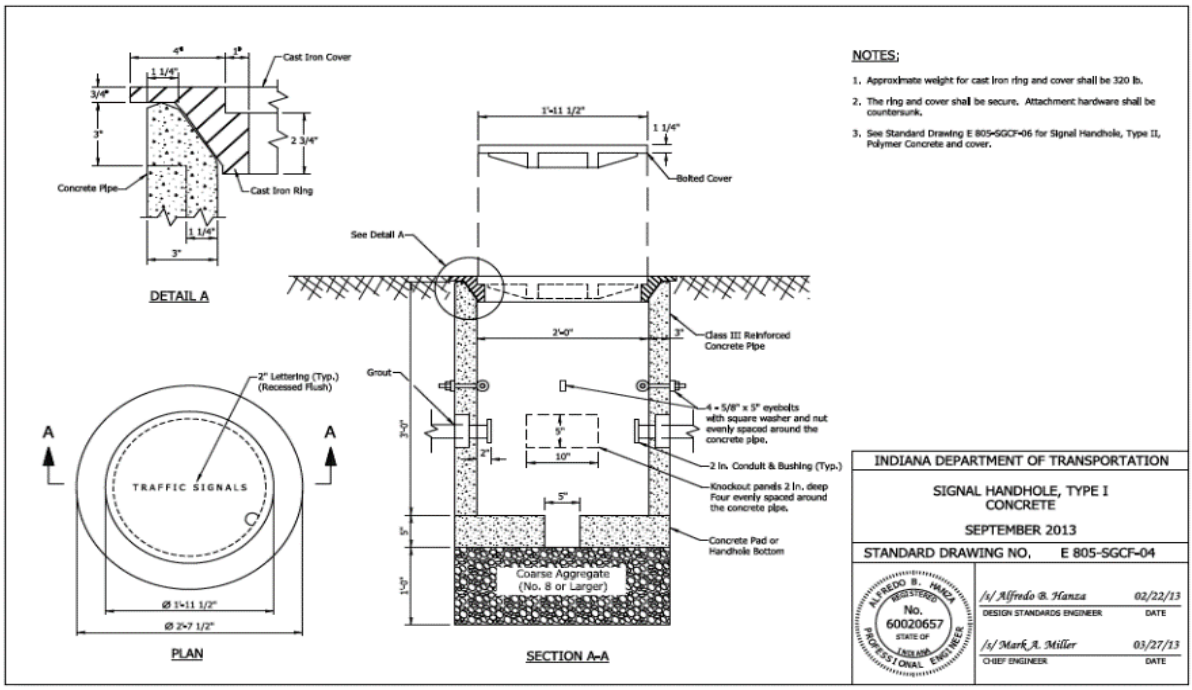


Figure 1-11 Signal Handhole, Type I Concrete (E 805-SGCF-04)

DETECTOR HOUSING AND TRAFFIC DETECTION LOOP INSTALLATION

Properly installed detector housings (***Figure 1-12***) and traffic detection loops are critical to the intended functioning and the expected service life of the detection system. The requirements for detector housings and detection loops are provided in Section **805**, additional details on appropriate installation are provided in Standard Drawings **E 805-SGLI-01** through **06** for loops and **E 805-SGDH-01** through **03** for housings. The technician must know what to look for to avoid potential future failures in the detection system.

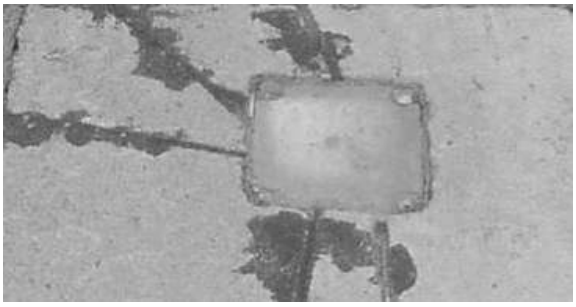


Figure 1-12 Detector Housing

DETECTION HOUSING INSTALLATION

When inspecting the installation of detector housings and traffic detection loops, the following items are required to be considered:

1. The Basis for Approval for the concrete, the aluminum detector housing, the 1C/14 loop wire, and loop sealant is in accordance with the Frequency Manual.
2. The detector housings, traffic detection loop corners, and the stop bars are first laid out according to the plans.

3. If possible, avoid crossing a pavement joint or crack with a loop wire. Moving the location of a detector housing or traffic detection loop 2 or 3 ft to avoid crossing a pavement joint or crack is acceptable. A detector housing may be butted up against a contraction joint.
4. If the side of a loop runs parallel to a joint or crack, at least 1 ft of clearance is required to be maintained between the loop and the joint or crack.
5. Observe traffic flow for drivers' habits, incidents of false calls, drivers overrunning the loops, or stopping too soon to be detected by the loops. If a major change in the location or number of loops is required, contact the Area Engineer or District Traffic Office before making such a change.
6. Detector housings are generally placed inside the pavement but should not be located where water is likely to stand, such as in a gutter line.
7. Galvanized steel elbows are used in the detector housings.
8. Detector housings poured in pavement under traffic are poured using high early strength concrete.
9. The freshly poured detector housing is covered with a steel plate, generally at least 3' by 3' by ¾", for the cure time of the concrete.
10. HMA cold mix around the edges of the plate works well to hold the plate in place.
11. Where a portion of the road is closed or where there is no vehicular traffic, class A concrete may be used to pour detector housings.
12. Work is required to be scheduled so that a detector housing is poured the same day that the area is dug.

The aluminum detector housing and surrounding concrete base are required to be finished flush with the surrounding pavement; however, the aluminum detector housing may be finished ½" below the surrounding pavement.

SAWING LOOPS

1. The Contractor has the option to use either wet or dry saw blades on the saw slots. However, wet blades are discouraged in freezing weather, and dry blades are discouraged in urban areas where air pollution standards may be violated.

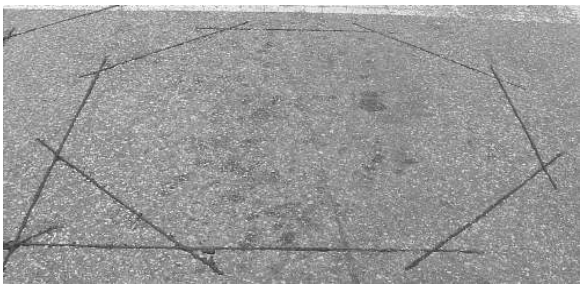


Figure 1-13 Saw Loops

2. The width of a saw slot must be between ⅜" and $\frac{7}{16}$". The minimum saw slot depth is 3" (2" + 1" of cable), and the maximum slot depth is 3 ½" (2 ½" + 1" of cable).
3. All loops must be octagonal with 2' 6" long sides or circular with a diameter of 6 ft.
4. All loop locations are subject to the approval of the District Traffic Engineer, who is notified at least two business days prior to any loop placement.
5. No more than one loop may be served by the same saw cut.
6. Always saw deeper and wider when crossing a working joint or crack and leave slack in each turn of the loop wire.
7. The saw slots are inspected for their total length for depth requirements. The saw slots are required to be totally dry before the loop wire is placed.

INSTALLATION OF LOOP WIRE

1. All loops are required to be wired with 4 turns unless otherwise noted.
2. IMSA 51-7 1C/14 (one conductor 14 gage wire) duct-loop wire inside a ¼" O.D. PVC or polyethylene jacket is specified for loop wire.
3. All loop wire is placed in the saw slots in a clockwise manner as viewed from above.
4. Loop wires are pressed into the saw slots with a blunt non-metallic object.
5. Two inch sections of ½" diameter backer rod are installed in 15" intervals over the loop wire to prevent the loop wire from floating up when the sealant is applied. The loop wire is placed on the bottom of the saw slot.
6. At no time is the loop wire bent at angles less than 120 degrees.
7. All loops are wired in series – the "in" end of one loop attached to the "out" end of the next loop – unless otherwise noted.
8. Lead-in wires between the loop and the detector housing are twisted around each other a minimum of 5 turns/ft, tied with cable ties, and coiled in the detector housing.
9. A maximum of 18" and a minimum of 12" of loop wire is allowed in the detector housing for each loop lead-in wire.
10. In the detector housing, each lead-in wire is tagged as either "in" or "out".
11. The black wire from the 2/16 shielded cable is spliced to the free loop's "out" lead-in wire, and the white wire from the 2/16 shielded cable is spliced to the free loop's "in" lead-in wire.
12. The Contractor is required to meter each loop at the detector housing and each 2C/16 shielded cable at the controller. The technician witnesses and records each of the following on the *805-T-039d Loop Testing Table* included in the contract as an RSP:
    a. Inductance, in microhenries, performed at the detector housing and at the controller cabinet.
    b. Resistance, in ohms, performed at the detector housing and controller cabinet.
    c. Induced A.C. voltage, in volts, performed at the detector housing and at the controller cabinet.
    d. Leakage resistance, in mega-ohms, performed at the controller cabinet after the splices in the detector housing have been fully submerged for two minutes in a solution containing water and one tablespoon of baking soda.
13. Values for the above tests are required to meet the following before the loop installation is accepted:
    a. Inductance between 80 - 800 microhenries.
    b. Resistance less than or equal to 8 ohms.
    c. Induced AC voltage less than or equal to 3 volts.
    d. Leakage resistance greater than 100 mega-ohms.
14. All loop testing is conducted at the detector housing before the loop wires are spliced and at the controller cabinet after the loop wires have been spliced. No loop sealant is placed until all the loop tests have been successfully completed. The loop sealant is not placed until all the loop tests have been successfully completed.
15. The vehicle simulator test is also required before the loops are accepted. The test vehicle is fabricated with an 8 ft long piece of #6 bare copper wire formed into a circle. The two ends are twisted together and the circle is drug across the loop by a non-

conductive string. The loop amplifier records a call as the circle is pulled across the loop and the call should be cancelled as the circle leaves the loop.

16. The loop sealant is required to be from a list of approved loop sealants issued by the Office of Materials Management.
17. All loop splices are soldered and waterproofed in accordance with Standard Sheets.

THERMOPLASTIC, PREFORMED PLASTIC AND EPOXY PAVEMENT MARKING INSTALLATION

The locations of stop bars and cross walk lines may depend on the locations of signal heads, walk/don't-walk indicators, wheelchair ramps, and traffic detection devices. When installing thermoplastic or preformed plastic pavement markings, consider the following:

1. The Basis for Approval for thermoplastic, multicomponent, and preformed plastic pavement markings is retro-reflectivity testing.
2. Check with a PEMS or the Specifications for the weather limitations of each material.
3. These design considerations are important in laying out stop bars and cross walks:
    a. Use common sense and observation of traffic movement to determine stop bar and cross walk locations. The stop sign location is usually not the best place to layout the stop bar due to the sight distance. Check with your PEMS, Area Engineer, or District Traffic for the best location.
    b. The beginning of the stop bar must be at least 40 ft from the nearest signal head and less than 120 ft from the farthest signal head serving that direction.
    c. A minimum of 4 ft clearance between the stop bar and the nearest point on the crosswalk line is required.
    d. Crosswalk lines run parallel and are separated by a minimum of 6 ft.
    e. Cross walk lines proceed in a straight line from curb ramp to curb ramp.
    f. Try to avoid crossing manhole covers or straddling transverse joints or cracks.
4. The following removal of existing pavement markings is included in the unit price for new pavement markings:
    a. All incorrect and clearly visible existing stop bars and crosswalk lines on HMA pavement.
    b. All existing preformed plastic pavement markings on HMA pavement. These are generally brittle and easily dislodged at the curb line, and show sign of deformation in the wheel tracks.
    c. All visible pavement markings on concrete pavement.
5. Thermoplastic may be placed over existing well-worn thermoplastic or well-worn traffic paint.
6. The pavement surface is required to be dry and at least 50° F and rising for thermoplastic and 50° F without a primer for preformed plastic pavement markings.
7. The application area is pre-stripped on all types of pavement with a manufacturer approved binder material to insure adhesion.
8. Thermoplastic application temperatures vary by manufacturer, but are generally required to be between 400° F and 450° F.

CHAPTER TWO: *GROUND MOUNTED SIGN INSTALLATION*

The installation of ground mounted signs requires the furnishing of approved materials, and the erecting of traffic supports and signs according to the Specifications and the contract plans. In this chapter, the installation of ground mounted signs is discussed for pre-construction, construction inspection, and measurement and payment.

TRAFFIC SIGNS

For ground mounted sign installation, review the following items:

1. Sections **206**, **802**, and **910**.
2. "Standard Highway Signs" and FHWA "Standard Highway Sign" 2004 Edition with 2012 supplement.
3. Indiana Manual on Uniform Traffic Control Devices (MUTCD) for highway construction and maintenance operations.

Figure 2-1 Panel Sign

PRE-CONSTRUCTION DUTIES

Generally, sheet signs are mounted on square posts while panel signs (***Figure 2-1***) use structural steel posts. The Technician should be familiar with both Plan sheets and Quantity sheets in the contract plans to determine the type and location of each sign.

WORKING DRAWINGS

Working drawings will be submitted by the contractor in accordance with Section **105** for structural sign support items.

1. Closely examine the working drawings. The details provided on the working drawings should meet the design intent shown on the plans.
2. Each sign location is required to be field checked.
3. Locate the station or mile designation indicated on the plans.
4. Verify that the location is acceptable for the visibility of the driver on the main line pavement and does not block the view of any driver on the approaches. Discuss possible adjustment of the sign, if needed with PEMS.

INSTALLATION OF SIGNS

The requirements for the installation of sheet signs and panel signs are as required by Section **802**. Standard Drawings **802-SNGP-01** through **16** provide the requirements for sign placement. Standard Drawings **802-SNGS-01** through **13** provide the requirements for route marker details, reflectorization, post selection, and sign identification. Consider the following at installation:

1. The contractor is responsible for Construction Engineering to locate each sign as shown on the plans which are then typically painted, with utility location requested in the area.

2. Inspect the planned locations marked by the contractor to ensure the layout meets the requirements of the plans and specifications. Notify the PEMS of any conflicts with utilities or any errors in layout that would cause the sign to encroach on any minimum horizontal or vertical clearance requirements as shown on the Standard Drawings.
3. Refer to the sheet sign's working drawing for hole punching details, accompanying the plans for channel post spacing, and for the panel sign size. Support spacing is dependent on the number of posts being installed and the sign width, as follows:
    a. 2 posts: spaced at points ⅕ and ⅘ the width of the panel
    b. 3 posts: spaced at points $^{3}/_{20}$, ½, and $^{17}/_{20}$ the width of the panel
    c. 4 posts: spaced at points ⅛, ⅜, ⅝, and ⅞ the width of the panel

    See ***Figure 2-2*** Post Spacing (**E 802-SNGP-02**) for more detail.
4. For square and U-channel posts:

    Length of Sign Support = (Embedment Length) + (Sign Clearance above Edge of Pavement) + (Height of Sign from the Working Drawings) ± (Vertical Distance Between Edge of Pavement and Ground Level Of Sign Support). See Standard Drawing **802-SNGS-08 and 09.**
5. For structural steel posts:

    Length of Sign Support = (Sign Clearance above The Ground) + (Height of Sign from The Working Drawings) + (Break-away Stub Length below the Ground) ± (Vertical Distance between Edge of Pavement and Ground Level of Sign Support.

In case of the main sign with Exit number panel on the top - add height of the Exit number panel in total length of the last post. See Standard Drawing **802-SNGP-02** (***Figure 2-2***).

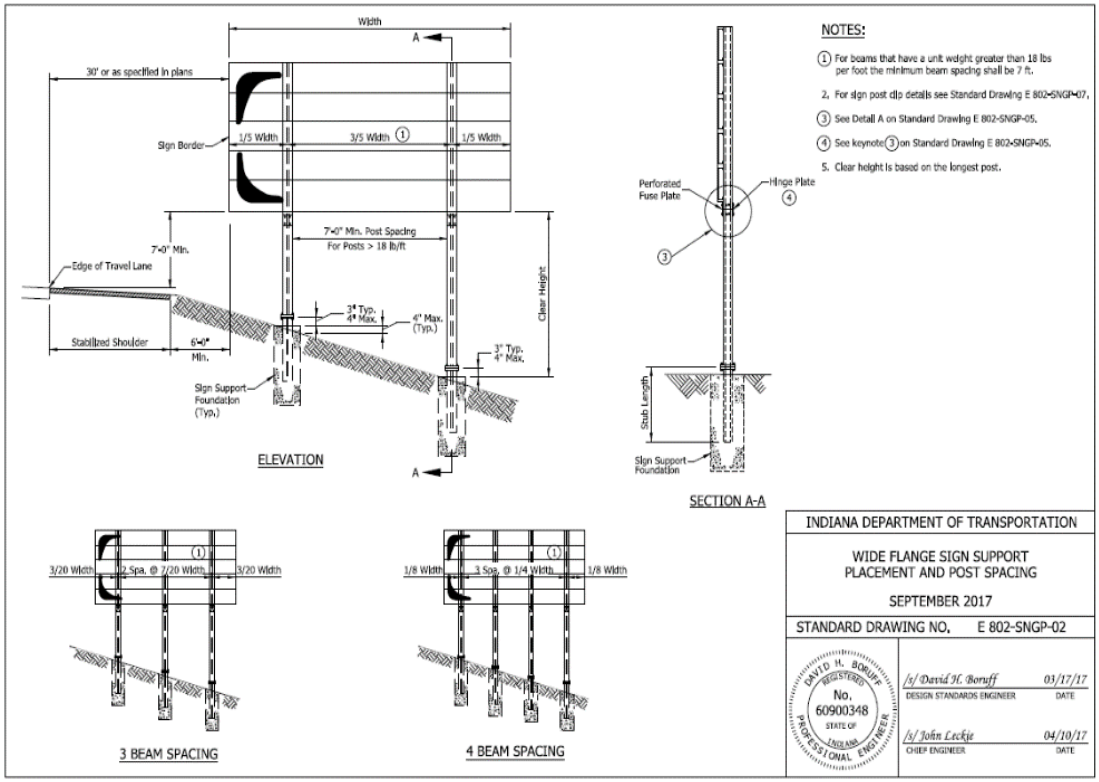


Figure 2-2 Post Spacing (E 802-SNGP-02)

REMOVAL, RESETTING, OR RELOCATION

The requirements for removal, resetting, or relocating of signs or support assemblies are provided in Section **802**. Signs to be relocated are to be installed in accordance with the MUTCD and on new posts. Signs to be reset shall be installed in accordance with the MUTCD and on existing posts.

Signs or support assemblies that are to be removed should be done so within five workdays after the required replacement signs or support assemblies are installed. Concrete foundations are to be removed to a minimum depth of 1 ft below the ground surface.

CONSTRUCTION INSPECTION DUTIES

After all utilities have been located, the Contractor stakes the locations of the sign supports. The contract personnel are given no less than two days' notice in advance of any staking of inspection required. All signs are placed at the proper elevation above the edge of pavement and at the proper offset, leveled, and oriented correctly.

INSTALLATION OF CHANNEL POSTS

When inspecting the installation of channel posts the following items are required to be considered:

1. The Basis For Approval for steel flanged channel posts is to be in accordance with the Frequency Manual.
2. All posts are required to meet utility clearance requirements.
3. No portion of a sign may overhang the R/W line.
4. Posts are not driven in a ditch line.
5. Posts are driven to the depth indicated on the sign detail sheets.
6. Posts are installed plumb.
7. Back-to-back posts are bolted together and driven simultaneously.
8. For a two-post installation, the second post is leveled to the 1" holes of the first post driven in order for the sign to be placed level.
9. Any post bent, damaged, or unfit for use in the finished work is removed from the site and replaced with an acceptable post with no additional payment.

INSTALLATION OF SHEET SIGNS

When inspecting the installation of sheet signs (***Figure 2-3),*** consider the following items:

1. Basis For Approval for traffic signs is in accordance with the Frequency Manual.
2. Sheet signs installed level on the channel posts.

Figure 2-3 Sheet Sign on Channel Posts

REFLECTIVE SHEETING

The reflective sheeting must be selected from the QPL of Reflective Sheeting. Fluorescent yellow sheeting must be used for the background color on warning signs. Sheet signs are fastened to the channel posts as follows:

1. Place a plastic washer against the sign face with a metal washer.

2. Insert a bolt through the metal washer against the plastic washer, the sign face, the post, the lock washer, and the nut.
3. After the bolts have been hand tightened snug, the bolt head is held by a wrench to prevent any movement of the washer or bolt head while the nut is being tightened.
4. Do not over tighten the nut to prevent twisting of the sign sheeting or denting of the sign metal. Refer to Standard Drawings **802-SNGS-01** and **06** for further details.

INSTALLATION OF CONCRETE FOUNDATIONS

When inspecting the installation of the foundation(s) for a signpost, the following items are required to be considered:

1. The Basis for Approval for the signpost, anchor bolts, concrete, and reinforcing steel is in accordance with the Frequency Manual.
2. Foundation excavation is completed to the levels and dimensions shown on the plans.
3. Foundation Types are determined by the post size in accordance with Standard Drawing **802-SNGP-16**. The foundation diameter and depth will vary depending on whether a Type A, B, or C foundation is required.
4. Concrete to be utilized in foundations will be in accordance with Section **702.**
5. Reinforcing steel is placed as set out in the plans and standard drawings. The proper sizing of bars, correct numbers and spacing of bars, and proper bar cover are checked.
6. The concrete is consolidated using a vibrator adequate for the size of the pour.

INSTALLATION OF STRUCTURAL STEEL POSTS

The W-beam structural steel supports for ground mounted panel signs are designed to meet the 2015 AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. As detailed in the Specification and Standard Drawings they are also compliant with FHWA's eligibility requirements for roadside hardware. Proper installation is necessary for supports to withstand the design wind loadings and to breakaway during impact from a vehicle in such a manner that vehicle occupants have a significantly reduced chance of being seriously injured or killed. Particular attention should be paid to the following:

1. There should be no perceivable gap between the upper and middle beam sections at the fuse/hinge plate – the allowable tolerance for this fit is 0" to 1/16". The fuse plate/hinge plate attachment hardware should be fully tightened to the specification requirements. Excessive gaps and loose hardware results in premature fatigue in the fuse plates which can result in structural failures. The fuse plates are intentionally weakened via the perforated holes - this feature facilitates breakaway performance during impact. Refer to Standard Drawing **E 802-SNGP-05** for fuse plate details.
2. The perforated fuse plate must be installed on the front (traffic approach) side of the sign and the hinge plate on the back side for the supports. Refer to Standard Drawing **E 802-SNGP-05** for plate connection details.
3. The hardware at the base plate must be properly tightened within the range provided in the specification. The specified torque values are sufficient so that the structure should not "walk-off" the base and foundation but not so great as to prevent the breakaway slip mechanism from engaging when the structure is impacted.
4. The beams must extend through the entire height of the sign; for signs with an exit panel at least one of the beams must extend to the top of the sign. Refer to Standard

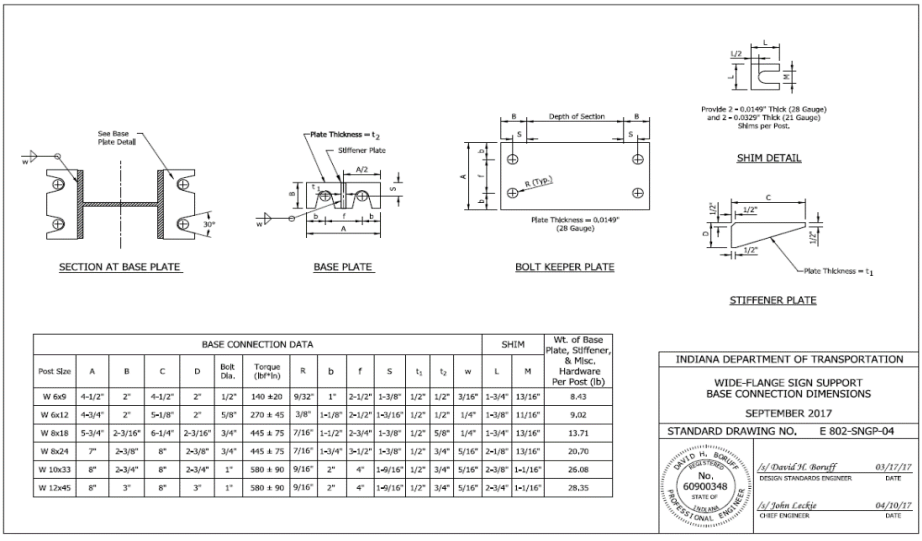
Drawing **E 802-SNGP-02** for beam placement. Properly installed sign clips allow an even distribution of the forces transmitted from the sign to the beams improving the service life of the structure. See Section **802** and the Standard Drawings.

In addition, when inspecting the installation of W-beam structural steel posts, consider:

1. The Basis For Approval for structural steel is per the Frequency Manual.
2. The foundation excavation is required to be completed to levels and dimensions as indicated in the plans.
3. In location where class X excavation is encountered, the PEMS will be notified in accordance with Section **206**.
4. Concrete utilized in the foundation will be in accordance with Section **702**. Anchor bolt alignment shall be maintained, and threads protected during concrete placement
5. Concrete is finished flush with the final grade, with maximum 4" exposure if on an embankment. Exposed concrete shall have a smooth surface and beveled edges.
6. The breakaway wide flange stubs (***Figure 2-4***) are placed plumb and to the proper height above the finished grade as shown on Standard Drawing **802-SNGP- 02**. A maximum of 4" is critical for the proper breakaway. If the top of the breakaway stub is level, the upper posts do not need shimming.

Figure 2-4 Structural Steel Post on a Breakaway Stud

7. The breakaway stubs are installed prior to ordering the posts. This means that the final length of the breakaway posts is based upon using the difference in elevation between the edge of pavement and the top of the breakaway stub.
8. In case of the main sign with Exit number panel on the top – add height of the Exit number panel in total length of the last post.
9. The breakaway posts are assembled, and anchor bolts torqued to the design specifications shown on Standard Drawing **802-SNGP-04** (***Figure 2-5***).



BASE CONNECTION DATA													SHIM		Wt. of Base Plate, Stiffener, & Misc. Hardware Per Post (lb)
Post Size	A	B	C	D	Bolt Dia.	Torque (lbf*in)	R	b	f	S	t_1	t_2	w	L	M	
W 6x9	4-1/2"	2"	4-1/2"	2"	1/2"	140 ±20	9/32"	1"	2-1/2"	1-3/8"	1/2"	1/2"	3/16"	1-3/4"	13/16"	8.43
W 6x12	4-3/4"	2"	5-1/8"	2"	5/8"	270 ± 45	3/8"	1-1/8"	2-1/2"	1-3/16"	1/2"	1/2"	1/4"	1-3/8"	11/16"	9.02
W 8x18	5-3/4"	2-3/16"	6-1/4"	2-3/16"	3/4"	445 ± 75	7/16"	1-1/2"	2-3/4"	1-3/8"	1/2"	5/8"	1/4"	1-3/4"	13/16"	13.71
W 8x24	7"	2-3/8"	8"	2-3/8"	3/4"	445 ± 75	7/16"	1-3/4"	3-1/2"	1-3/8"	1/2"	3/4"	5/16"	2-1/8"	13/16"	20.70
W 10x33	8"	2-3/4"	8"	2-3/4"	1"	580 ± 90	9/16"	2"	4"	1-9/16"	1/2"	3/4"	5/16"	2-3/8"	1-1/16"	26.08
W 12x45	8"	3"	8"	3"	1"	580 ± 90	9/16"	2"	4"	1-9/16"	1/2"	3/4"	5/16"	2-3/4"	1-1/16"	28.35

INDIANA DEPARTMENT OF TRANSPORTATION

WIDE-FLANGE SIGN SUPPORT
BASE CONNECTION DIMENSIONS

SEPTEMBER 2017

STANDARD DRAWING NO. E 802-SNGP-04

DAVID H. BORUFF REGISTERED No. 60900348 STATE OF INDIANA PROFESSIONAL ENGINEER

/s/ David H. Boruff 03/17/17
DESIGN STANDARDS ENGINEER DATE

/s/ John Leckie 04/10/17
CHIEF ENGINEER DATE

Figure 2-5 Wide-Flange Sign Support Base Connection Dimensions (E 802-SNGP-04)

10. The breakaway posts are installed plumb using the proper bolts, washers, and nuts, and in proper sequence as indicated on Standard Drawing **802-SNGP-03** (***Figure 2-6***).
11. The perforated fuse plate and hinge plates are required to be detailed and installed in accordance with **802-SNGP-05** (***Figure 2-7***).

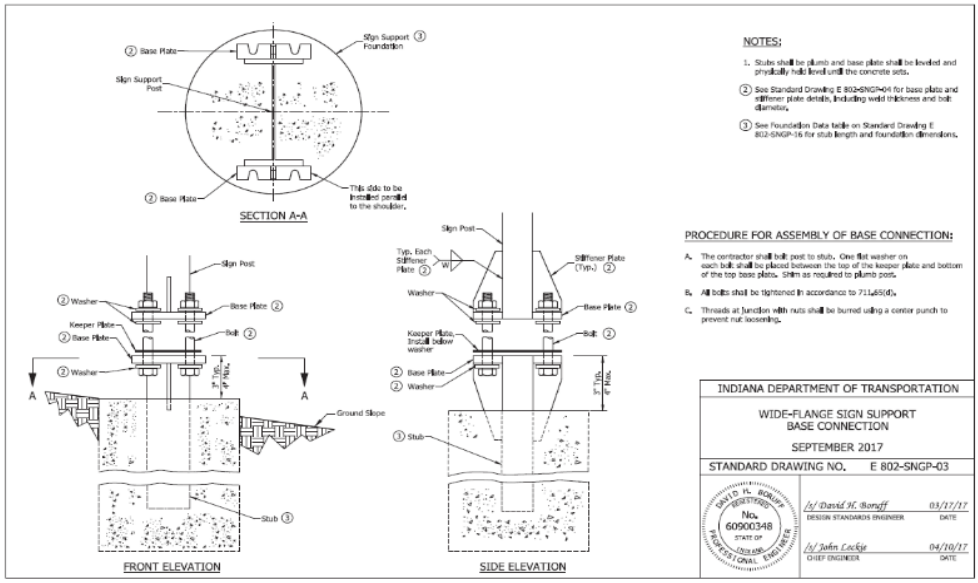
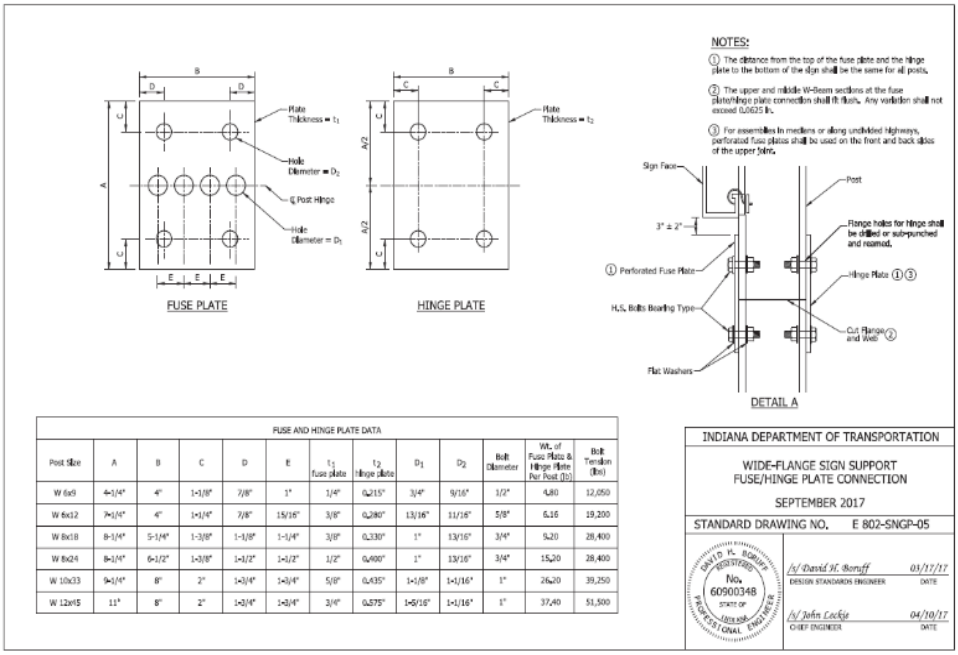


Figure 2-7 Wide-Flange Sign Support Base Connection (E 802-SNGP-03)



Post Size	A	B	C	D	E	t_1 fuse plate	t_2 hinge plate	D_1	D_2	Bolt Diameter	Wt. of Fuse Plate & Hinge Plate Per Post (lb)	Bolt Tension (lbs)
W 6x9	4-1/4"	4"	1-1/8"	7/8"	1"	1/4"	0.215"	3/4"	9/16"	1/2"	4.80	12,050
W 6x12	7-1/4"	4"	1-1/4"	7/8"	15/16"	3/8"	0.280"	13/16"	11/16"	5/8"	6.16	19,200
W 8x18	8-1/4"	5-1/4"	1-3/8"	1-1/8"	1-1/4"	3/8"	0.330"	1"	13/16"	3/4"	9.20	28,400
W 8x24	8-1/4"	6-1/2"	1-3/8"	1-1/2"	1-1/2"	1/2"	0.400"	1"	13/16"	3/4"	15.20	28,400
W 10x33	9-1/4"	8"	2"	1-3/4"	1-3/4"	5/8"	0.435"	1-1/8"	1-1/16"	1"	26.20	39,250
W 12x45	11"	8"	2"	1-3/4"	1-3/4"	3/4"	0.575"	1-5/16"	1-1/16"	1"	37.40	51,500

Figure 2-6 Wide-Flange Sign Support Fuse/Hinge Plate Connection (E 802 SNGP-05)

INSTALLATION OF PANEL SIGNS

When inspecting the installation of panel signs (***Figure 2-8)***, the following items are required to be considered:

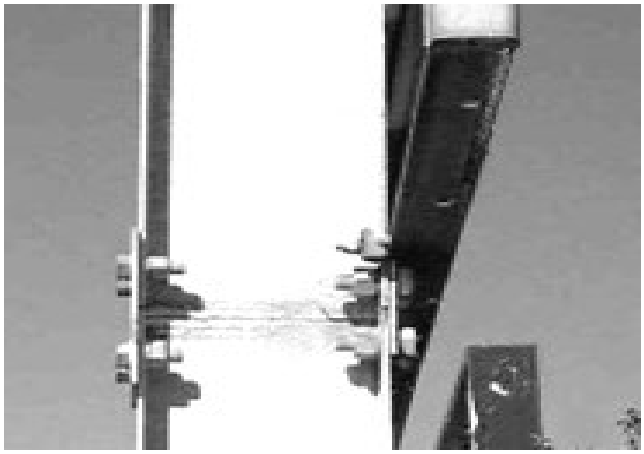


Figure 2-8 Panel Sign on Structural Steel Post

1. The Basis For Approval for panel signs is in accordance with the Frequency Manual.
2. Panel signs are installed level on the wide flange posts and are placed at 3" ± 2" above the fuse plate as indicated in ***Figure 2-7*.**
3. For 2 post installations, the supports are at ⅕ and ⅘ points; for 3 posts installations, the supports are at the ³⁄₂₀ point with 2 spaces at ⁷⁄₂₀ points; and for 4 post installations, the supports are at the ⅛ point with 3 spaces at ¼ points.
4. Signs are marked and are required to correspond with the centers of the wide flange posts. See Standard Drawing **802-SNGP-02** for details.
5. Panel sign clips are attached to each sign support. The top and bottom of the panel sign are clipped to both sides of the wide flange post. The intermediate clips are staggered on either side of the wide flange post. For signs equal or greater than 24' width, clips are required on both sides of all posts. See Standard Drawing **802-SNGP-06** in ***Figure 2-9***.

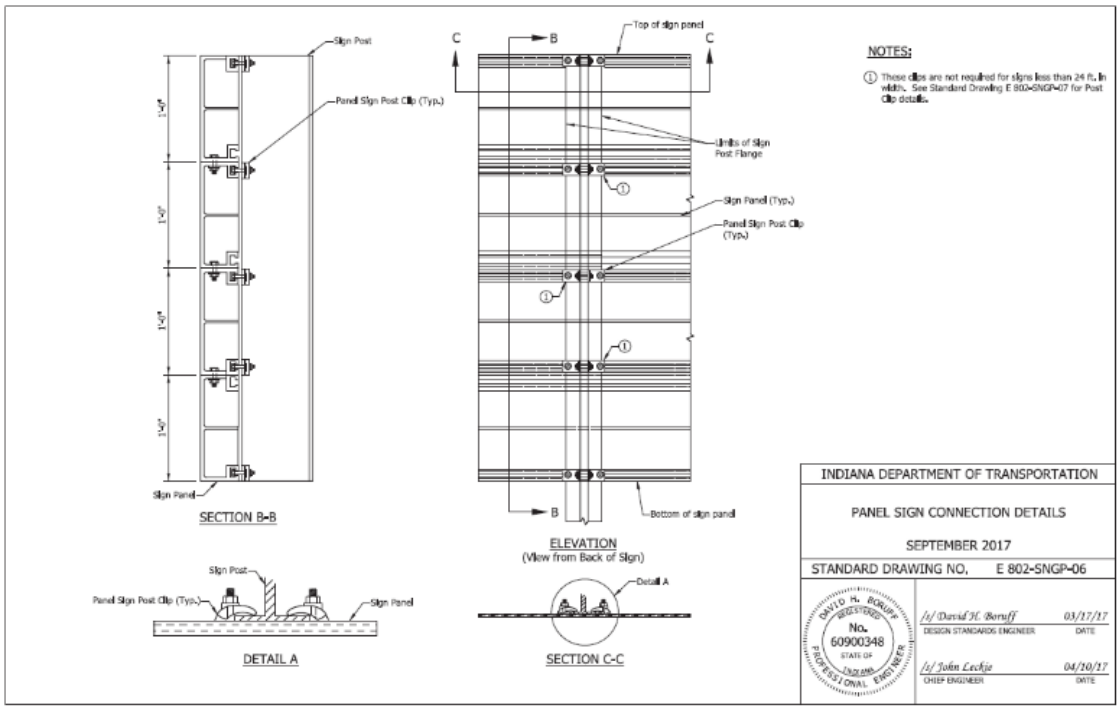


Figure 2-9 Panel Sign Connection Details (E 802-SNGP-06)

MEASUREMENT AND PAYMENT

Proper measurement and documentation of the installed ground mounted sign and support is essential for maintaining the progressive estimate, paying the Contractor, filling out the material records, and completing the final construction record.

Ground mounted sign structures and related items are measured and paid for as follows:

1. Sheet signs and panel signs will be measured and paid for by the square foot for the type and thickness specified. If the pay unit for sheet signs is shown in the Schedule of Pay Items as each, the number of sheet signs specified, including posts, hardware, and erection, will be measured by the number of units installed.
2. Signposts will be measured and paid for by the linear foot. Square signposts will be measured from the top of the post to the termination of the post in the anchor base.
3. Traffic sign support foundations will be measured and paid for by the number of units of each type installed.
4. If class X material is encountered during the foundation excavation, the quantity to be measured and paid for will be that authorized and removed and in accordance with Section **206.**
5. Structural steel, breakaway, will be measured and paid for by the pound. Such measurement will include the weight of breakaway sections such as stiffeners, base plates, and fuse plates.
6. Reference posts, including post, sign, and hardware, will be measured and paid by the number of units installed.
7. Existing ground mounted signs reset will be measured and paid by the number of signs removed and reinstalled.

CHAPTER THREE: *OVERHEAD SIGN STRUCTURES*

Overhead sign structures (***Figure 3-1***) support signs over the traveled roadway. The work requires furnishing and erecting of overhead sign structures, walkways, and sign lighting according to the Specifications and the contract plans. In this chapter the installation of overhead sign structures includes the pre-construction, construction inspection, and measurement and payment duties. Review the following sources:

Figure 3-1 Overhead Sign Structure

1. Sections **702**, **802**, **803** and **910.**
2. Standard Sheets **802-DBCS-01 to 16, 802-SBTS-01** to **41, 802-SCLS-01** to **22**, **802-SCSB-01** to **09**, **802-TCSS-01 t**o **15, 802-SNBB-01** to **05**, and **802-SNCS-01** to **03.**

PRE-CONSTRUCTION DUTIES

Overhead sign structures require much tighter horizontal and vertical tolerances than ground mounted signs. The Technician is required to become familiar with both the plan and quantity sheets before any work is started on the contract and preferably before the pre-construction conference. The following items are required to be considered:

1. Prior to the fabrication of an overhead sign structure, shop drawings and calculations are submitted by the Contractor's supplier to the INDOT PEMS which are forwarded to the INDOT Office of Traffic Design Manager .
2. The Contractor is responsible for checking the roadway cross sections and structure dimensions prior to the preparation of the shop drawings. If any discrepancies are found, the INDOT PEMS is required to be notified prior to the preparation of the shop drawings.
3. Overhead sign structures are staked by the construction engineering sub-Contractor. The overhead sign structure is required to comply with the following requirements:
    a. The sign structure is required to be perpendicular to the centerline of the pavement. A total station is used to set the alignment stakes.
    b. The outline of the foundation of the sign structure is staked per the plans.
    c. All utility clearances requirements are required to be observed. Since there is little or no tolerance in the location of an overhead sign structure, utility relocation may be necessary.
    d. Any possible drainage structure and highway lighting circuit conflicts are required to be checked.

4. The length of the upright(s) is determined. The calculations for truss, monotube, and cantilever sign structures are all unique, but the following criteria apply to all:
    a. The requirements for a sign box truss structure spread foundation in the median or on the shoulder are shown on Standard Drawing **802-SBTS-24.**
    b. The minimum required vertical clearance indicated on the plan detail sheets is used, which is typically 17' 6" minimum.

CONSTRUCTION FOUNDATION INSPECTION DUTIES

The Contractor may not begin any work on the sign structure foundation until:

1. Approved sign structure shop drawings are received by the PEMS.
2. Approved panel and sheet sign shop drawings are received by the PEMS.
3. All relocation work has been complete.

CONCRETE FOUNDATIONS

When inspecting the installation of the foundation(s) for an overhead structure, the following items are required to be considered:

1. The Basis for Approval for the overhead sign structure, anchor bolts, concrete, and reinforcing steel is in accordance with the Frequency Manual.
2. The foundation excavation is completed to the levels and dimensions per the plans.
3. If bed rock or boulders are encountered during excavation, they are removed to the depth indicated on the plans.
4. Concrete to be utilized in foundations will be in accordance with Section **702.**
5. Reinforcing steel is placed as set out in the plans and standard drawings. The proper sizing of bars, correct numbers and spacing of bars, and proper bar cover are checked.
6. For cantilever sign structure foundations, a tremie is used until the concrete is within 5 ft of the top of the foundation.
7. The concrete is consolidated using a vibrator adequate for the size of the pour.
8. Foundations incorporated into sections of concrete barrier wall receive a finish in accordance with Section **702.**

STRUCTURE ERECTION

The Contractor is responsible for handling the overhead sign structure carefully during loading, shipment, unloading, and erection to avoid damage to any member of the structure. When erection of the structure has been started, it will be completed the same day. The structure will be loaded, to prevent vibration, by attaching signs or lighting supports the same day. The Technician is required to consider the following items:

1. The Basis for Approval for overhead sign structures and the signs is a Type C Certification and a Buy America Certification.
2. The structure is inspected before unloading, during all operations, and until the structure erection is complete. Any damage detected is required to be repaired before final acceptance.
3. Field welding is not allowed per Section **802.**
4. For sign trusses or monotubes, the required camber is in accordance with Section **802.**

5. Gaps in the flange connections not exceeding ⅛" are shimmed before tightening the flange bolts.
6. Fasteners for chord splice connections will be high strength heavy hex bolts conforming to ASTM F3125, grade A325 with matching lock nuts having steel inserts.
7. Anchor bolts will be tightened in accordance with the steps noted in Section **802.**
8. Sign, walkway, handrail, and lighting support brackets are generally installed on the ground in accordance with the approved sign structure shop drawings before the structure is lifted in place.
9. For bridge brackets, before placing aluminum in contact with concrete, both the concrete and aluminum surfaces shall be coated with an aluminum-impregnated caulking compound. Where aluminum surfaces are to be placed in contact with steel, the steel surface shall be given one coat of zinc chromate and the aluminum surfaces shall be coated with an aluminum-impregnated caulking compound before placement.
10. Damage that is detrimental to the structural integrity of the frame or aesthetic appearance must be repaired.
11. Traffic must be maintained during erection in accordance with Section **801.**

SIGN INSTALLATION

When inspecting the installation of sign, walkway, handrail, and lighting support brackets the Technician is required to consider the following items:

1. The same support bracket may support the sign, the walkway, the handrail, and the lighting assembly.
2. Additional supports are added if any of the following conditions is not met:
    a. For sign widths greater than 30", a minimum of two sign supports are required.
    b. For sign heights of 7 ft or less, the maximum sign support spacing is 7 ft, and the maximum sign overhang beyond the sign support is 2.5 ft.
    c. For sign heights greater than 7 ft, the maximum sign supports spacing is 5 ft, and the maximum sign overhang beyond the sign support will be 2.5 ft.
    d. The maximum spacing of walkway support brackets is 7 ft, and the maximum walkway overhang beyond the walkway support brackets is 1 ft.
3. All signs must be marked for identification as shown on the plans. The marking consists of a type II sheeting material, with a class I adhesive, shown on the QPL of Reflective Sheeting. It shall be applied to the back of the sign on the lower corner closest to the nearest edge of pavement and shall not be covered by the sign's supports (***Figure 3-2***).
4. For panel signs up to 24 ft of width, panel sign clips are attached to each sign support required to support the panel sign. The top and bottom of the panel sign is clipped to both sides of the sign support bracket. The intermediate clips are placed one on each panel at each post and are staggered on either side of the sign support bracket. See Standard Drawing **802-SNGP-06** for details.

Figure 3-2 Overhead Sign Structure Identification Numbers

5. For panel signs over 24 ft of sign width, double clips shall be used, one on the right side and one on the left side on each post per panel width, plus the sets necessary to attach the top and bottom of the sign.

During the erection of the overhead sign structure, traffic is required to be safely controlled in accordance with Section **801**.

TRAFFIC CONTROL

Traffic is required to be maintained in accordance with Section **801** and the Indiana MUTCD during installation of signs, walkways, railings, and support brackets.

MEASUREMENT AND PAYMENT

Overhead sign structures and related items are measured and paid for as follows:

1. Sheet signs and panel signs will be measured and paid for by the square foot for the type and thickness specified. If the pay unit for sheet signs is shown in the Schedule of Pay Items as each, the number of sheet signs specified, including posts, hardware, and erection, will be measured by the number of units installed.
2. Signposts will be measured and paid for by the linear foot. Square signposts will be measured from the top of the post to the termination of the post in the anchor base.
3. Traffic sign support foundations will be measured and paid for by the number of units of each type installed.
4. If class X material is encountered during the foundation excavation, the quantity to be measured and paid for will be that authorized and removed and in accordance with Section **206.**
5. Structural steel, breakaway, will be measured and paid for by the pound. Such measurement will include the weight of breakaway sections such as stiffeners, base plates, and fuse plates.
6. Overhead sign structures will be measured and paid for by the number of units of each type installed.
7. Overhead sign structures to be removed will be measured and paid for by the number of structures removed.

CHAPTER FOUR: *HIGHWAY LIGHTING*

Highway lighting consists of installing wire, cable, conduit, light poles, luminaires, lamps, and incidental materials in accordance with the Specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans, or as directed. Lighting installations are required to be in accordance with the National Electrical Code and the National Safety Code, and local and State codes.

Existing highway illumination is maintained on all contracts unless discontinuance of the highway illumination is specifically permitted.

Manufacturers' descriptive and technical literature for major items is required to be submitted for approval. Where it is normal trade practice to furnish a warranty, a warranty may be furnished on major items such as: luminaires, lamps, poles, brackets, cable-duct, wire and cable, fuse connectors, and major equipment. The effective date of the warranty commences on the date of final acceptance. These items are required to bear the seal of approval of the Underwriters Laboratory. See Section **807** for warranty requirements.

All flexible conduit is required to be galvanized steel, polyvinyl jacketed, and watertight.

Reinforcing steel is required to be epoxy coated.

CONSTRUCTION REQUIREMENTS

EXCAVATION

All excavation for the roadway lighting installation is conducted in accordance with the dimensions, elevations, and grades shown on the plans, or as directed. If class X material is encountered, foundation excavation is completed in accordance with Section **206**.

TRENCH EXCAVATION

Excavation may be done either manually or with mechanical trenching equipment. The depth of trenches is required to be a minimum of 2 ft. Walls of trenches for cable-duct or conduit are essentially vertical, while the bottoms should be smooth and free from aggregate larger than ½". Bracing, shoring, and sheathing are provided as necessary. If the excavation is below the required level, the excess excavated area is refilled in a satisfactory manner with no additional payment. The accumulation of water in excavated areas is prevented by the use of pumps or other approved means. When rocks or other materials which might damage the cable- duct or conduit are encountered, the excavation is extended to a depth of at least 27" and backfilled with a 3" compacted layer of sand or earth containing no particles that are retained on a ¼" sieve. No extra payment is made for additional excavation or backfill.

FOUNDATION EXCAVATION

If possible, excavation for concrete foundations is done by means of drilling with an auger of sufficient size to admit the width of the foundation. Work is scheduled so that all open excavations are poured with concrete during the workday they are dug. No excavations may

remain open over night or over a weekend or holiday. Accumulated water is removed from the excavation before concrete is poured. If class X material is encountered, foundation excavation is completed in accordance with Section **206**.

LANDSCAPE REPLACEMENT

Where roadside shrub plantings interfere with the location of illumination installations, the plantings are reset at other locations and at such times as directed in accordance with Section **622**. The cost of this work is not paid for directly but is included in the costs of other pay items.

All slopes for foundation grading are required to be sodded. Sod is placed in accordance with Section **621**.

BACKFILLING

Wherever practicable, all suitable materials removed from the excavated areas are used in refilling cable-duct and conduit trenches. No excavated material is wasted without authorization. Materials authorized to be wasted are disposed of as approved. Backfill for trenches is placed in layers not to exceed 6" by loose measurement. The first layer is sand or earth containing no particles or lumps that would be retained on a ¼" sieve. The second layer contains no particles or lumps that would be retained on a 1" sieve. Subsequent layers may contain no particles or lumps that would be retained on a 3" sieve. The second layer and each subsequent layer is compacted with pneumatic hand tamps to the satisfaction of the PEMS to prevent any future settlement of the backfilled area. Backfilling of cable-duct and conduit trenches around lighting standard foundations, handholes, manholes, and other structures is required to be in accordance with the applicable provisions of Section **211**. Finish grading of earthwork is accomplished in a satisfactory manner.

PLACING CONDUIT

Conduit is placed as shown on the plans and per the applicable provisions of Section **805**. Conduit is required to be large enough to readily permit the passing of the cable being used.

Conduit installed under pavement is extended a minimum of 2 ft beyond the edge of the paved surface or improved shoulder. The ends of such conduit terminate a nominal 2 ft below the ground surface. The ends are pitched so as to provide a positive drain to the surrounding soil. The ends are protected by threaded cap fittings until the time of installation of cable or cable-duct. Threaded bushing fittings are used on all ends before cable installation.

Conduits installed in bridge railing concrete sections terminate a minimum of 2 ft beyond the end of the bridge railing outside of the paved surface and a minimum of 2 ft under the ground surface. Existing conduit is extended as necessary to satisfy these requirements.

Conduit for service supply is mounted on a service pole, either company or INDOT owned, near the right-of-way line. For simple supply circuits, one straight, continuous, conduit riser is used. The top end terminates with a weatherhead device, and the lower end terminates at least 2 ft below ground level with a threaded grounding bushing fitting. Unless otherwise directed, the weatherhead is 24 ft above the ground. However, the actual elevation of the weatherhead is required to meet the requirements of the utility concerned.

CONNECTIONS IN BASE OF LIGHT POLE

Conductors are required to be electrically bonded to each other, as required to satisfy circuit requirements, by means of compression type fittings of the style and type shown on the plans. Inhibitor compound is used on each compression connection. Conductor identification is maintained by connecting like color connectors.

A multiple conductor compression fitting is used to connect supply conductors, and an insulating link is used to provide an extension as shown on the plans. These fittings are covered with snap-on fiber or plastic covers designed to protect them from electrical contact. Taping is not permitted. The bare extension of the supply conductor from the multiple fitting to the insulation link is no longer than necessary to admit the application of the snap-on cover for the multiple fitting.

The pole circuits are connected by means of easily separated, single conductor connector kits. The connector kit on the "hot" side of the pole circuit is fused, while the neutral side is not fused. *KTK* series fuses with a rated capacity three times the operating amperage of the luminaire are used. If the required capacity is not a standard size, the next size fuse is used.

The connector kit on the hot side of the pole circuit is required to have the following features:

1. A line side and load side housing made of plastic or water resisting synthetic rubber suitable for direct burial in the ground or installation in sunlight.
2. A water seal between the two housings .
3. Each housing permanently marked "Line Side" or "Load Side".
4. A spring loaded, 90% minimum conductivity contact suitable for gripping the "KTK-10" cartridge fuse in each housing. These contacts are required to be fully annealed.
5. An interior arrangement for each housing that adequately receives and rigidly maintains the fuse contacts.
6. A terminal on each housing designed for a crimp type connection to the conductor that securely retains the conductor in the proper position.
7. A water seal between the conductor and the housing.
8. A disconnecting means that retains the fuse on the load side when disconnected and keeps the conductive parts of the line side inaccessible.
9. Sufficient silicone compound provided and used to lubricate the metal parts and the rubber housings or boots for easy assembly.

The neutral side connector kit is similar in all respects to that described for the hot side except that a dummy fuse is used for the purpose of completing the electrical circuit. The bayonet disconnect feature of the connector kits is part of the load side of both the neutral side and the hot side conductors. The line side has a socket to receive the bayonet. These kits are installed in the pole circuit between the luminaire terminals and the compression connection to the underground distribution circuit as shown on the plans. A separate insulated conductor is used to connect the neutrals from the underground distribution circuit and from the pole circuit to the ground lug in the pole base from the point at which both neutrals are connected together by a compression connection. The bayonet disconnect features from the neutral side and the hot side connector kits are included in the sign structure circuitry when luminaires are installed on the sign structures. Sign luminaires on both individual structures and consecutive structures

are alternately connected to opposite load conductors R or B as specified in the plans to balance the load.

PLACING WIRE AND CABLE

All wire and cable shall be installed in accordance with Section **807.**

UNDERGROUND

All underground distribution conductors must be continuous runs between splice points. Unless otherwise authorized, splice points are inside the bases of light poles, inside handholes, in service distribution boxes, at points of connection to power supply in switch boxes, or in junction boxes. All splices are made with the proper connector per Section **807**.

UNDERGROUND THROUGH CABLE-DUCT IN TRENCH

Cable-duct is placed either in a trench or plowed into place. Cable-duct is installed without sharp bends or kinks and in straight runs to permit withdrawal of a conductor and the installation of a new conductor without additional excavation or backfill.

Plowed cable-duct is installed at a minimum depth of 2 ft in a single cavity gored into the earth by a vibrating plow blade. The equipment used for plowing the cable-duct is designed specifically for that purpose with the power and versatility to easily and accurately bury the various sizes of cable-duct under all normal soil conditions. This equipment places the cable-duct without twisting, kinking, or damaging the material in any way. Dragging or pulling the cable-duct from the start of the trenching operation is not permitted. Where two ducts are to be installed in parallel, the distance between is required to be between 12" and 24".

The plastic duct of the conduit is terminated 4" above the top of foundations or 4" inside handholes with sufficient excess conductors as directed. All terminations of this plastic duct are beveled and free from any sharp edges or burrs. Insulation of the electrical conductor may not be damaged when cutting the duct.

UNDERGROUND THROUGH CABLE-DUCT IN CONDUIT

The underground distribution circuit is protected by galvanized steel conduit when installed under pavement, in road shoulders, or elsewhere as shown on the plans, or as directed.

Cable-duct is pulled through the entire length of galvanized steel conduit if at all possible. If this is not possible, written authorization is obtained to permit the duct to be cut away and the conductors installed in the conduit with a minimum of 2 ft of duct extended into the conduit. Where so authorized, the plastic duct is terminated in the proper transition fitting attached to the end of the conduit and each conductor of the cable-duct assembly continues undamaged and uninterrupted through the galvanized steel conduit to the other end of the conduit. A transition to the cable-duct is used again and the cable-duct is continued uninterrupted to the next designated splice point. All transitions from galvanized steel conduit to cable-duct are done with the proper adapter. This adapter provides a durable, watertight transition that has a smooth uniform interior.

CABLE MARKERS

The location of underground conduits or is marked with cable markers. The marker is placed at all changes in direction, where the underground distribution circuit is split, and at a maximum of 400 ft intervals on straight runs. Cable markers are a slab of concrete 2 ft square by 4" thick. The word "Cable" is impressed into the surface of the marker a minimum depth of ⅜" with letters a minimum of 2" high. Arrows showing the direction of the cable are die impressed or saw cut a minimum depth of ⅜" into the marker surface.

Curing of the concrete is required to be in accordance with Section **702**. The cable marker is required to have a smooth metal trowel finish without scaling.

IN CONDUIT RISERS

Cable-duct enters the bottom of the conduit riser with a sweeping radius bend and continues up the riser to within 3" of the top of the conduit riser. At this point the plastic duct is terminated, and the conductors continue uninterrupted and undamaged into the service cabinet, underpass switchbox, or through the weatherhead with sufficient excess to make the required connections.

THROUGH CONDUIT IN BRIDGE COPING

Where a cable-duct underground distribution circuit is run through conduit installed in bridge coping, the duct is cut away and the conductors are installed in the conduit with at least 2 ft of duct extended into the conduit. The conductors, through this transition, are continuous between authorized splice points. Where more than one lighting standard is to be installed on the same side of the bridge structure and connected to the same distribution circuit, the cables pulled between these light poles is of the same type and size used in the cable-duct underground distribution circuit.

FOR AERIAL CABLE

Aerial cable for overhead distribution circuits is supported and terminated as shown on the plans. The aerial cable may have sag of no more than 5 % of the distance between lighting poles except where slack spans are indicated on the plans. Aerial cables are required to have a minimum vertical clearance of 18 ft.

LIGHTING HANDHOLES

Handholes are not placed in areas subject to flowing or ponding water and are installed with the top flush with adjoining surfaces. Precast handholes with integral bottoms are considered acceptable.

Multiple compression fittings and insulating links installed in handholes are taped and waterproofed by application of an approved waterproofing device. The insulation around the area to be waterproofed is required to be cleaned before applying the waterproofing device. These waterproofing devices are designed for insulating multi-conductor cables with a minimum voltage carrying capacity of 600 volts.

Handholes of an alternate material are allowed as a substitute for street and alley handholes providing they fulfill Section **922** requirements and locationally meet the following criteria:

1. There is no evidence of vehicles traveling over the area the handhole is to be located.
2. The handhole is located a minimum of 15 ft from the edge of pavement, unless protected by guardrail, non-mountable curb, a structure, or a non-traversable ditch.

The handhole is backfilled with sand or earth containing no particles that would be retained on a ¼" sieve. The backfill is placed as shown on the detail sheet of the plans. No additional payment is allowed for this backfill.

CONCRETE FOUNDATIONS FOR LIGHT POLES

Foundations are required to be class A concrete in accordance with Section **702**. Footings may be either round or square in shape as shown on the plans. Anchor bolt circle dimensions are furnished, and the anchor bolts are required to be in accordance with Section **920**. A rigid template is used to center the anchor bolts in the foundation. Unless otherwise specified, the template is oriented so that the mast arm of the light pole is perpendicular to the centerline of the roadway.

Each foundation installation is required to have provisions for grounding the light pole in accordance with Section **807**. The tops of the concrete foundations are constructed level and only shims used to rake the light pole are permitted. Shims are not permitted with break-away couplings. Each foundation has an imprinted arrow or arrows on the top of the foundation to indicate the direction of the cable duct run.

Foundations for high mast towers are constructed prior to constructing foundations for conventional roadway lighting.

CAST-IN-PLACE FOUNDATIONS

If the sidewalls of the excavated areas remain firm and stable, concrete may be poured directly against the dirt below the level of the top 6" form. Otherwise, the concrete foundation is fully formed by means of a paper preformed liner or other approved means. However, the foundation is formed to the proper size for the top 6" before concrete is poured. If a paper liner is used, the liner may be withdrawn as the concrete is placed or may be left in place permanently. If the liner is left in place, all voids between the excavation walls and the form are filled and compacted using size No. 53 aggregate. If the liner is withdrawn, the top 12" of the foundation remains formed until the concrete has obtained initial set.

PRECAST FOUNDATIONS

Precast foundations include reinforcing bars, tie bars, anchor bolts, and entry sleeves located to provide a level mounting for the light pole after installation. The grounding coil, as shown on the plans, may be used for grounding light poles set on precast foundations. Foundation backfill consists of compacted size No. 53 aggregate.

GRADING OF FOUNDATIONS

Foundation projection above the finished grade is as shown on the plans. Excavated material may be used for this grading if not granular and will readily stabilize and support the growth of sod. If the excavated material is unsuitable, the material is properly disposed of and approved materials used. The area is required to be sodded in accordance with Section **621**.

PLACING LIGHT POLES

LIGHT POLES UNDER 45 FT IN HEIGHT

The light pole assembly consists of a metal pole, a shoe base, a frangible breakaway base or coupling where shown on the plans, and a metal mast arm for attaching the luminaire. The unit is assembled on the ground. Pole circuit wiring is installed, and the luminaire is attached prior to erection. The factory finish of the pole assembly is protected from mars, blemishes, scratches, or other damage. Slings and chokers for lifting purposes are of nylon or other approved material. Chains, metal rope, or other abrasive materials are not permitted for lifting devices. If damage to the factory finish occurs, repair or replacement is as directed.

The base plate is designed to carry the pole assembly. The plate assembly is supported by a transformer base in accordance with the breakaway requirements in the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.

After erection and attachment to the foundation, the pole assembly must be plumb. The luminaires are required to be level in both horizontal areas. Shims are not permitted with breakaway couplings but are permitted on other types of installations to rake the pole assembly to the desired attitude of the luminaire where the combined weight of the pole and mast arm requires shimming, and the luminaire saddle does not permit the adjustment. The mast arm is required to be perpendicular to the axis of roadway travel unless special orientation is noted on the plans. Unless otherwise specified, the lighting system consists of metal pole supports for the luminaires with an underground electrical supply system.

HIGH MAST TOWERS 60 FT IN HEIGHT AND OVER

High mast tower pole sections are mechanically fitted in the field using a factory supplied hydraulic jack or hoist puller that produces a minimum force of 10,000 lb per side. Field assembly procedures and assembly apparatus requirements are required to be submitted for approval. Field welds are not permitted except where shipping limitations prevent permanent factory assembly. Prior approval for field welds is required.

The pole is erected on the lower set of the anchor bolt nuts and secured with the top nuts. The adjustments to plumb the pole are made prior to the final tightening of the top nuts.

The pole is plumbed under no wind conditions before sunup, after sundown, or on an overcast day. The deviation from vertical may not exceed ¼" within any 10 ft of height.

When installing the high mast power cable, one end of the power cable is securely connected to the luminaire ring. The other end of the power cable is secured to the support and terminated 3 ft below this support with a heavy duty three wire electrical plug. Adjustments of the three support cable lengths are made prior to lowering the ring for the first time. After the

support cables have been adjusted and the luminaires installed on the ring, at least one complete cycle operation of the ring is conducted on each structure.

As shown on the plans, should the ring provide more luminaire attachment positions than luminaires to be installed, counterweights of the same weight of the luminaire shall be installed on those positions.

GROUNDING

Ground wire is required to be # 4 AWG solid bare copper. Ground rods are ½" diameter by 8 ft long copper-weld ground electrodes except where larger sizes are specified. The top of the ground rod is driven at least 6" below grade. Ground rods are not installed within the light pole, sign structure, or high mast tower foundations.

The ground wire is connected to the top or side of the ground rod. The ground rod, ground wire connection is made by a thermo weld process. The wire and ground rod are required to be free of oxidized materials, moisture, and other contaminates prior to inserting the wire and the ground rod into the properly sized mold. The welding material is required to sufficiently cover and secure the conductor to the rod. The completed connection is required to be nonporous.

As an acceptable substitute to this process, a mechanical ground grid connection of an approved type may be used. Tap type clamps, parallel type clamps, U-bolt flat clamps, and crossover clamps are not accepted.

Luminaire poles are grounded by connecting the free end of the ground wire to the grounding lug in the transformer base or pole. The free end of the ground wire enters the pole base through the entry sleeve installed in the foundation.

The neutral conductor of the underground distribution circuit is connected to the ground lug in the transformer base or pole. This connection includes a quick-disconnect type connector kit so that in the event of a pole knockdown the connection readily breaks without damage to the buried conductor.

The breaker boxes for the sign and underpass circuits are grounded by connecting the free end of the ground wire to the neutral grounding terminal in the breaker box and connecting this terminal to a grounding lug securely fastened to the metal interior of the breaker box. The conduit terminating in the breaker box and the sign or underpass luminaire housing are required to have a good, clean, tight connection and act as a grounding conductor for these luminaires. The neutral conductors of the feed and distribution circuits for underpass and sign illumination are connected to the neutral grounding terminal in the switch box or breaker box. The neutral conductor of the distribution circuit for underpass and sign illumination are grounded in each luminaire by connecting a jumper from the neutral terminal of the luminaire to a ground lug fastened to the metal housing of the luminaire.

Sign structures are grounded at one sign column by connecting the free end of the grounding wire at that column to the grounding lug in the column base.

A type I service for supply of electrical energy consists of a conduit riser to a weatherhead. This conduit is grounded at the lower end by means of a standard strap grounding connection to

the ground wire and ground rod. A type II service consists of a multiple number of conduits from underground to the bottom of the service cabinet and a single conduit to a weatherhead from the top of the service cabinet. All of these conduits are connected by a single ground wire from the grounding terminal to a grounding bushing for each conduit within the interior of the service cabinet. In addition, a ground wire from the grounding terminal of the service cabinet is required to be connected through a conduit to a ground rod.

Bridge railing conduits are grounded at each end of the bridge railing by means of a standard grounding strap connected to a ground wire and ground rod. The ends of the conduits terminating in a bridge anchor location provide ground continuity by means of a grounding bushing on each conduit end and the connection of the bushing to a ground wire.

All equipment used in the highway lighting system is required to be grounded. If necessary, additional grounding is installed as directed.

LUMINAIRE INSTALLATION

Luminaire installation consists of the physical placing of the luminaire. Each installation includes the furnishing and placing of the luminaire as designated. Luminaires shall be compatible with other lighting materials as specified in **920**.

ROADWAY LUMINAIRES

Each luminaire is leveled in both directions in the horizontal plane after the light pole has been erected and adjusted. Rotary adjustment of the mast arm and vertical adjustment of roadway luminaires to obtain an installed level position in both directions is accomplished by means of the bolted saddle arrangement used to attach the luminaires to the mast arm. For certain light source types such as metal halide, lamp socket positions may be shown on the plans by type of Illuminating Engineering Society of North American (IES) and light pattern. The specified lamp socket position or comparable arrangement of LEDs is used to obtain the desired light pattern delivery. Proper connections shall be made to provide operation at the voltage being supplied. Replacements needed because of faulty or incorrect voltage connections are made with no additional payment. All roadway luminaires provided for an intersection, interchange, or contiguous highway segment shall be the same type, model, and wattage.

SIGN LUMINAIRES

Connections in which plain and galvanized steel are in contact are protected such that aluminum surfaces receive one coat of zinc chromate primer. Steel surfaces shall be prepared and coated with a structural steel system in accordance with Section **619**. All coatings are required to be dry before assembly. Conduit fittings, if required, are required to be watertight. Required conduit may be either rigid or flexible as necessary. Conduit is not clamped to a sign panel.

Figure 4-1 Illuminated Signs

Sign luminaries are mounted on overhead sign structures on two metal

channels located at the extremity of the sign walkway support brackets. The distance between lighting unit support channels is required to be 7". These channels are located in such a manner that they readily receive the mounting bolts from the rear of the sign luminaire. The installation of the sign luminaire consists of the physical placement of the luminaire on the channels.

Sign luminaries are connected to a phase conductor and a neutral conductor. The luminaries are alternately connected to opposite phase conductors to balance the load. The connections in the base of the sign structure are required to be in accordance with Section **807**. Conductor splicing is required to be in junction boxes, in-ground handholes, inside handholes of sign structures, and circuit breaker enclosures.

All sign luminaires provided for an interchange or continuous highway segment shall be the same model.

UNDERPASS LUMINAIRES

Underpass luminaries are mounted on the vertical side surfaces of bridge bent structures or suspended by means of pendants supported by angle-iron struts or clips fastened to the structural beam members of the bridge. All parts of the pendent pipe assembly are hot-dipped galvanized after the threads are cut. Silicone caulking compound is applied to the threads during assembly of the pendent. Underpass luminaries may require separately mounted ballasts, which are installed in close proximity to the luminaries.

Underpass luminaries are connected to a phase conductor and a neutral conductor. The luminaries are alternately connected to opposite phase conductors to balance the load. Conductor splicing is only allowed in junction boxes, in ground handholes, and circuit breaker enclosures. All underpass luminaires provided for an interchange shall be the same model.

HIGH MAST LUMINAIRES

The aiming of the luminaries is required to be as shown on the plans. During the aiming and adjustment process, the luminaire is oriented to conform to the raised position and the ring properly tethered to prevent rotation. The long axis of the luminaire is required to be parallel to the aiming direction indicated on the plans. All high mast luminaires provided for an interchange shall be the same model and wattage.

LUMINAIRE WARRANTY REQUIREMENTS

A non-prorated manufacturer's written warranty, against loss of performance, defects in materials and defects in workmanship, shall be provided to and in favor of the Department. Requirements are in accordance with Section **807** including:

- Warranty provided for 10 years from date of shipping of luminaire
- Covers all components of luminaire
- Covers loss of performance of luminaire and components
- Warranty documents submitted to PEMS with type C certification

SIGN, UNDERPASS, ROADWAY, HIGH MAST LIGHTING LOCATION, AND LUMINAIRE IDENTIFICATION

All high mast towers, roadway light poles, underpass lighting installations, and sign lighting installations must have an identification code number as shown on the plans. In addition, each luminaire at a sign or underpass installation is individually identified with a single capital letter.

The code number is displayed on the light pole, sign structure column, and high mast tower as shown on the plans, or at a location as directed for underpass code numbers.

The code number for the light pole and sign structure column is applied to the pole, as specified by the manufacturer, by using individual, pressure sensitive, adhesive backed tags. The code number for the high mast tower is applied to an aluminum plate, which is mounted with spacers away from the structure as shown on the plans.

A luminaire identification sticker shall be provided on each luminaire and on the light pole or tower that supports the luminaire. The sticker shall be titled “LUMINAIRE” and contain the following information: light source type, luminaire manufacturer, model, wattage, LED or lamp model, power drive model, surge protection device model, date of shipping, and warranty period. The luminaire identification sticker shall be attached underneath the light pole/tower ID tag, facing the roadway, with ¾" lettering, and be no greater than 8" by 8".

SERVICE POINT POWER ENTRY

The utility's requirements for service locations are required to be coordinated. Unless otherwise specified, a pole is furnished for the service point. If the utility requires metering or is specified on the plans of the lighting system, a meter socket is obtained from and installed in accordance with the requirements of the utility. Grounding is required to be in accordance with Section **807** and be a part of the service installation.

Energy is required to be provided with 120/240 V service or 240/480 V service with the proper KW capacity on poles located immediately inside the right-of-way at locations designated on the plans. Electrical materials incorporated in the work are required to be compatible with the service voltages supplied by the local utility.

The service voltages supplied by the local utility are checked for compliance with the planned voltages. If a discrepancy exists, a resolution is required as directed before work is started or any electrical equipment is purchased.

TYPES OF SERVICE POINTS

Service point installations are required to be of two types as shown on the plans:

1. Type I Service Point: This service point installation consists of class 5 timber pole, 2.75" galvanized steel conduits, weatherhead, photocell, and multiple relay switch. The conduit riser is fastened and supported on the pole by means of galvanized hook pipe straps and secured to the pole by means of a galvanized lag screw, all of the proper size for the conduit being installed. Cable-duct is installed in the conduit riser in accordance with Section **807**. The conductors extend beyond the weatherhead a minimum of 4 ft. The conductors outside of the weatherhead are ringed to prevent moisture from entering the conduit enclosure.

2. Type II Service Point: This service point installation consists of a service cabinet with a single galvanized steel or aluminum conduit riser to the weatherhead. Multiple galvanized steel conduits extend from the bottom of the service cabinet in accordance with Section **807**. Underground cable-duct is installed in accordance with Section **807**. Connections, connectors, and fixtures are required to be as shown on the plans.

The service cabinet is secured to the pole by means of a galvanized steel channel post or other approved device.

SIGN AND UNDERPASS CIRCUITS

The illumination circuits for sign structures with an overhead power supply are protected by circuit breakers mounted on the end support.

Circuits for adjustable end support sign structures, bridge bracket signs, or underpasses are protected by circuit breakers mounted on the bridge or sign structure and connected to the underground distribution circuit in a handhole. ***Figure 4-2*** shows several errors in the construction of underpass breaker boxes. ***Figure 4-3*** shows an acceptable installation of the underpass circuitry.

Circuits for sign structures with an underground power supply are protected by fuse connector kits in the base of the sign support. The fuse connector kits include bayonet disconnect features for the "neutral" side and "hot" side.

Figure 4-2 Errors in Underpass Breaker Box Installation
(a) Top entry is not allowed
(b) 2" conduit not attached at 4' intervals

Figure 4-3 Acceptable Underpass Circuitry

TESTING OF HIGHWAY LIGHTING SYSTEMS

TESTING LIGHTING CIRCUITRY

All necessary equipment and apparatus properly calibrated for testing the lighting circuits is required to be furnished. The supplying utility is given advance notice of the test scheduling so their representative may witness the testing procedures, if desired. Each main lighting circuit, including the branches, is tested for insulation resistance and continuity after completely installed but before the pole circuits, underpass circuits, sign circuits, and grounding circuits are connected.

The insulation resistance test is made with a megohm meter and the resistance to ground is required to be no less than 50 megohms in all lighting circuit power cables. The meter is set for the voltage rating of the insulation. The continuity test is made with an ohmmeter properly scaled for measuring the resistance of the power cables. This test verifies the following:

1. That each power cable is continuous to the termination points.
2. That the cable coding at junction and termination points is consistent with cable coding at the supply point.
3. That power cables are not crossed with the neutral or each other.
4. That the main circuit through each of the branches does not have unusual resistance values.

The entire completed installation is tested by circuit or by such portions as may be selected, and at night, if directed. Tests are required to demonstrate the following:

1. That all power, lighting, and control circuits are continuous, free from short circuits, and free from unspecified grounds.
2. That all circuits are properly connected in accordance with applicable wiring diagrams.
3. That all circuits are operable, which is demonstrated by continuous operation of each lighting circuit for at least 1 hour.
4. That voltage at the ends of each lighting circuit and at inter points is within allowable limits. A maximum of 10% voltage drop is permitted for each complete circuit.

TESTING AND INSPECTING LUMINAIRES

The lighting system from the service point through the last luminaire is subjected to 14 days of normal operation prior to final acceptance. This testing procedure may be conducted separately on each circuit or on the entire system.

Normal operation is defined as the luminaires being on during the darkness hours and off during the daylight hours as controlled by the service point photocells and relay switches. Malfunctioning equipment is replaced or repaired before final inspection. The pattern of light and correlated color temperature delivered to the pavement by roadway, high mast, and underpass luminaires is required to be inspected at night. At this inspection, the proper tools, equipment, and personnel are required to be available to make all adjustments. These items include a bucket truck capable of reaching all luminaires in the system, safety equipment, and a level to determine the proper luminaire position.

PAY ITEM AND INSTALLATION SUMMARY SHEETS

Prior to final inspection, two sets each of shop drawings, installation summary, and pay item summary marked Final Record are furnished for the light pole as installed. The installation summary shows the effective mounting height, mast arm length, foundation elevation, pay item, type of base, and catalog number or drawing for each light pole furnished. The pay item summary indicates the pay item, quantity, effective mounting height, mast arm length, and type of base for each type of light pole furnished.

MEASUREMENT AND PAYMENT

Luminaire, light pole with mast luminaire arm, high mast tower, identification number, connector kit, multiple compression fitting, insulating link, foundation, handhole, service point, and cable marker are required to be measured by the number of units installed. Pole circuit conductor and circuit conductor in conduit are measured by the linear foot. Pole circuit conductor is measured from the base of the light pole to the terminal block of the luminaire. Pole line extension is measured in a straight line between each pole.

Conductor in bridge conduit is measured by the linear foot from end to end of conduit or from the end of conduit to the last bridge light pole foundation entry. An allowance of 5 lft is made for each foundation entry. An allowance of 2 lft is made for each junction box.

Removal of existing light structure, which includes the pole, mast arm, and foundation, is measured by the number of units removed.

Cable-duct and conductor in underground duct or conduit is measured by the linear:

1. From the face of the concrete foundation to the center of the handhole or face of the next concrete foundation: An allowance of 5 lft is made for each entry at foundations. An allowance of 2 loft is made at handholes for connection purposes.
2. From light pole bases or handholes to switch boxes at underpasses: An allowance of 4 lft is made at the switch box for electrical connections.
3. From end to end of the conduit when the cable is in conduit under a roadway surface or shoulder: No measurement is made of cable-duct in conduit where the cable-duct is part of a service point, sign installation, or underpass lighting system.

Luminaire is paid for at the contract unit price per each for the type specified. Service point is paid for at the contract unit price per each for the type specified. Light pole is paid for at the contract unit price per each for the estimated mounting height, length of mast arm, and base type specified. High mast tower will be paid for at the contract unit price for the specified mounting height.

Concrete lighting foundation with grounding is paid for at the contract unit price per each for the size specified. If class X material is encountered during lighting foundation excavation, payment is made for such excavation in accordance with Section **206**. Partial payment for lighting foundation in the amount of 80% is made if all such work is complete except for finish grading and sodding. The remaining percentage of payment is made upon completion of the finish grading and sodding.

Connector kit is paid for at the contract unit price per each for fused or unfused, as specified. Multiple compression fitting and insulation link are paid for at the contract unit price per each for waterproofed or nonwaterproofed, as specified.

Cable-duct marker, high mast tower winch drive, and handhole, lighting is paid for at the contract unit price per each. Sign, underpass, and roadway lighting location identification are paid for at the contract unit price per each. Circuit installation is paid for at the contract unit price per each for the type, structure number, and number of luminaires specified. Removal of light structure and the portable tower lighting drive system are paid for at the contract unit price per each.

Wire is paid for at the contract unit price per linear foot for the designation, copper gage, housing, and number of conductors specified. Pole circuit cable, THWN, stranded is paid for at the contract unit price per linear foot for the copper gauge and number of conductors specified. Conduit, steel, galvanized, 2" diameter is paid for at the contract unit price per foot.

The cost of circuit breakers; breaker enclosures; conduit; flexible conduit; conduit fittings; grounding; weatherhead; aerial cable termination; and incidentals required from the last luminaire to the point of attachment by the utility, the bottom of the riser at the structure base, or the connector kits in the base of the sign supports shall be included in the cost of circuit installation.

If not listed in the Schedule of Pay Items, the cost of connector kit, fused or unfused, multiple compression fitting and insulation link, waterproofed or non-waterproofed, shall be included in the cost of the other items.

The cost of aerial distribution service drops to sign structures branching off from the pole line extension, weatherheads, and risers required to connect the line extension to the underground electrical distribution circuit, all anchorage guy wires, hardware, aerial cable, electrical connections, timber poles, and incidentals required to complete the pole line extension shall be included in the cost of cable, pole circuit.

The costs of the mast arm, J-support hook for pole circuit, handhole with cover, shoe base, transformer base or frangible coupling if required, installation of the pole on the foundation with the pole circuitry included in the cost of light pole.

The costs of the pole, lowering system including winch assembly, power cable, support cable, concrete pad, luminaire ring, anchor bolts and nuts, lightning rod assembly, grounding system, and all incidental materials necessary to complete the installation are included in the cost of high mast tower. The costs of excavation, concrete, sleeves for cable duct, non-metal pipe, reinforcing steel, backfill, finish grading, and sodding are included in the cost of lighting foundation.

The cost of wood poles, multiple relay switches, service cabinet, photocells, photocell receptacles, weatherhead, conduit, and other miscellaneous items shall be included in the cost of the service point.

The cost of lamps, LED arrays, plasma emitters, drivers, optical systems, weatherproof housings, surge protection devices, electrical connections, and installation of the luminaire on the pole shall be included in the cost of luminaire.

The costs of snap-on coverings in light pole bases and waterproof coverings in underground handholes is included in the cost of multiple compression fitting.

The cost of maintaining highway illumination during the contract time is included in the costs of other pay items.

CHAPTER FIVE: *CURBS*

This chapter discusses the construction and inspection of the various types of curbs. Curbs are used to channelize both traffic and water. They are mainly used in or near urban areas where traffic speeds are low. Curbs are also used in rural areas where traffic speeds are higher, but usually only in conjunction with guardrail for safety reasons.

Curbs vary in exposed height with the higher curbs providing more traffic restriction abilities and allowing for future resurfacing without losing all of the curb exposure.

CURB TYPES

The types of curbs and their associated Standard Drawings are as follows:

1. Concrete Curb - **E605-CCSJ-01**
2. Combined Curb and Gutter - **E605-CCCG-01**
3. Integral Curb - **E605-CCIN-01**
4. Concrete Center Curb - **E605-CNCC-01 to 03**
5. HMA Curb - **E605-CCSJ-01**, **E605-CNCB-01** and **02**

CONCRETE CURB

Free-standing *Concrete Curb* is 20" in height, with the top 6" to 8" exposed. Good drainage is difficult to maintain with this type of curb when grades are relatively flat.

COMBINED CURB AND GUTTER

Combined Curb and Gutter is good for maintaining drainage where grades are relatively flat (***Figure 5-1***). There are three types of combined curb and gutter:

Figure 5-1 Combined Curb and Gutter

1. Combined concrete curb and gutter has a 6" exposure.
2. Combined concrete curb and gutter, Type B (Mountable) has a 4" exposure.
3. Combined concrete curb and gutter, Type C has an 8" exposure.

INTEGRAL CURB

Integral Curb is used in conjunction with concrete pavement and is normally poured monolithic with the pavement. Stirrup bars are placed in the curb base concrete at the time the pavement is placed. The exposed portion of the curb is then placed over the roughened base with the stirrup bars permanently connecting the two parts. There are three types of integral curbs:

1. Integral concrete curb has a 6" exposure.
2. Integral concrete curb Type B (Mountable) has a 4" exposure.
3. Integral concrete curb Type C has an 8" exposure.

CONCRETE CENTER CURB

Concrete Center Curb (***Figure 5-2***) is used mainly to separate traffic, and is classified as Type A, B, C, or D. Each type has different exposure height as indicated on its respective Standard Drawing, from **E605-CNCC-01** to **E605-CNCC-03.**

Figure 5-2 Concrete Center Curb

HMA CURB

There are three types of *HMA Curbing*, each with Standard Drawings available as follows:

1. HMA Curb - **E605-CCSJ-01**
2. HMA Center Curb Type A - **E605-CNCB-01**
3. HMA Center Curb Type B - **E605-CNCB-02**

HMA curb is generally used on HMA pavement to separate traffic but are easily damaged by snowplows. As such, they are best used on a shoulder where guardrail prevents that.

When HMA curbing is being placed, the surface upon which it is placed must be cleaned and tacked as specified in Section **605**. The curb is placed by a machine that extrudes the HMA through a mold conforming to the typical section. Irregular sections may be placed, formed, and compacted by hand. HMA Curb mix is required to be HMA Surface Type B in accordance with Section **402** and **605**. A DMF meeting the proper criteria must be submitted, accepted, and assigned to the appropriate Contract Item by the Contractor in *DMF Entry*.

HMA curb is unsatisfactory if any of the following characteristics are evident:

- Incorrect alignment
- Poor density
- Improper section
- Doesn't comply with maximum straight edge deviation of ¼" in 10'

Curb having any of these characteristics should be removed immediately while the HMA is still hot and replaced with curb that meets Specification requirements.

OTHER CURB TYPES

A few other infrequently used curb types exist outside of those mentioned above. These curb types, if used, will only be detailed in the plans as Standard Drawings do not exist for them. Two such curb types that may be encountered are as follows:

1. *Integral Curbwalk* is poured monolithic with a sidewalk in a similar manner that Integral Curb is poured monolithic with pavement. However, many of the benefits attained by integrating curb with pavement are not similarly attained when integrating with sidewalk due to the Specification differences between pavement and sidewalk. If specified for use on a contract, it will only be detailed in the plans.
2. *Precast Concrete Curb* is used to retain soil at a turn lane. Recently, this has been primarily used as parking lot curbing. Placement requirements for precast curbs are specified in the plans or contract proposal. The applicable portions of Section **605** that are not in conflict with the plans or contract proposal still apply to precast curb.

CAST-IN-PLACE CONCRETE CURB

INDOT predominantly uses cast-in-place curb. This curb is placed using forms or with a slipform curb machine. All concrete curbs indicated on the Standard Sheets are constructed using these methods. Applicable Specifications to cast-in-place concrete curbing are found in Section **605.**

GRADE PREP

The subgrade is cut so that the required curb grade is obtained when the curb is placed. Any soft or yielding material is removed and replaced with suitable material. The curb subgrade is compacted to a firm even surface. Although there are no specific density requirements, soft or non-compacted areas allow the curb to settle causing water to pond. For this reason, the Technician is required to observe the compactor during this operation to determine if any correction is required.

FORMS

Curb forms (***Figure 5-3***) may be made of wood or metal. They are required to be straight and free of warping, extend for the full depth of the curb, and secured so that they maintain the correct grade and alignment. Forms that are not straight, warped, or not strong enough to resist springing when concrete is placed will be rejected. Forms are set such that the elevation of the top of curb should be approximately ¼" lower than the sidewalk or ground line. This lower elevation allows the sidewalk to drain and prevents standing water from accumulating. Curb and gutter must be formed and constructed in accordance with the contract documents, and the PEMS must verify that positive drainage is established.

Figure 5-3 Curb Forms

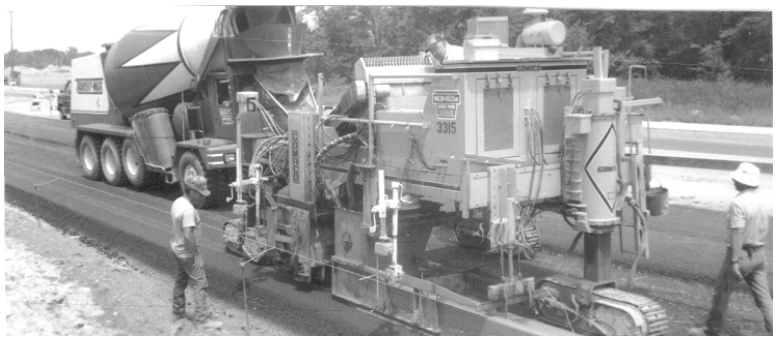


Figure 5-4 Concrete Curb Machine

CONCRETE CURB MACHINES

Concrete curb machines (***Figure 5-4***) may be used provided they produce a curb that meets the Specifications. Curb machines use low slump concrete and vibration for consolidation.

CONCRETE COMPOSITION AND PLACEMENT

Integral curb or integral curb and gutter usually has the portion of the curb below the surface of the pavement poured with the pavement. The concrete used for this purpose is PCCP paving concrete as specified in Section **502**. All other concrete for curb, integral curb, and integral curb and gutter is required to be concrete meeting the requirements of Section **605**.

After the concrete is placed in the forms, the concrete is consolidated by tamping, spading, or vibrating. Forms are left in place until the concrete has set sufficiently so that removal of the forms does not cause damage to the curb surface or cause the concrete to slump.

After the forms are removed, the exposed surfaces are rubbed immediately to a uniform surface. Curb machines use vibrators for consolidation, and as little hand finishing as possible is done behind the machine. Excess hand finishing in conjunction with a curb machine may cause the curb to slump or be pushed out of alignment. A fine broom finish is normally used. This procedure produces an acceptable finish for either formed or machine placed curbs.

JOINTS

Pavement joints continue through integral concrete curb to allow expansion along with the integrated pavement. Pavement contraction joints are required to be continued through the integral concrete curb with preformed joint material ¼" thick.

Curb that is not integral is required to have joints at 10 ft intervals. These joints may be sawed or formed at a depth and width indicated in the plans or standards. Preformed expansion material is placed at the beginning and end of all radii and at castings. This material is required to be ¼" thick.

CURING

As soon as the finishing of the curb is complete, the curb is cured by keeping the curb wet for three days or by applying a liquid membrane curing compound as used for pavement (***Figure 5-5***). Curing compound forms a barrier which prevents moisture loss and cools concrete by reflecting light. It is essential that it be applied correctly for it to work. The Standard Specifications state the following: *curing compound shall be applied to provide a uniform, solid white opaque coverage on all surfaces similar to a white sheet of paper.*

Figure 5-5 Applying Curing Compound

During the curing period concrete must not be allowed to become either extremely hot or extremely cold. Concrete must be protected from freezing temperatures and thermal blankets should be used if temperatures will fall below 40 degrees during the curing period. Thermal blankets are not a substitute for curing. Water curing methods or curing compound must be in place prior to covering with thermal blankets.

ADDITIONAL REQUIREMENTS FOR CONCRETE CENTER CURB

The subgrade is required to be prepared the same for concrete center curb as for the adjacent pavement. If the adjacent pavement has subbase, the subbase is carried through the full width of the center curb and at the same thickness. Likewise, the joints in the center curbs adjacent to the PCCP are to be aligned with joints in the adjoining PCCP. In addition, where joints are

constructed in the PCCP adjacent to the concrete center curb, these joints are extended to the center curb in accordance with Section **503**. If the concrete center curb is placed adjacent to HMA, then the joints are to be spaced a maximum of 18 ft apart.

Per Standard Drawings **E605-CNCC-01** through **03**, a minimum ⅜" thick expansion material is also placed at the beginning and end of all concrete center curb where the ends are adjacent to concrete pavement.

CONSTRUCTION AND INSPECTION PROCEDURES

All dimensions of curbs are required to be checked for compliance to the plans and standards. The tops and faces of all curbs are measured with a straight edge to check the ¼" in 10 ft tolerance. With experience, a visual inspection may reduce this checking to areas that appear to be out of tolerance. All curb that does not meet the straight-edge requirement is removed and replaced. All materials are required to be checked for compliance with the Specification and approved in accordance with the Frequency Manual. Any substandard curb will be removed and replaced at no additional cost to the Department.

MEASUREMENT AND PAYMENT

Curbing is measured and paid for by the linear foot along the front face for the type specified. Curb and gutter is measured and paid for along the face of the curb for the type specified. No deduction is made for castings installed in the curbing. Center curb is measured and paid for by the linear foot or by the square yard for the type specified. Bed course material is paid for at the contract unit price per ton, complete in place.

CHAPTER SIX: *CURB RAMP, STEPS AND SIDEWALK*

Sidewalks, curb ramps, and steps are paved areas for pedestrian traffic. In highway work, sidewalks are usually parallel to the roadway with occasional short lengths connecting the main walk to adjacent walks. Sidewalks are normally constructed only to replace existing sidewalks and are placed only were indicated on the plans.

CURB RAMPS

Curb ramps (***Figure 6-1***) are sloping sidewalks that allow individuals with low mobility or requiring the use of a wheelchair to easily move from the sidewalk at curb height to the adjacent pavement at points of pedestrian street crossings. If the plans do not accurately reflect the field conditions encountered, particularly when curb ramps are involved, the PEMS should work through the AE and the designer to examine alternative solutions. "Doing the best you can" is not sufficient for ADA compliance.

Steps are used to move pedestrian traffic from one elevation to another in a short distance. HMA sidewalks are rarely built today.

Figure 6-1 Sidewalk with Curb Ramp

This chapter discusses the construction of concrete and HMA sidewalks, concrete curb ramps, and steps. Sidewalks, curb ramps, and steps will be constructed, measured, and paid for in accordance with Section **604**. Standard Drawing Series **604-SDWK and 604-SWCR** for sidewalk and curb ramp details should be reviewed.

GRADE PREPARATION

Excavation is simply made to the required depth and to a width that accommodates the forms and braces. The base is shaped and compacted to a firm, even surface and all soft and yielding material is required to be removed.

FORMS

Forms may be wood, metal, or other approved material and are required to extend for the full depth of the concrete. Forms are also required to be straight, free from warp, and strong enough to resist the pressure of the concrete without springing. A sufficient number of stakes and braces are used to maintain proper vertical and horizontal alignment until the forms are removed. Once the forms are set, running slopes and cross-slopes should be checked with a level and straightedge. The running slope is parallel to the direction of pedestrian travel and the cross-slope is perpendicular to the direction of pedestrian travel.

The grade (running slope) of the sidewalk may match the adjacent roadway profile grade. Sidewalks should be formed and constructed with a minimum clear width of 5 ft. Where a 5 ft clear width is not provided, passing spaces of a minimum of 5' by 5' must be provided every 200 ft. The minimum clear width of a curb ramp, turning space, or sidewalk, is 4 ft. A 3 ft pinch point is not acceptable. Where street furniture, utilities, or other obstructions are present on the sidewalk, a clear width (measured between obstructions or from the obstruction to the back of curb or sidewalk) can be 4 ft. The minimum 4 ft dimension is for pinch points only and should not be used as a continuous width.

PLACING CONCRETE

The base is required to be thoroughly moistened before placing concrete. A dry base draws moisture from the fresh concrete and may cause a premature failure.

Class A concrete is normally used. Section **702** contains information on proportioning, mixing, and placing of the concrete. The thickness of the concrete in the curb ramp and sidewalks shall be as shown on the plans.

FINISHING

Immediately after striking off, the grade, running slopes, and cross-slopes shall be checked with a 2ft level and a long-handled straightedge of light construction that can completely span the surface. All high spots shall be removed, and depressions filled with fresh concrete and then leveled. The sidewalk surface is finished with a wooden float. No plastering of the surface is allowed. The final finish on curb ramps requires a rougher texture than the sidewalk for better traction and skid resistance. The texturing, usually achieved by coarse brooming, is required to be done transverse to the ramp slope.

Curb ramp components are required to have a running slope and a cross-slope that does not exceed the maximums detailed in Standard Drawing Series **E-604-SWCR**. Sidewalks are required to have a running slope that does not exceed the profile grade of the adjacent roadway and a cross-slope that does not exceed 2.0%. The curb ramp running slope shall not exceed 8.3% and the curb ramp cross-slope shall not exceed 2.0%. The curb ramp turning space shall not exceed a 2.0% slope in any direction. In order to meet the slope criteria, the contractor should ensure forms are set with slope percentages below the criteria noted here which allow for variations in slope of the final product due to the finishing and curing process.

All exposed edges are edged with a ¼" radius edging tool.

DETECTABLE WARNING SURFACES

All curb ramps are provided with detectable warning surfaces (i.e. truncated domes). Detectable warning surface shall extend the full width of the curb ramp as shown on the Standard Drawing Series **E604-SWCR**. Detectable warning surfaces must contrast visually with the adjacent gutter, street, or pedestrian access surface. Surfaces shall be installed to be level across joints or seams and shall be flush with the edges of the adjoining concrete. Surfaces from varying manufacturers shall not be mixed within any individual curb ramp. Detectable warning surfaces shall be listed on the Departments QPL of Detectable Warning Surfaces.

When a brick surface is selected, it shall be placed in a mortar setting bed ⅜ to ¾ in thick within the hardened concrete block out. Brick surfaces shall be installed in a running or stack bond pattern with a 1/16 in average joint width not to exceed a maximum of ⅛". The joint between the bricks shall be filled with a dry fine aggregate.

When a cast iron surface is selected, it shall be installed and cut when required in accordance with the manufacturer's recommendations. Cut edges shall be ground to a smooth shape consistent with the manufactured edges.

JOINTS

The type and location of joints and the size of preformed joint filler required are included in the plans and standard drawings.

Contraction joints (***Figure 6-2***) are formed with a ¼" radius jointing tool. All other joints are formed with a ¼" radius edging tool.

Figure 6-2 Contraction and Preformed Joints

Preformed ½" joint filler is placed around all manholes, utility poles etc. that extend into or through the sidewalk. This material is also used where the sidewalk abuts a structure, such as a building or bridge. The preformed joint filler is required to extend for the full depth of the concrete and be flush with the surface of the adjacent concrete.

CURING

The concrete is required to be cured for at least 72 hours. This is done by means of wet burlap mats, plastic sheeting, liquid membrane curing compound, or other approved methods. No liquid membrane curing compound is permitted at or near the detectable warning surfaces of curb ramps. No pedestrian traffic is allowed on the concrete during the curing period.

CONCRETE STEPS

The construction requirements for concrete steps are the same as previously discussed for sidewalks. All exposed edges of the concrete steps are rounded to a ¼" radius.

RECONSTRUCTED CONCRETE SIDEWALK AND CURB RAMP

Where existing sidewalk or curb ramp is to be reconstructed, all disintegrated concrete, brick, stone, or other material is required to be completely removed and replaced with new concrete, unless otherwise noted.

Unless otherwise specified, the reconstructed portion of the sidewalk is constructed to a minimum depth of 4" and to the width of the adjoining walk but not less than 48" from the back face of the curb. A reconstructed curb ramp is constructed to a minimum depth of 6" and to the width as noted on the plans.

Before removal of the existing concrete, a straight saw cut is made with an approved power-driven saw at the limits of the removal. If the adjacent sidewalk is damaged during the sawing operation, the sidewalk is replaced with no additional payment.

Unless otherwise directed, sidewalk is removed between tool marks and joints. Any adjacent curb that is deteriorated is also removed and replaced at the contract unit price for curb.

The new sidewalk joint pattern is required to be similar to that of the surrounding sidewalk. Sidewalk placed at drives is 6" thick or the same depth as the existing drive, whichever is greater.

Where the curb ramp is flush with the pedestrian street crossings, the algebraic difference between the running slope of the curb ramp and the street or gutter counter slope should be checked. An algebraic difference greater than 11% is not acceptable. Where this exceeds 11%, a 2' wide level strip should be placed per ***Figure 6-3*** Detectable Warning Surface (**E 604-SWCR-14**).

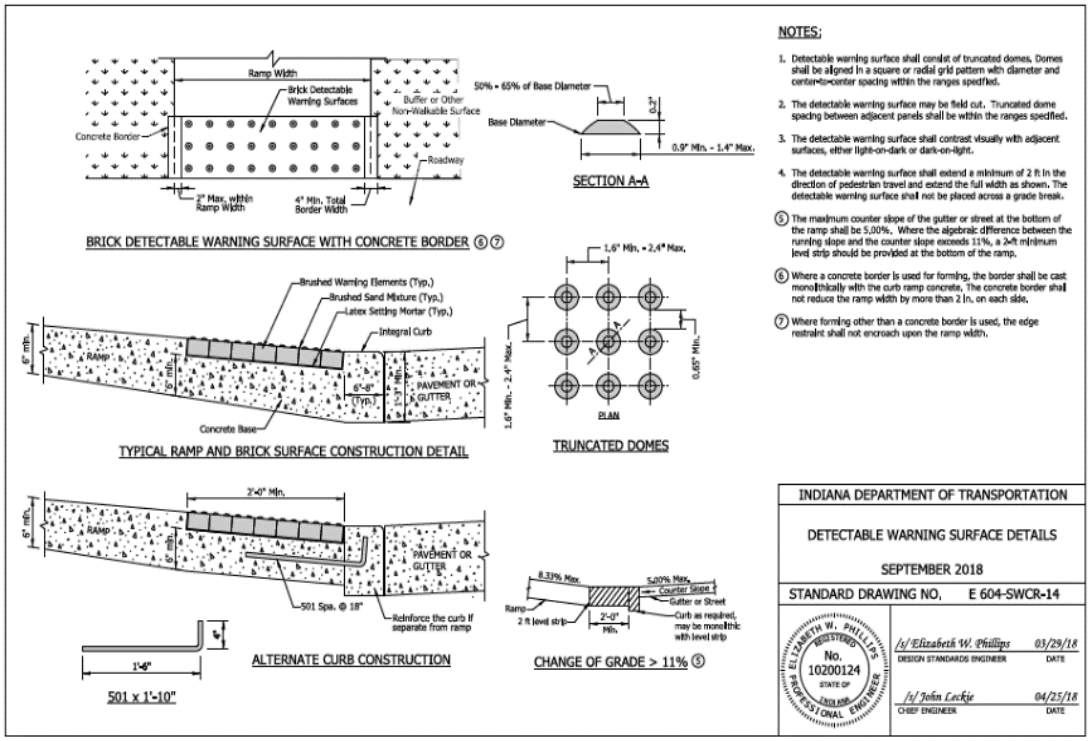
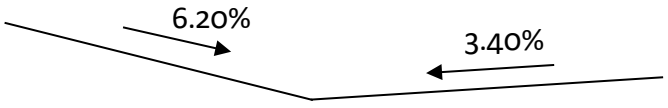


Figure 6-3 Detectable Warning Surface (E 604-SWCR-14)

EXAMPLE #1

Calculate the algebraic difference:



Solution:

$$6.20\% - (-3.40\%) = 9.60\%$$

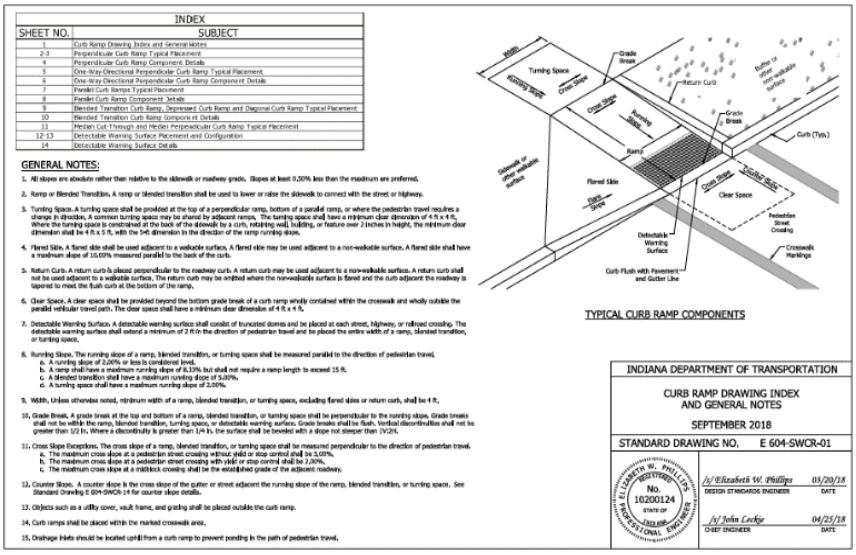
EXAMPLE #2

Calculate the algebraic difference:

Solution:

$$4.12\% - (1.20\%) = 2.92\%$$

For both new and reconstructed curb ramps, the general notes shall apply as shown in ***Figure 6-4*** Curb Ramp Drawing Index and General Notes (**E 604-SWCR-01**).



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GENERAL NOTES:

1. All slopes are absolute rather than relative to the sidewalk or roadway grade. Slopes at least 0.20% less than the maximum are preferred.
2. Ramp or Blended Transition. A ramp or blended transition shall be used to lower or raise the sidewalk to connect with the street or highway.
3. Turning Space. A turning space shall be provided at the top of a perpendicular ramp, bottom of a parallel ramp, or where the pedestrian travel requires a change in direction. A common turning space may be shared by adjacent ramps. The turning space shall have a minimum clear dimension of 4 ft x 4 ft. Where the turning space is constrained at the back of the sidewalk by a curb, retaining wall, building, or feature over 2 inches in height, the minimum clear dimension shall be 4 ft x 5 ft, with the 5-ft dimension in the direction of the ramp running slope.
4. Flared Side. A flared side shall be used adjacent to a walkable surface. A flared side may be used adjacent to a non-walkable surface. A flared side shall have a maximum slope of 10.00% measured parallel to the back of the curb.
5. Return Curb. A return curb is placed perpendicular to the roadway curb. A return curb may be used adjacent to a non-walkable surface. A return curb shall not be used adjacent to a walkable surface. The return curb may be omitted where the non-walkable surface is flared and the curb adjacent the roadway is tapered to meet the flush curb at the bottom of the ramp.
6. Clear Space. A clear space shall be provided beyond the bottom grade break of a curb ramp wholly contained within the crosswalk and wholly outside the parallel vehicular travel path. The clear space shall have a minimum clear dimension of 4 ft x 4 ft.
7. Detectable Warning Surface. A detectable warning surface shall consist of truncated domes and be placed at each street, highway, or railroad crossing. The detectable warning surface shall extend a minimum of 2 ft in the direction of pedestrian travel and be placed the entire width of a ramp, blended transition, or turning space.
8. Running Slope. The running slope of a ramp, blended transition, or turning space shall be measured parallel to the direction of pedestrian travel.
   a. A running slope of 2.00% or less is considered level.
   b. A ramp shall have a maximum running slope of 8.33% but shall not require a ramp length to exceed 15 ft.
   c. A blended transition shall have a maximum running slope of 5.00%.
   d. A turning space shall have a maximum running slope of 2.00%.
9. Width. Unless otherwise noted, minimum width of a ramp, blended transition, or turning space, excluding flared sides or return curb, shall be 4 ft.
10. Grade Break. A grade break at the top and bottom of a ramp, blended transition, or turning space shall be perpendicular to the running slope. Grade breaks shall not be within the ramp, blended transition, turning space, or detectable warning surface. Grade breaks shall be flush. Vertical discontinuities shall not be greater than 1/2 in. Where a discontinuity is greater than 1/4 in, the surface shall be beveled with a slope not steeper than 1V:2H.
11. Cross Slope Exceptions. The cross slope of a ramp, blended transition, or turning space shall be measured perpendicular to the direction of pedestrian travel.
   a. The maximum cross slope at a pedestrian street crossing without yield or stop control shall be 5.00%.
   b. The maximum cross slope at a pedestrian street crossing with yield or stop control shall be 2.00%.
   c. The maximum cross slope at a midblock crossing shall be the established grade of the adjacent roadway.
12. Counter Slope. A counter slope is the cross slope of the gutter or street adjacent the running slope of the ramp, blended transition, or turning space. See Standard Drawing E 604-SWCR-14 for counter slope details.
13. Objects such as a utility cover, vault frame, and grading shall be placed outside the curb ramp.
14. Curb ramps shall be placed within the marked crosswalk area.
15. Drainage inlets should be located uphill from a curb ramp to prevent ponding in the path of pedestrian travel.

TYPICAL CURB RAMP COMPONENTS

INDIANA DEPARTMENT OF TRANSPORTATION

CURB RAMP DRAWING INDEX AND GENERAL NOTES

SEPTEMBER 2018

STANDARD DRAWING NO. E 604-SWCR-01

REGISTERED No. 10200124 STATE OF INDIANA PROFESSIONAL ENGINEER

/s/ Elizabeth W. Phillips 03/20/18
DESIGN STANDARDS ENGINEER DATE

/s/ John Lechje 04/25/18
CHIEF ENGINEER DATE

Figure 6-4 Curb Ramp Drawing Index and General Notes (E 604-SWCR-01)

RE-LAID SIDEWALK

If re-laying of concrete sidewalk is specified, then the work consists of removal and re-laying of concrete, stone slab, or brick sidewalk. Care is taken not to damage the sections. Damaged sections are required to be replaced. Before re-laying, a cushion of fine aggregate shall be spread on the prepared subgrade to a depth of no less than 2". The cross-slope of the re-laid sidewalk shall be checked with a 2 ft level.

HMA SIDEWALK

Grade preparation for HMA sidewalk is much the same as that for concrete sidewalk; however, the base is required to be constructed with compacted coarse aggregate as indicated in the plans.

The HMA mixture is placed in one or more courses and each course is compacted with a hand operated or power roller of an acceptable type and weight. Inaccessible areas may be compacted with a hand tamper. In any case the HMA material shall be uniformly compacted.

If the HMA finished surface is too open or remains sticky, the surface may be given a coat of fine aggregate that is broomed over the surface, leaving no excess. This fine aggregate, however, is not paid for directly. The grade and cross-slope shall be checked with a 2 ft level.

CONSTRUCTION AND INSPECTION PROCEDURES

Sidewalks and ramps are always built with smooth transitions to existing walks. There is never a vertical lip left anywhere that a pedestrian may trip on or present a barrier. When constructing curb ramps, the maximum slopes indicated in the standards are not to be exceeded. Pedestrian accessibility is required to be provided and maintained during the construction of the project where facilities currently exist. Accessibility consists of signed pedestrian detours utilizing existing and temporary features including curb ramps, detectable warning surfaces, pedestrian signals, pavement markings, pedestrian phasing, or sidewalks effected by the work zone. The contract plans should be reviewed to identify the methods to be used for pedestrian access. Allowable height of a pedestrian pushbutton clear space is between 42” to 48”.

When inspecting the various items, all dimensions and slopes are checked carefully, before the concrete is poured, to ensure that they meet the requirements of the plans and Specifications. Occasionally, Contractor’s form sidewalks with two-by-fours which are only 3 ½" high and pour the walk that thickness. This practice is not acceptable.

Positive drainage shall also be provided to carry water away from the intersection of the curb ramp and the gutter line.

The joints are required to be checked for the proper vertical depth and radius as well as the spacing of the different types.

Drainage structures and poles shall not be located within the limits of a curb ramp, exclusive of flared sides. Poles located within a sidewalk shall not reduce the pedestrian walking path clear width to less than 4 ft.

On-site testing of materials is required to be done according to the Frequency Manual. All materials are checked to verify that they are approved for use. All required Basis for Use documents are obtained for the material records.

MEASUREMENT AND PAYMENT

Measurement and documentation of all items is required for payment on a daily basis. These measurements are required to be accurate enough for final payment so that additional measurements at a later date are not required.

The accepted quantities of concrete sidewalk, curb ramps, detectable warning surface, retrofitted detectable warning surface, and reconstructed & re-laid sidewalk are measured and paid for at the contract unit price per square yard. HMA for sidewalk is measured and paid for at the contract unit price per ton, complete in place. Bed course material is measured and paid for at the contract unit price per ton. Concrete steps are paid for at the contract unit price per cubic yard. The costs of excavation, backfill, expansion joint material, and necessary incidentals are included in the costs of these pay items.

CHAPTER SEVEN: *CONCRETE APPROACHES*

This chapter discusses the construction requirements for PCCP approaches including concrete private driveways, concrete commercial drives (***Figure 7-1***), and concrete mailbox approaches. PCCP approaches are to be constructed in accordance with the applicable portions of Section **610**. Drives that are to be constructed as a part of a contract will be shown on the plans and listed in the Approach Table of the plans. In that table, the approaches are described by location and class as well as the length and width of the drive, the radii, estimated quantities of earthwork and concrete. In general, commercial drives, private drives, and mailbox approaches will be replaced in kind. Drives will typically not extend beyond the right of way line unless temporary right of way is shown on the plans and the extension of the drive into such areas is then acceptable.

Figure 7-1 Commercial Drive Approach

CONCRETE APPROACHES

Construction techniques for each type of approach are basically the same, with differences in their thickness, shape, and classification. The type or class of drive is specified in the plans. Details of these may be found on Standard Drawings **E 610--DRIV-01** through **E 610--DRIV-21**.

GRADE PREPARATION

Grade preparation for commercial and private driveway approaches is much the same as for concrete pavement. Specifications that apply to this work are found in Section **207** which provides further details of the requirements.

The subgrade is required to be shaped to the required grade, free from all ruts, corrugations, or other irregularities, and uniformly compacted and tested in accordance with the type of material specified. If any of the subgrade material is soft or yielding or cannot be satisfactorily compacted, the subgrade is required to be corrected or removed. After the removal of any unsuitable materials, the excavated areas shall be filled with approved material and compacted.

During subgrade preparation and after completion, adequate drainage is provided to prevent water from standing on the subgrade; however, the subgrade is required to be uniformly moist prior to concrete placement.

FORMS

Forms should be wood, metal, or other approved material (***Figure 7-2***) and are generally required for concrete approaches. The forms are required to be of sufficient strength to resist springing and have enough stakes, pins, or bracing to firmly hold true to the specified alignment and grade during placement of the concrete and until removal. The alignment of the forms is

required to not deviate more than ¼" in the horizontal direction from the planned PCCP width tangent sections. Forms are staked into place with a minimum of three pins for each 10 ft section. A pin is placed at each side of every joint. Form sections are locked tightly and are required to be free from play or movement in any direction. Forms are also required to be clean and oiled prior to the placing of concrete.

Figure 7-2 Approach Forms

When a construction joint or a dowelled joint is required, the forms used are required to be drilled or slotted to allow for the placement of the steel or dowels.

CONCRETE COMPOSITION AND PLACEMENT

The concrete used for private and commercial drives may be paving concrete in accordance with Section **502**. Proper consolidation of the concrete is vital to the integrity of the approach. Consolidation is obtained in place through use of vibration equipment to consolidate the full width and depth of PCCP being placed. Vibrators may be either the surface pan type or the internal type with either immerse tube or multiple spuds. Vibrators shall not operate in any one location so as to bring excessive mortar to the surface and shall not come in contact with a dowel bar assembly, subgrade, subbase, or forms.

FINISHING AND CURING

Concrete for approaches is finished in accordance with Section **504.** Hand methods of finishing are commonly used for small and medium sized approaches (***Figure 7-3).*** Hand placed concrete is further finished by means of a longitudinal float or an approved transverse smoothing float. Larger approaches may be placed with the use of finishing equipment in accordance with Section **508**.

Figure 7-3 Strike-Off Screed

The finishing operation is required to be done so that an excess of mortar and water is not worked to the top of the concrete. Particles collected in front of the screed are required to be thoroughly mixed into the unfinished concrete, while keeping a sufficient roll of material in front of the screed. This procedure helps prevent depressions or "ponds" from forming in the approach.

After final strike-off, floating is done to obtain a truer and even surface. All edges are finished using a ¼" radius edging tool. Finally, the PCCP surface shall be textured with a double thickness burlap drag or a minimum 4 ft wide turf drag; for small and medium size drives that connect with concrete sidewalks the final surface may be coarse broomed transverse to the running slope.

Curing is required for a period of 96 hours after placement of the concrete. Curing materials shall be applied to exposed surfaces and sides of newly placed concrete within 30 minutes after the finishing operations have been completed. When forms are used, the edges of the pavement shall be cured immediately upon removal of the forms. Section **504** provides for curing to be achieved by liquid membrane compounds, double burlap, waterproof covers, or straw (***Figure 7-4).*** If there is the danger of freezing, sufficient straw or blankets are required to be used to prevent the concrete from freezing during curing.

Figure 7-4 Curing with Plastic Sheeting

JOINTS

Joints shall be constructed in accordance with the type and dimensions and at the locations shown on the plans or as directed. Joint requirements are specified in the Standard Drawings. Joints that may be required are longitudinal joints, expansion joints, keyway joints, and ear construction joints. Longitudinal joints shall be parallel to the centerline of the drive and not deviate from the true line shown on the plans by more than ¼". Transverse joints shall be at right angles to the centerline of the drive and be continuous for the full width.

CONCRETE APPROACH THICKNESS

The thickness of the approach shall be in accordance with the type and dimensions and at the locations shown on the plans. The standard drawings provide further construction details in addition to those shown on the plans.

OPENING TO TRAFFIC

Concrete approaches may be opened to traffic as per the requirements of the specification. At a minimum, approaches are required to be closed to traffic for 14 days after placement. If opening to traffic sooner than 14 days is desired, test beams will be produced and tested to ensure a modulus of rupture of at least 550 psi or “as specified”. If fly ash is used in the concrete, the 14-day rule does not apply and only the modulus of rupture is used for this determination.

CONSTRUCTION AND INSPECTION PROCEDURES

The following construction and inspection procedures are required:

1. The subgrade is required to be firm. The length, width, and depth are required to be checked before the concrete is poured
2. A string or other device is required to be placed across the top of the forms using the same procedure for striking off the concrete to verify the depth

3. If the drive is over 10 ft in length and not reinforced, a transverse joint is required to be placed so that no section of the drive is over 10 ft long. The joint depth and location are required to be as shown in Standard Drawings **E 610-DRIV-01** (***Figure 7-5***) through **13**

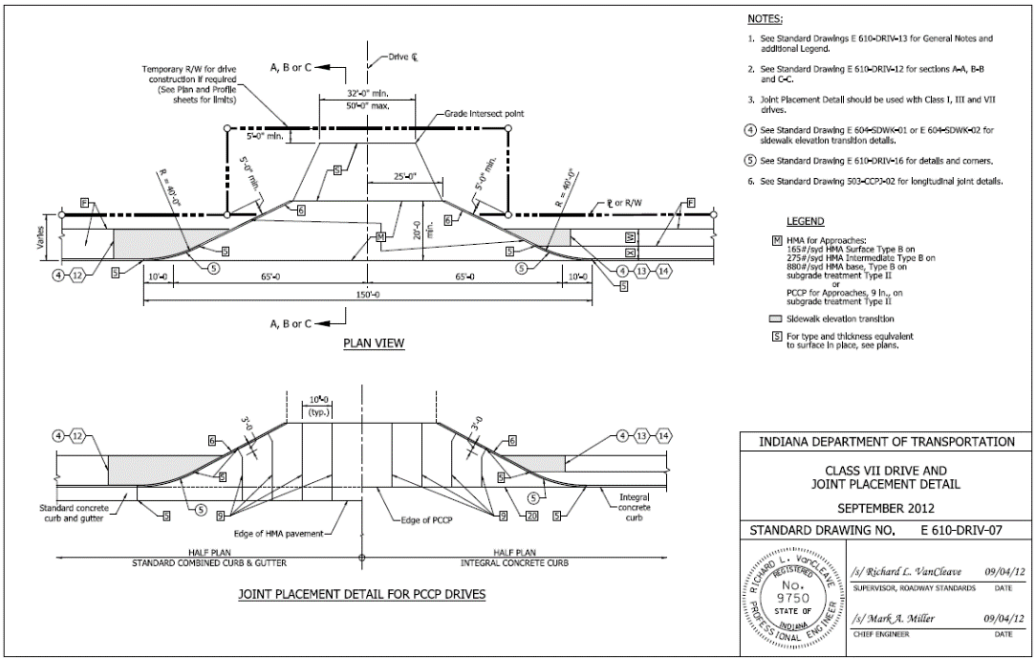

Figure 7-5 Class VII Drive and Joint Placement (E 610-DRIV-07)

4. Opening to traffic is required to be controlled so that premature cracking or damage to the drive does not occur. Close adherence to curing requirements also helps prevent damage to the concrete
5. All on-site testing of materials is required to be done according to the frequencies stated in the Frequency Manual. Materials are checked to verify they are approved for use. All required Basis for Use documents are required for the material records
6. All items are required to be measured and documented for payment on a daily basis. These measurements are required to be accurate enough for final payment so that additional measurements are not required at a later date

MEASUREMENT AND PAYMENT

Concrete for approaches is measured by the square yard of the thickness specified and paid for as Portland Cement Concrete Pavement (PCCP) for Approaches. The length and width of the approach are required to be as indicated on the plans.

The cost of excavation, shaping, leveling, forming, compaction, placing, and all necessary incidentals are included in the cost of the PCCP for Approaches.

CHAPTER EIGHT: *PAVED SIDE DITCH AND CONCRETE GUTTER*

Paved side ditches and concrete gutters are used to prevent erosion at locations where the ditch grade is 3% or more, and sometimes on flatter grades at locations where the soils are prone to erosion, such as sand.

PAVED SIDE DITCH/CONCRETE GUTTER

This chapter covers the different procedures of paved side ditch and concrete gutter construction from preparation to measurement and payment. Standard Drawings **607-PSDT-01** through **607-PSDT-06** for paved side ditch and **605-GTRC-01** through **605-GTRC-03** for concrete gutter are used.

GRADE PREPARATION

Excavation for a paved side ditches or concrete gutters is required to conform to the size and shape of the bottom of the type of the ditch being built. Compaction is required to be sufficient to prevent settlement after the paved side ditch is in use. Such settlement causes the ditch to break which results in severe erosion. Also, any soft or yielding material is required to be removed and replaced with a suitable material.

FORMS

The same requirements for curb forms also apply to paved side ditch and concrete gutter. The forms may be made of wood or metal and are required to be straight and free of warping. The forms are required to extend for the full depth of the paved side ditch and be secured so that they maintain the correct grade and alignment.

REINFORCEMENT

Reinforcement are required for all paved side ditches and concrete gutters, cut-off-walls, lugs, and turnouts are used as shown in the plans and Standard Drawings: **607-PSDT-01** through **607-PSDT-06** for paved side ditch and **605-GTRC-01** through **605-GTRC-03** for concrete gutter.

CONCRETE COMPOSITION AND PLACEMENT

Class A concrete in accordance with Section **702** is used in paved side ditch or concrete gutter construction. After the concrete is placed in the forms, the concrete is consolidated by tamping, spading, or vibrating.

CUT-OFF WALLS AND LUGS

Cut-off walls and lugs are required to keep the paved side ditch or concrete gutter in the proper location on a slope. A cut-off wall is constructed at the beginning and end of any paved side ditch. If a paved side ditch is placed on a steep grade there is the possibility of surface drainage flowing parallel alongside the side ditch causing scour under it. For this condition, lugs should be constructed as shown in the plans with the upstream edge of the lug lowered so that water

will be diverted into the paved side ditch. Lugs are poured monolithic with the paved side ditch on steep grades. The location and spacing of the lugs are as shown on the plans or as directed; ***Figure 8-1*** Paved Side Ditch Cut-off Wall and Lug (**E 607-PSDT-03**) provides the requirements for the spacing of lugs based on the unique features of the project.

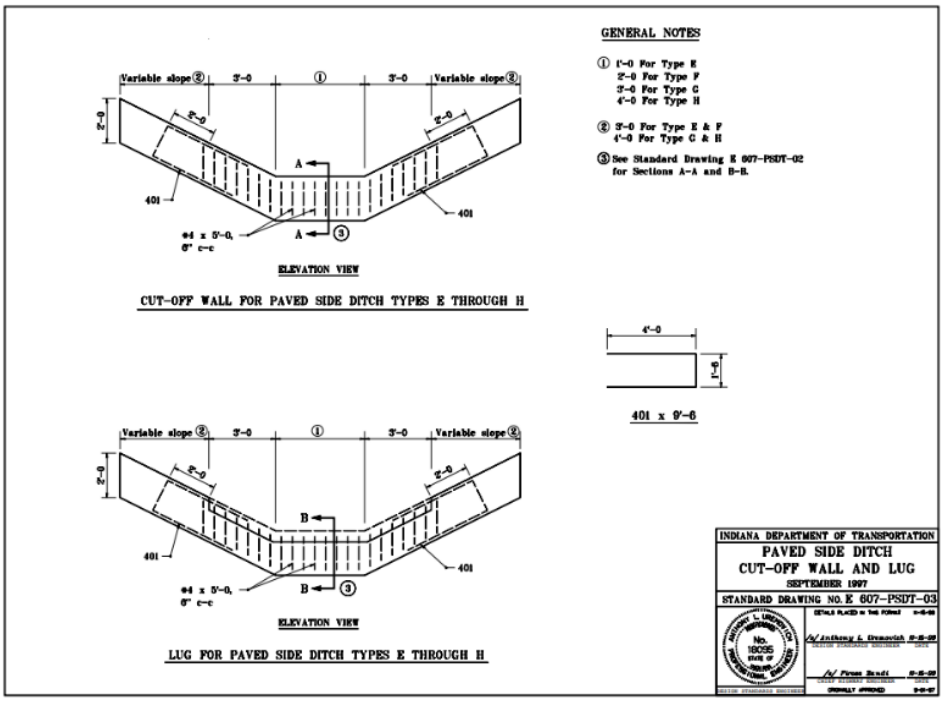

Figure 8-1 Paved Side Ditch Cut-off Wall and Lug (E 607-PSDT-03)

FINISHING AND CURING

Finishing and curing shall be in accordance with Section **605** except the curing period shall be no less than 72 hours. The finish surface need not be brushed. Floating is done using hand floats or bull floats on larger ditches. Brooming of the surface is not required on paved side ditches.

Forms are required to be left in place until the concrete has set sufficiently so that the removal does not cause damage to the paved side ditch or concrete gutter.

During curing the newly placed concrete shall be moistened and kept moist for the entire cure period, or it may be cured by the use of membrane forming material. Curing compound forms a barrier to prevent moisture loss and to cool the concrete by reflecting light. In order for it to work, it is very important that it be applied correctly. The standard specification states the following: *curing compound shall be applied to provide a uniform, solid white opaque coverage on all surfaces similar to a white sheet of paper.*

During the curing period concrete must not be allowed to become either extremely hot or extremely cold. Concrete must be protected from freezing temperatures and thermal blankets should be used if temperatures will fall below 40 degrees during the curing period. Thermal blankets are not a substitute for curing. Water curing methods or curing compound must be in place prior to covering with thermal blankets.

Backfilling around the newly placed concrete is done with suitable material in layers of no more than 6", and this material is compacted sufficiently to prevent erosion.

CONSTRUCTION AND INSPECTION PROCEDURES

A visual inspection of the contract is required to determine the exact locations of the paved side ditch or concrete gutter. Slight errors in grading or existing conditions varying from the plans may cause major location changes in the paved side ditch construction. The PEMS is consulted for the correct locations and lengths.

The edges of the paved side ditch or concrete gutter are required to be at grade or below the adjacent earth so that water may flow into the ditch and not along the side of the ditch. The forms are required to be removed and the sides of the ditch backfilled above the top of the ditch edge. This procedure is required to be done before any rains occur if possible.

All on-site testing of materials is required to be in accordance with the Frequency Manual, and all materials are verified before being approved for use. All required Basis for Use documents are obtained for the material records.

MEASUREMENT AND PAYMENT

All items are required to be measured and documented for payment on a daily basis. These measurements are required to be accurate enough for final payment so that additional measurements are not required at a later date.

Paved side ditch or concrete gutter will be measured by the linear foot along the centerline of the ditch per each type specified. Each cutoff wall or lug will be measured as 8 lft of paved side ditch or concrete gutter. Paved side ditch transitions at earth ditches and pipe culverts will be measured as equivalent lengths in linear feet of the paved side ditch specified at each location. Transitions at the intersection of two different types of paved side ditch will be converted to equivalent lengths in linear feet of the larger type of paved side ditch specified at each site.

Reinforced concrete gutter turnout will be measured as 50 lft of concrete gutter. Additional length, if required, will be measured by the linear foot of concrete gutter.

The cost of reinforcing bars or welded wire reinforcement, excavation, joints, and necessary incidentals shall be included in the cost of the pay items.

CHAPTER NINE: *CONCRETE BARRIERS*

The concrete median barrier and the temporary concrete barrier are the two types of concrete barriers used. A concrete median barrier is used for safety by separating traffic traveling in opposite directions, traveling in the same direction, and by redirecting errant vehicles, as a permanent barrier. Temporary concrete barriers may be used as a median barrier for certain situations or may be used to protect traffic from a temporary construction hazard such as bridge repairs. Concrete barriers are either cast in place (***Figure 9-1***) or precast.

Figure 9-1 Slip-forming a Concrete Barrier

CONCRETE BARRIER

Standard Drawings **E 602-CCMB-01** to **04** contain the dimensional and other requirements for concrete barriers. Standard Drawings **E 801-TCCB-01** to **06** contain the dimensional and other requirements for temporary concrete barriers.

GRADE PREPARATION

Grade preparation for the concrete median barrier is the same for cast in place or precast. The excavation is made to the required depth and width for the barrier and compacted to a firm even surface. All soft and unsuitable material is required to be replaced with acceptable material and thoroughly compacted.

PRECAST CONCRETE MEDIAN BARRIER

Precast concrete median barriers are produced in a casting yard or a concrete plant. After casting and inspection, they are shipped to the jobsite and set in place. Precast units should be at least 20 ft in length but may be longer. Whatever length is selected must not vary throughout the Contract except at special situations such as inlets or bridge abutments. Special situations may require a small section of barrier to be cast in place.

Consult Standard Drawings **E 602-CCMB-01** to **04** for proper cross-sectional dimensions. Consult Construction Memorandum, RSPs and USPs for other requirement updates.

HANDLING AND SHIPPING

Precast barriers must be handled with a suitable hoisting device provided with a spreader sling. The sling prevents horizontal forces from being produced in the member due to lifting. To avoid damage to the concrete barriers during handling, storing and transportation, the barriers are required to remain in an upright position at all times and be lifted by the inserts or other approved devices.

During transportation, the barriers are supported with truck bolsters or battens no less than 4" wide and padded with ½" of rubber. Wood blocks are placed under all tie chains to prevent chipping of the concrete.

PLACEMENT OF PRECAST UNITS

Of major importance during placement of concrete barrier units is to assure the requirements for horizontal and vertical alignment are met. The maximum variation in the horizontal and vertical alignment of adjacent units may not exceed ¼" across joints as measured from a 10 ft straightedge. In addition, the surface of individual precast units shall vary no more than ¼" in 10 ft from the specified cross section when utilizing a 10 ft straightedge.

TESTING AND INSPECTION REQUIREMENTS

Only Certified Precast Concrete Producers may produce precast concrete median barriers. These barriers are required to be clearly marked with the name or trademark of the manufacturer, the year of manufacture, and an *INDOT* marking. The markings shall be indented on an end or on top of each barrier section. The Technician must verify the Producer is on the Approved List for Certified Producers, the barrier markings, and that the precast unit visually meets INDOT requirements. Material received from a Certified Precast Producer with obvious defects or poor workmanship should not be accepted. The source, type of precast units and dates should be reported to the District Testing Engineer.

All items are measured and documented for payment daily. Measurements must be accurate enough for final payment to ensure additional measurements are not required at a later date.

CAST-IN-PLACE CONCRETE MEDIAN BARRIERS

Cast-in-place concrete median barriers are dimensionally similar to precast concrete median barriers; however, the forms are set at the exact location of the finished product. The testing requirements and Basis for Use is different than that required for precast barriers. Cast-in-place concrete barrier is to be constructed in accordance with the applicable portions of Section **706**.

FORMS

Requirements for forms for concrete median barriers are much the same as for curbs. These forms are generally made of wood or steel and are in 8-10 ft sections. Forms are required to be cleaned and oiled before use. Wooden forms are inspected often between pours as they tend to wear out quickly and may need to be repaired or replaced often.

Vertical and horizontal alignment is vital to the appearance of the barrier. The Specifications require that the surfaces of the concrete vary by no more than ¼" in 10 ft. This tolerance may easily be achieved if the forms are set true and straight.

When pouring barriers in conventional wood or metal forms, the force of the concrete and the vibration tends to push the forms up from the ground. For this reason, forms are required to be tied to the grade either by a combination of stakes, braces, or weights before the pour.

CONCRETE COMPOSITION, PLACEMENT AND FINISHING

Concrete for cast-in-place concrete median barriers is required to be class A concrete in accordance with Section **702**, unless otherwise specified. Concrete is placed in the forms in at least two layers, with each layer vibrated as the concrete is poured.

The top is finished with a hand trowel, and edges are chamfered or beveled (***Figure 9-2***). Immediately after removing the forms, any fins and irregular projections must be removed from exposed surfaces.

All cavities and holes from form ties, honeycomb spots, broken corners or edges, or other defects are required to be thoroughly cleaned, saturated with water, and carefully pointed and trued with mortar.

Figure 9-2 Hand-finishing Concrete Barrier

SLIP-FORMED

If the barrier is being slip-formed, the applicable portions of Section **706** shall be met during performance of the work. A signed and dated QCP shall be prepared and submitted to the Engineer for acceptance at least 15 days prior to the start of slip form barrier placement. The QCP shall include as a minimum, the Contractor's concrete mix design, the Contractor's methods of materials control and testing, and the Contractor's proposed method of placement, finishing, and curing. In addition, the QCP should describe corrective action to be taken when defects are found.

For slip-forming, the concrete is placed into the slip-form machine to convey it into the form. The slip-form machine (***Figure 9-3***) uses vibrators to consolidate the concrete as it enters the form. The slip-form paver consolidates, screeds and finishes the concrete in one complete pass in a manner that requires minimal hand finishing to provide a dense and homogeneous railing in conformance with the plans and specs.

Figure 9-3 Slipform Machine

The final finish on a slip-form barrier may be an approved brush finish. Sprinkling the surface with water to aid finishing or excessive rubbing makes the surface less durable by increasing the water-to-cement ratio at the surface and lowering air content. Well-designed mixes with proper equipment and vibration create a wall that requires very little finishing effort. In some cases, brushing may be all that is needed. The focus should be to get curing in place as soon as possible – excessive time should not be spent trying to achieve a flawless finish.

JOINTS

Standard Drawing **E-602-CCMB-01** and **02** show the various types of joints that may be required for the construction of cast-in-place concrete median barriers. The type, size and location of joints and preformed joint filler shall be as shown on the plans.

A Type A expansion joint is required 5' before/after an inlet and 10' from bridge piers or bents. There may be no more than 400' between these joints.

Type B joints are sawed (***Figure 9-4***) to a depth of 1½" and at intervals no greater than 20'. When full depth saw cuts are made they shall be made before uncontrolled shrinkage cracking occurs and within 24 h of concrete placement. Before full depth sawing, partial depth saw cuts of 2 1/2 in. ±1/2 in. at the joint locations may be made as soon as the concrete has hardened sufficiently to enable sawing without raveling. All sawcuts shall be made at the locations shown on the plans or as directed.

Figure 9-4 Sawing Concrete Joint

SEALING

If the barrier is placed next to a concrete pavement or base, a double application of curing compound is required before the barrier is poured.

Regardless of the method of construction, all exposed surfaces of the concrete median barrier are required to be sealed in accordance with the applicable requirements of Section **709**. The sealers that may be used are included on the Approved List of Portland Cement Concrete Sealers. The time of application, the rate of application and temperature requirements are listed on the Approved List for the particular sealer used.

Before application of the sealer, the surface of the median barrier must be thoroughly cleaned by air blasting with compressed air that is free of water, grease, or other foreign substances.

REFLECTORIZATION

All concrete median barriers are required to be reflectorized with barrier delineators as indicated on the plans. These reflectors are glued to the barrier with mastic. The minimum spacing of the delineators shall be 40 ft apart and centered at 2 ft above the surface of the adjacent pavement or shoulder.

The color of the delineators shall match the color of the adjacent pavement traffic markings. All delineators damaged during installation or placement of the concrete barrier shall be replaced with no additional payment.

CONSTRUCTION AND INSPECTION PROCEDURES

Slip-formed cast-in-place concrete median barrier must meet straightedge requirements of ¼" in 10 ft and should be reviewed frequently during installation. Stop the operation if the tolerance is not being met to prevent the removal of excessive amounts of out-of-spec barrier.

All on-site material testing is done per the Frequency Manual. Materials used are verified for approval and tested, and Basis for Use documents are obtained for the material records.

All items for payment are measured and documented on a daily basis. Concrete barrier will be paid for at the contract unit price per linear foot, complete in place. Barrier delineators used on concrete barriers will be paid for at the contract unit price per each, complete in place. Concrete barrier will be measured by the linear foot along the centerline of the barrier, including irregular barrier sections around median obstructions such as bridge piers. These measurements are required to be accurate enough for final payment so that additional measurements at a later date are not required.

TEMPORARY CONCRETE BARRIERS

There are three types of concrete barrier listed in Section **801** which are permitted to be utilized as temporary traffic barriers:

- ***Type 1*** – used to separate two way traffic
- ***Type 2*** – used to separate traffic from the workzone
- ***Type 3*** – used in the same manner as type 1 and remains in place at the completion of the contract

Temporary concrete barriers are precast in a manner similar to precast concrete median barriers and are fabricated with the same strength and straight-edge requirements. Temporary Traffic Barriers shall meet the requirements of Section **801** and shall be utilized and installed in accordance with Standard Drawings **E 801-TCCB-01** through **06**.

PLACEMENT AND ANCHORING

Temporary concrete barriers are located as indicated on the plans or as directed. Anchoring of the barriers is required based on the barrier type and shall fully meet the requirements of Section **801** and as shown on the Standard Drawings noted herein.

DELINEATION

Temporary concrete barriers are marked with side-mounted delineators and either Type C construction warning lights or top-mounted delineators. The type C lights, or top delineators shall be spaced at a number of feet equal to the miles-per-hour of the posted speed limit, with a minimum spacing of 20 ft. Bi-directional lenses will be required on the warning lights when the barrier is adjacent to a lane that is carrying alternating one-way traffic. The color of the barrier delineators shall be white when located on the right side of the traffic lane, and yellow when located on the left side of the traffic lane. The color of the barrier delineators shall be white when located adjacent to a lane that is carrying alternating one-way traffic.

CONSTRUCTION AND INSPECTION PROCEDURES

Temporary concrete barriers are inspected for correct location as indicated on the plans, correct anchoring hardware, and anchoring locations and methods to ensure conformance with the specification and standard drawings. The visibility and spacing of warning lights and barrier delineators is also checked.

The Contractor's Certified Worksite Traffic Supervisor, CWTS must direct all field layout, placement, operation, maintenance, and removal of traffic control devices including temporary concrete barriers. The field layout will be reviewed by the Engineer prior to placement. A copy of the CWTS certification shall be provided to the Engineer prior to the start of the installation or if the CWTS changes.

All on-site approval of materials is done in accordance with the Frequency Manual. Any required Basis for Use documents are obtained for the material records.

MEASUREMENT AND PAYMENT

Concrete barrier will be measured and paid for at the contract unit price per linear foot, complete in place. Barrier delineators used on concrete barrier will be measured and paid for at the contract unit price per each, complete in place.

The cost of surface seal and curing material will be included in the cost of concrete barrier.

Temporary traffic barrier will be measured and paid for at the contract unit price per linear foot per the type specified. Payment will be made only once, regardless of the number of times the barrier is moved to accommodate different phases of traffic maintenance or construction operations as shown in the contract. Anchored traffic barrier will be measured by the linear foot, separately from unanchored temporary concrete barrier per the type specified. End treatments, other than construction zone energy absorbing terminals, CZ, used on Type 1, Type 2, or Type 3 temporary traffic barrier will be measured by the linear foot as part of the barrier. Warning lights, wide angle reflectors, and anchoring is all included in the cost of the barriers.

CHAPTER TEN: *UNDERDRAINS*

A stable, long-lasting pavement requires reducing the moisture content of the subgrade. This is generally accomplished by installing *underdrains*. Underdrains are constructed in accordance with Section **718**, with guidance from Standard Drawings **E 718-UNDR-01** to **07**. In general terms, an underdrain requires the following:

1. A trench excavated along the edge of the pavement deep enough to drain the subgrade and with adequate slope to drain properly.
2. A perforated pipe in the trench bottom to provide for entry and movement of water.
3. Trench backfill with granular filter material to allow ready entry of water from any soil layer above the bottom of the pipe.

TYPES OF UNDERDRAINS

The types of pipe allowed for underdrain installations by Section **718** are as follows:

1. Corrugated Polyethylene Drainage Tubing
2. Corrugated Polyethylene Pipe, Type SP
3. Non-Reinforced Concrete Pipe
4. Perforated Polyvinyl Chloride (PVC) Semicircle Pipe
5. Profile Wall Polyvinyl Chloride (PVC) Pipe

The contract item is typically "Type 4 Pipe for Underdrains" per Section **715**. Outlet pipes for underdrains must be non-perforated sections of pipe per Section **907**.

The item most often used for underdrain is plastic corrugated drainage pipe (***Figure 10-1***). It comes in long rolls to reduce splicing, is durable, and is easily cut or spliced.

Figure 10-1 Plastic Corrugated Drainage Pipe

PRE-CONSTRUCTION

Due to the stabilizing effect of underdrains on the highway subgrade, the underdrains are required to be installed properly. Proper installation of underdrains requires good planning.

Prior to installation, the PEMS must review the Contract to determine the need for underdrains. Granular materials, with less than 10% passing the No. 200 sieve, in well-drained fills do not require underdrains. The underdrains are eliminated only if the same granular material is brought up to the subgrade elevation. A new borrow source may consist of materials that would require underdrains.

Prior to installation, the Technician is required to check the contract for positive underdrain drainage as follows:

1. Check the necessity for special grades and depths. In poorly drained areas, go deeper, if possible, to ensure positive drainage.
2. Check to see that minimum slope requirements are met. Usually, the minimum slope is listed in the Plan General Notes and is 0.2 % or 0.2 ft/100 ft. Special grades are established if the profile grade is less.

3. Check outlet pipes to verify they drain. Relocating the outlet for better drainage may be necessary, rather than raising a length of underdrain to provide for outlet drainage.
4. Check for conflicts with cross structures. Make sure there is an outlet before a structure or that the underdrain is high enough to clear the structures. If the outlet is into a cross structure, make sure the underdrain is high enough to provide positive drainage. Do not allow the underdrain to saturate the subgrade anytime there is rain.

The Technician is required to inspect, measure, and document the work appropriately to ensure that the Contract plans and specifications are being met for the following reasons:

1. To familiarize the Technician with the work.
2. To help detect possible conflicts.
3. To show where special grades and depths are required.
4. To provide accurate information for the Final Construction Record showing quantities actually placed. If plan quantities change, the quantity is crossed out and the placed quantities are used.

TRENCH EXCAVATION

Underdrains are required to be placed as soon as possible after the subgrade is substantially complete to promote positive drainage and expedite construction.

Trench excavation (***Figure 10-2***) is required to begin at the outlet end and proceed towards the upper end. The trench excavation is made to the required line and grade. The trench depth is required to be checked to ensure that the depth paid for is obtained.

The trench bottom (***Figure 10-3***) is shaped as shown on Standard Drawings **E 718-UNDR-01** to **07**. Recesses are cut in the trench bottom to receive any projecting pipe hubs or bells. If the trench is excavated too deep, the trench is backfilled to the required elevation with approved soil, and cave-ins are re-excavated as necessary.

Figure 10-2 Underdrain Trencher

Figure 10-3 Underdrain Trench

CONSTRUCTION REQUIREMENTS

PIPE INSTALLATION

The pipe is laid into the trench. Splices and other connections are required to be correctly made. Perforated pipe is placed with holes down, to keep out silt, gravel, and other solids. Plastic corrugated drainage pipe is unrolled into the trench. Minor cave-ins that occur after pipe placement do not have to be cleaned, unless the cave-in alters the flowline of the pipe. The pipe sections are joined securely with the appropriate couplings, fittings, or bands. The pipe should be installed in the underdrain trench such that a minimum clearance of 2 inches exists between the pipe and trench walls. If plain end concrete pipe is being placed, no joint opening width may exceed ¼".

GEOTEXTILES

Storage and handling of geotextiles is required to be in accordance with the manufacturer's recommendations. Each geotextile roll is required to be labeled or tagged. The Technician should ensure that the geotextile provided is on the Departments approved list of Geotextiles for Underdrains. Damaged or defective geotextile are replaced as directed. The geotextile is placed loosely, but with no wrinkles or folds. The ends of subsequent rolls of geotextile are overlapped a minimum of 1 ft. The upstream geotextile overlaps the downstream geotextile. Placement of the aggregate is done following the placement of the geotextile.

BACKFILL

The trench is backfilled with No. 8 or No. 9 stone. Coarse aggregate No. 8 or 9 is used for 6" underdrain installations and for underdrains for MSE walls; coarse aggregate No. 9 is used for 4" underdrain installations. The backfilling operation is done with a device designed to fill the trench without promoting cave-ins and minimize contamination. Prior to placing open graded HMA above the underdrain aggregate, the underdrain aggregate is required to be clean and exposed to facilitate drainage.

After the outlet pipe installation, the trench is backfilled as indicated on the plans. B Borrow for structure backfill may not extend into the limits of the underdrain trench. The trench, outside of the limits of B borrow for structure backfill, is filled with materials suitable for growing vegetation. Aggregate and stabilized materials removed from an existing shoulder may not be used as backfill and are disposed of in accordance with Section **206**.

UNDERDRAIN OUTLETS

Figure 10-4 Underdrain Outlet

Underdrain outlets (***Figure 10-4***) are to be selected and installed in accordance with Section **715** and **718**. Pipe for underdrain outlets is required to be PSM PVC pipe, profile wall PVC pipe, smooth wall polyethylene pipe, or smooth wall PVC pipe selected from the Department's qualified material list in Section 907. If the underdrain pipe and the outlet pipe are of different sizes, an increaser of the same material as the outlet pipe shall be installed 2 ft from the 45-degree elbow and prior to the transition pipe. The outlet pipe should be located as close as possible to the center of the outlet protector.

Rodent screens are placed in the end of the outlet pipe when located within inlets or catch basins as shown in Standard Drawing **E 718-UNDR-07**. Rodent screens are required to be woven stainless steel wire mesh or galvanized hardware cloth.

Figure 10-5 Underdrain Outlet Protector

OUTLET PROTECTORS

Underdrain outlet protectors (***Figure 10-5***) are required to be constructed as indicated on the plans.

The outlet pipe or pipes shall be located as close as possible to the center of the outlet protector. Types 1, 2, and 3 may be used. If the underdrain pipe and the outlet pipe are of different sizes, an increaser of the same material as the outlet pipe shall be installed 2 ft from the 45-degree elbow and prior to the transition pipe.

VIDEO INSPECTION

Underdrains and outlets are required to be inspected using high resolution, high sensitivity, waterproof, color video camera/recording equipment. The camera/recording equipment is specifically designed for continuous viewing and recording of detailed images of the interior wall of pipes and transitions of the specified sizes. The equipment has the capability of viewing a minimum of 450 ft into the pipes and is designed to include sufficient lighting to view the entire periphery of the pipe. The equipment has appropriate attachments to maintain a position in the center of the pipe and an electronic counter to continuously record the location of the equipment in the pipe. The recording equipment is required to record video of a quality and in a format acceptable to the Engineer. A color video printer shall be included in the equipment for printing observations during inspection.

The PEMS determines the runs of the underdrain installations to be inspected. Video inspection is conducted after guardrail, lighting, sign installation, and final seeding or sodding operations are completed.

Damage discovered by the video inspection is required to be repaired. Damage includes but is not limited to crushed or partially crushed pipes that impede the progress of the camera, blockages, vertical pipe sags filled with water depth of d/2 or greater, 90-degree connections, connector separations, cracks, or splits in the pipes. All repaired sections are video reinspected prior to acceptance. A copy of the video inspection is submitted to the PEMS.

MATERIALS AND BASIS FOR USE

All materials in an underdrain installation are required to meet the requirements of Section **718**. Specifications and the Material Record Basis for Use requirements for the most commonly used items are as follows:

TYPE 4 PIPE FOR UNDERDRAINS

1. Corrugated Polyethylene Drainage Tubing, Corrugated Polyethylene Pipe Type S and SP – See Approved List in Section **907**
2. Non-Reinforced Concrete Pipe – See Requirements of Section **907**
3. Perforated PVC Semicircular Pipe, Profile Wall PVC Pipe – See Approved List in Section **907**

AGGREGATE

1. Coarse Aggregate, Size No. 8 or 9 - Section **904**
2. The Basis for Use is the “D” number from the CAPP source

MEASUREMENT AND PAYMENT

Underdrains and outlet pipes are measured and paid for in accordance with Section **715**.

Underdrains and outlet pipes are measured and paid for by the linear foot installed as follows:

1. If the pipe connects to structures such as manholes, inlets, or catch basins, the pipe will be field measured and paid to the outside face of the structures
2. Tee and wye fittings are measured along the centerline of the barrel and an additional 5 ft of the same diameter pipe is paid for making the connection. If one of the pipes is a smaller diameter, then the 5 additional ft is paid at the price of the smaller diameter pipe
3. Elbow connections are measured along the center line of the elbow and an additional 2 ft of the same diameter pipe is paid for the connection
4. Increaser and reducer connections are measured by the length of the connection and are paid at the price of the larger diameter pipe
5. Sub-tee connections are measured and paid the same as a tee connection. Payment includes the required connecting bands, cement mortar beads, or concrete collars

Aggregate is measured and paid for by cubic yards complete in place to excavated lines. The trench width may not extend past neat lines shown on the plans, and the trench is required to be as specified.

Outlet protectors are measured and paid for by the number and type of each of the units installed.

Structure backfill is measured and paid for in accordance with Section **211**.

HMA for underdrains is measured and paid for by the ton.

Geotextiles are measured and paid for by the square yard based on the neat limits shown on the plans. Geotextile which has been rejected due to contamination or other reasons is required to be replaced with no additional payment.

Video inspections for underdrains are measured and paid for by the linear foot as determined by the electronic equipment.

The costs of excavation, forming, reinforcing steel, concrete, curing materials, and sod shall be included in the cost of outlet protector.

The cost of providing the video inspection equipment, technician, videotapes, or computer disks is included in the cost of the underdrain video inspection.

The cost of repair of underdrain pipes, aggregates, backfill, outlet protectors, geotextile fabric, etc. is included in the cost of the other pay items. The cost of providing video reinspection of the repairs is included in the cost of the pay items.

The cost of disposal of unsuitable excavated materials, installation of pipe end caps, rodent screens, and other incidentals is included in the cost of other pay items.

CHAPTER ELEVEN: *GUARDRAIL*

The purpose of placing guardrail is to reduce the severity of potential accidents caused by an errant vehicle leaving the roadway down a steep embankment or impacting an obstacle. Because guardrail is also a hazard, the guardrail is only installed if the installation offers less potential hazard than the embankment slope or obstacle.

The Technician is required to ensure the guardrail is placed according to the requirements set forth in the plans and Specifications and to keep accurate accounts of all guardrail placed.

Due to ever changing research and development associated with guardrail, the most current Standards and Specifications are required to be consulted prior to the construction of any guardrail. The requirements for fabrication, assembly, and installation of guardrail, transitions, and end treatments will be in accordance with Section **601** of the specification.

W-BEAM AND MGS W-BEAM GUARDRAIL

INDOT currently details in the Standard Drawings two different types of guardrail, W-Beam guardrail and MGS W-Beam guardrail. MGS W-Beam is preferred over W-Beam, although some locations may require the use of W-Beam instead. Where W-Beam has been called out in a project, the designers are to have coordinated with INDOT Standards to approve its usage. It is possible for both guardrail types to be used on a single project. In this case, the location of each type should be clearly labelled on the plans.

W-beam and MGS W-beam guardrail elements must be in accordance with Specifications and Standard Drawing Series **E 601-CWGS**, **E 601-CWGT**, **E 601-GRET**, **E 601-MGSA**, **E 601-RHPG**, **E 601-WBGA**, **E 601-WBGC**, and **E 601-MGSA**. Aluminum tubular, rub-railing, and steel block-outs are not used on new contracts, and associated information in the Specifications are used only for maintaining existing installations.

All guardrail and connection hardware shall be supplied from a source listed on the Department's list of Certified Guardrail Suppliers in accordance with Section **910**.

Guardrail posts shall be either steel or timber as specified and require a type C certification in accordance with Section **916**.

The components, assembly, post spacing, post lengths, and installation for each location are indicated on the plans and/or the Specifications and Standard Drawings. Double facing of the guardrail or reduced post spacing is required at the locations on the plans. In locations that do not allow for the standard 7' posts, 6' posts approved for W-beam guardrail may be substituted. MGS W-beam guardrail uses a 6' post which must not be reduced in length unless noted on the plans or approved by INDOT Standards Section. When approved for use, the Standard Drawing Series **E 601-NWGA** provides the requirements for nested guardrail around structures such as three- and four-sided boxes.

PRE-INSTALLATION

Prior to the inspection of guardrail placement, the Technician is required to review all of the following information:

1. The General Notes section of the plans may specify a type of railing, end section, and post spacing. The latest manufacturers manual may also be checked.
2. The Detail Sheets section of the plans indicate the specific location, length, and type of rail required, along with the locations and type of end treatment.
3. Specifications from the INDOT Specifications Book and Contract Information Book provide a description of the work, materials used, general requirements, the method of measurement and basis of payment.
4. The General Instructions to Field Employees provides helpful ideas concerning the guardrail procedures.

Before guardrail is placed, the Technician is required to verify that the correct type and quantity of guardrail is specified, and that the basis of use requirements are met.

INSPECTION DURING INSTALLATION

The Technician is required to carefully inspect the Contractor's work to ensure proper placement. The following items are checked:

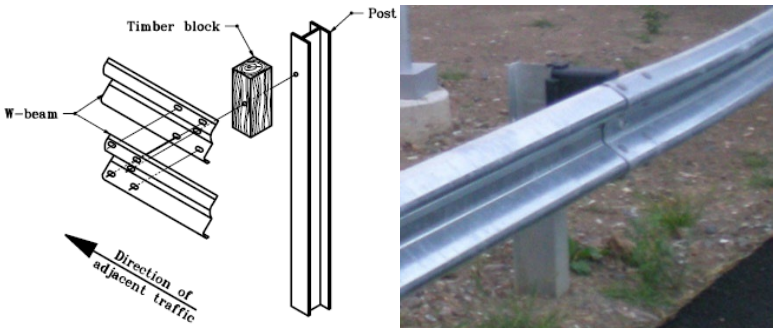

Figure 11-1 W-Beam at Post Splice

1. The slope of shoulder from the edge of the pavement to the face of the guardrail is required to be the same as that of the planned shoulder slope, with a distance between the two of no more than 2' (Standard Drawing **E 601-WBGA-01** and **E 601-MGSA-02**).
2. The guardrail is required to be placed at the correct height, 2' 3 ¾" for W-Beam and 2' 7" for MGS W-beam, measured along the front face of the rail. W-beam guardrail must not be placed at a height of 2' 7"; the maximum height for such guardrail is 2' 5" ± 1" (Standard Drawing **E 601-WBGA-01** and **E 601-MGSA-02**).
3. The guardrail splice for W-Beam guardrail must be at the post (***Figure 11-1***). For MGS W-beam guardrail the splice must be midspan between the posts (***Figure 11-2***) unless plans call for reduced post spacing.
4. The front face of the rail must be the correct distance from the edge of the pavement as specified in the plans. Except for flares and tapers at the end of the railing, the shoulder is paved up to the front face of the railing, unless otherwise specified.

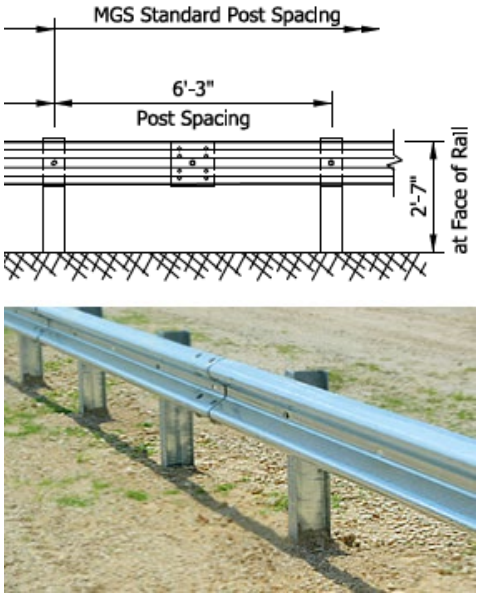

Figure 11-2 MGS W-Beam Midspan

5. The rail is required to be built as parallel to the ground as possible; however, the rail is adjusted vertically to maintain a uniform appearance.
6. Metal posts are required to be driven. If conditions do not allow driving the posts, a hole of at least 12" diameter is drilled and backfilled with soil in 6" lifts, then the post is driven. Guardrail placed in rock should be set according to the plans.
7. Rail elements must be lapped in the direction of closest traffic, similar to how roofing shingles are lapped in the direction of the flow of water down the roof (***Figure 11-3***).

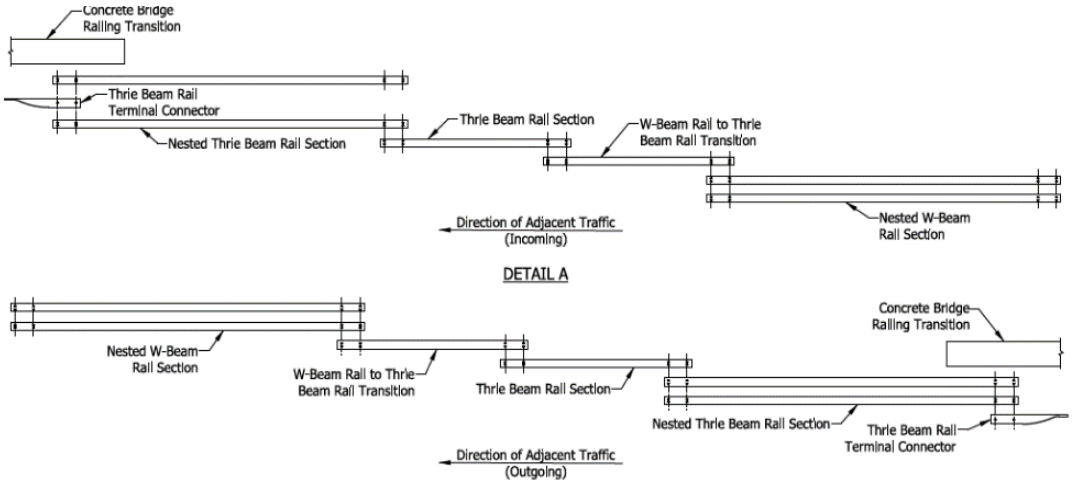

Figure 11-3 Lapping Rail Elements

8. When new guardrail is being installed to replace existing guardrail and traffic is maintained during the work, the installation of the new guardrail follows the removal of the existing guardrail as closely as practical. Adequate safety protection is provided as directed between the time that the existing guardrail is removed and the time that the installation of the new guardrail is complete.
9. If new guardrail is being installed where there is no existing guardrail and traffic is to be maintained during work, the time between the installation of the posts and the mounting of blocks and rail elements may not exceed 24 hours. Drums are placed to mark installed guardrail posts left bare overnight.
10. Blocks and rail elements must be erected in a manner resulting in smooth, continuous installation. Rail installed along a radius of 150 ft or less shall be shop-curved.

MODIFIED GUARDRAIL

Modified guardrail is regular railing with adjustments like longer or shorter posts, reduced post spacing, nesting of the railing, or the use of double-faced railing. When a pay item of modified guardrail is included in the contract, the Specifications are checked. An example of an area requiring modified guardrail would be at supports for overhead sign structures or over an underground structure. Placement is required to be as indicated on Standard Drawing **E 601-RHPG-03** and **E 601-MGSA-08** (*MGS W-Beam*) or **E 601-NWGA-01** (*W-Beam*).

When existing guardrail no longer meets the 2' 3" minimum height requirement, usually due to the addition of resurface material, one of the following contract items is specified:

1. “Adjust Guardrail Height, Adjustable Post Bracket” is used if the existing adjustable post brackets allow existing railing to be raised to the required 2' 3 ¾" minimum.

2. “Adjust Guardrail Height” is used when existing post brackets will be replaced with adjustable post brackets to raise the existing railing to the required 2' 3 ¾ " minimum.
3. “Reset Guardrail” is used when the addition of adjustable post brackets does not raise the existing railing to the required 2' 3 ¾" minimum height. Reset guardrail is set with a 2' 5" ± 1" rail height and consists of the careful removal of existing guardrail, possible storing, and then erecting where shown on plans or as directed. This work also includes the replacement of damaged or missing parts and new posts as directed.

Complete replacement of the guardrail may be another option, particularly if the guardrail is not up-to-date and the cost is comparable to resetting.

END TREATMENTS AND TRANSITIONS

The end of the guardrail which faces approaching traffic is required to have some type of end treatment to decrease the chances of vehicle impalement. The Certified End Treatment List provides approved end treatments for INDOT projects. The Technician is required to have a complete set of shop drawings and/or latest manufacturers manual if the item is not clearly indicated on the Standard Sheets. Incorrectly following the shop drawings and/or latest manufacturers manual may cause serious injury to a motorist hitting the end treatment.

For example, placing washers in the correct place is critical to the end treatment because the end treatment does not function properly without the washers. The Technician must also verify the required shoulder slopes and rail height are placed in the vicinity of the end treatment.

End treatments (***Figure 11-4***) may be detailed on the plans as is the case for Type I and II sections or may be selected from the Certified End Treatment List including OS and MS end treatments. Plans include grading and reflectorization requirements for each of the end treatments. Each unit is required to be installed in accordance with the manufacturer’s recommendations and within 24 hours of completion of the guardrail.

Figure 11-4 Guardrail End Treatment

The Basis for Use requirements and acceptance of impact attenuators is as follows, PEMS will ensure certification by reviewing the Department lists for Certified MASH End Treatment and Attenuators and Certified NCHRP 350 End Treatment and Attenuators.

Assembly and installation of end treatments must be supervised at all times by an installer trained and certified by the unit’s manufacturer. Basis for use for all guardrail end treatments is a six digit “W” number, which represents the manufacturer of the specified treatment.

When installing end treatments to rub-rail type guardrail, the rub-rail must be cut at the last existing post, the end repositioned behind the post flange (Standard Drawing **E 601-TTVH-01**).

Guardrail transitions are required to connect guardrail to bridge rails and piers, seen in Standard Drawing **E 601-TTGB-01** (*W-Beam*) or **E 601-MGSA-11** and **E 601-MGSA-12** (*MGS W-Beam*).

Guardrail height transitions are required to connect the new guardrail to the existing guardrail. The W-Beam guardrail height transition only transitions the height of the rail and would be used to connect existing W-beam to new W-beam as shown in Standard Drawing **E 601-TTVH-01** (*W-Beam*). The MGS W-beam guardrail height transition transitions the height of the rail and the location of the rail splice and would be used to connect existing W-beam to new MGS W-beam as seen in Standard Drawing **E 601-MGSA-16** *(MGS W-Beam*).

The height of the existing guardrail shall be adjusted by the use of moveable block-outs as shown on the plans. The height shall be measured to the top of the rail element along the face of the rail. Existing fixed block-outs shall be replaced with moveable block-outs installed at the proper height. Existing moveable block-outs shall be disconnected from the posts and remounted at the proper height.

Guardrail buried end sections are considered a Type I end treatment and are rarely used (Standard Drawing **E 601-GRET-3**).

FOOTINGS AND ANCHORS

Some modified guardrail sections require concrete either as concrete footings or as anchors. The recommended inspection is required to be as follows:

1. Inspect the excavation for the required dimensions.
2. Inspect the proposed finished concrete grade. The air content, yield, and slump are required to be checked as required by the Frequency Manual.
3. Verify that the excavation is reasonably dry.
4. Verify the posts are plumb and to the required grade.
5. Verify that the concrete anchors have the proper attachments set into the concrete at the proper position, along with any specified reinforcements.
6. Verify that concrete utilized is class A and in accordance with Section **702**.

IMPACT ATTENUATORS

Impact Attenuators (***Figure 11-5***) are used as crash cushions in high-speed environments on the face of blunt objects located within the clear zone. They are very similar to end treatments but are designed to prevent vehicles from coming into contact with hazards at speeds of up to 70 mph. Notable locations of use would be bridge piers, overhead signs, and other such objects that pose a hazard to the traveling public.

Figure 11-5 Impact Attenuator

Selected Impact Attenuators must be on the Certified Attenuator List. The installation must be supervised by an installer trained and certified by the unit's manufacturer, and each unit must be placed in accordance with the manufacturer's recommendations on a concrete pad (Standard Drawings **E 601-GAIA-01 through-03**, and **E 601-IAED-01.**

The Basis for Use requirements and acceptance of impact attenuators is as follows, PEMS will ensure certification by reviewing the Department lists for Certified MASH End Treatment and Attenuators and Certified NCHRP 350 End Treatment and Attenuators.

MEASUREMENT AND PAYMENT

Measurement of guardrail is done by the linear foot along the top of the rail. End treatments, transitions, Long Span System (*MGS W-Beam*), terminal systems, and attenuators are excluded from the measurement because they are paid for at the contract unit price per each completed and in place.

Nested guardrail will be measured per each 100 lft run placed.

All items are measured and documented for payment on a daily basis. These measurements are required to be accurate enough for final payment so that additional measurements are not required at a later date.

CHAPTER TWELVE: *RIGHT-OF-WAY FENCING*

Under certain conditions, right-of-way, or *R/W*, fence is specified on contracts at various locations. For example, right-of-way fences are placed along limited controlled access highways for the purpose of denying access to the highway except at designated locations. The types of fencing, materials, placement procedures, and basis of payment are discussed in this chapter. The specification Section **603** and the standard drawings cover the details of material and installation for all types. In order to construct any type of fence to the proper grade and horizontal alignment, clearing and grubbing must first be performed.

FENCE TYPES

Right-of-way fencing normally consists of six types:

1. Farm Field Type Fence, or *FFTF*
2. Chain Link Type Fence, or *CLTF*
3. Barbed Wire Type Fence
4. Temporary Fence
5. Reset Fence
6. Gates

FFTF is the most commonly used and consists of a woven wire fabric. Often known as Farm Fence, FFTF is used in agricultural or non-residential areas.

CLTF is used in residential, industrial and commercial areas, or areas with a high concentration of people. For example, CLTF is used in rest areas around sewage treatment plants and between the rest area and the roadway. CLTF consists of a woven wire fabric sometimes known as industrial fence.

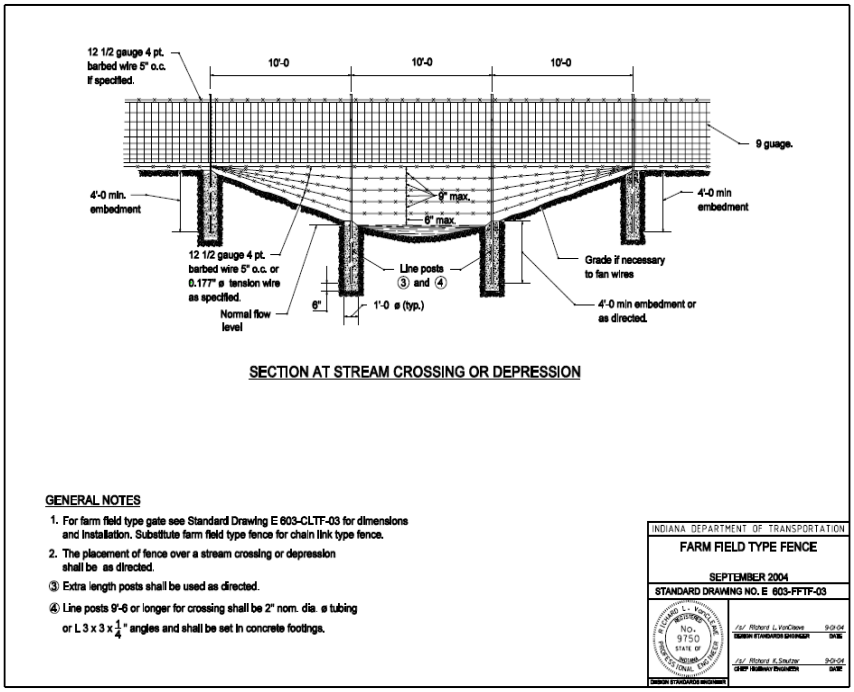

Figure 12-1 Farm Field Type Fence, Barbed Wire Application

Barbed wire type fence is not commonly used. This fence consists of two strands of barbed wire on "T" posts. Barbed wire, however, is a component of FFTF as shown on the Standard Drawings as covered below. Barbed wire is also a component of Chain Link Fence as shown on the standard drawings where it is typically utilized at stream crossings. An example of barbed wire utilized at a stream crossing is shown in ***Figure 12-1***.

Temporary fence is used only on a temporary basis. On portions of a contract where fence is required on the right-of-way, the required permanent fence is erected and maintained at locations where the property owner desires to use the adjacent area for pasture for livestock.

If permanent fence has not been erected by the time the adjacent property owner uses the pasture, a temporary fence is erected and maintained. Temporary fence is required to be sufficient to prevent the livestock from entering the right-of-way but is not paid for unless it is listed as a contract item. If the temporary fence is a pay item, the fence is measured and paid for by the linear foot.

Resetting fence consists of the removal of an existing fence within the limits of a new improvement, storing the fence, and resetting the fence as indicated on the plans. Resetting fence is completed as if the fence were new fence. The replacement of damaged or missing parts, including posts, is included in resetting. Reset fence is paid for per linear foot.

Gates are used to give access to an area so that maintenance activities may be done. Gates are of the same woven fabric as the fencing that is interrupted.

Occasionally an existing fence, comparable to the fence proposed for placement, such as the type installed by some industries or institutions is found paralleling and directly adjacent to the right-of-way line. Normally under such circumstances we would terminate our fence at the point where the existing fence and the right-of-way coincide, starting our fence again where the existing fence terminates or leaves the right-of-way. In such case, we abut the existing fence but will not fasten our fence to it.

FARM FIELD TYPE FENCE

There are basically seven individual parts to FFTF, as seen in ***Figure 12-2***:

1. End, Corner, & Pull Posts
2. Diagonal Braces
3. Line Posts
4. Woven Wire Fabric
5. Barbed Wire
6. Concrete
7. Fasteners

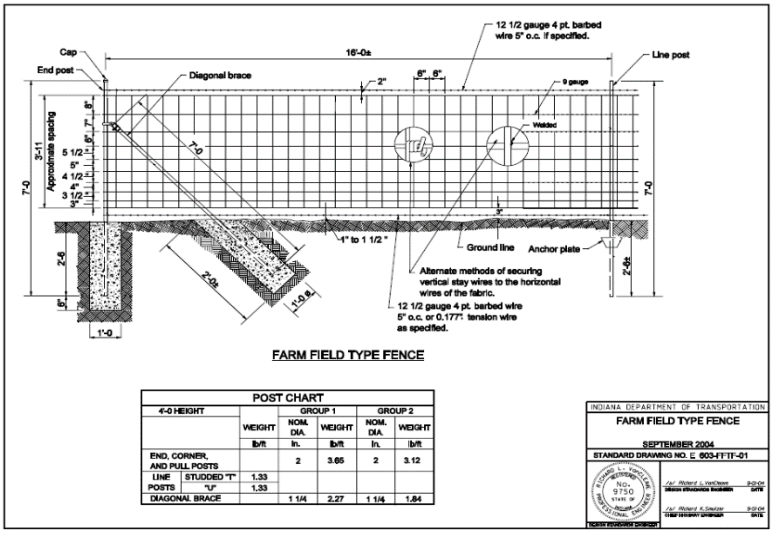

Figure 12-2 Farm Field Type Fence Components

POSTS

End, corner, or pull posts are made of galvanized or aluminum coated tubular steel. These tubular steel posts have a diameter of 2", a weight of 3.65 lb/lft, and a length of 7 ft. The posts act as an anchoring device for the fence fabric and barbed wire:

- End posts are placed at the beginning or end of a run of fence.
- Corner posts are placed at locations in which there is a horizontal change in the property line/right-of-way where there's a *horizontal* direction change of 10° or more.
- Pull posts are intermediate posts between end posts and corner posts. Pull posts are required to be placed no farther than 500 ft intervals in straight runs and at each *vertical* angle point of 10° or more.

Being anchoring devices, end, corner, and pull posts are placed in either Class A or B concrete. The concrete and post are placed in a 36" deep drilled hole with a 1 ft diameter. The post

extends 2' 6" into the concrete and must be at the required grade and alignment. For any posts set in concrete, the concrete must be allowed to set for 96 hours before fencing materials are attached. Hollow posts are fitted with caps to protect against moisture.

DIAGONAL BRACES

Diagonal braces are placed at all end, corner, and pull posts. The purpose of a diagonal brace is to keep posts in alignment. Diagonal braces are made of galvanized tubular steel with a diameter of 1 ¼", a weight of 2.27 lb/lft, and a length of 7 ft.

Diagonal braces are fastened to a post by as detailed in Standard Drawing **E 603-FFTF-01**. The opposite end is placed in a Class B concrete anchor. This anchor, as detailed in the same Standard Drawing, is approximately 2 ft in length and 1 ft in diameter.

Care must be taken placing anchors for end, corner, and pull posts, and diagonal braces. If the concrete is allowed to take a "mushroom" shape, future damage may occur – a mushroom shape allows the freeze-thaw action of the surrounding soil to lift the post or diagonal brace. To prevent this, the upper limit of the concrete must not exceed the circumference of the hole. Place no tension or strain on posts or braces until the concrete has cured 4 days.

LINE POSTS

Line posts in FFTF are the intermediate posts between end, corner, or pull posts. Their function is to give the fence fabric and barbed wires support and correct the alignment. Line posts may be studded T or U posts. Line posts are required to:

1. Be galvanized.
2. Have an anchor plate.
3. Be spaced as uniformly as practicable.
4. Be driven to the required grade and alignment.
5. Be set on 16 ft centers.
6. Be set with a 2 ft spacing tolerance at special locations.

Occasionally, special cases arise, and the PEMS may direct other placements. For example, if a tree is located on the right-of-way and is to remain in place, the fence may be set offline enough to miss the tree. Such a case requires a gradual offset for at least three posts in each direction to eliminate sharp bends. Place a pull post at each abrupt change in vertical angle.

WOVEN WIRE FABRIC

Forty-seven-inch woven fence fabric for FFTF is a series of 10 horizontal line wires kept in alignment by vertical stays. Both the line wires and vertical stays are galvanized or aluminum coated No. 9 gauge wire. Standard Drawing **E 603-FFTF-01** details the “wrapped” and “welded” methods of securing vertical stays, with wrapped being more commonly used.

Placement of the fence fabric has several factors to consider during inspection:

1. The tension required to stretch the fabric is applied by mechanical fence stretchers.
2. All slack is removed before making permanent attachments elsewhere.
3. Line wires are fastened to end, corner, and pull posts by wrapping around the post and tying the wire back on the wire with no less than 1 ½ tightly wrapped twists.

4. All splices in the fabric are securely made with the best practice and the recommendations of the manufacturer.
5. The fabric is placed on the side of the post facing the pavement.
6. The fabric is fastened to intermediate or line posts with at least five wire ties.

BARBED WIRE

Two strands of barbed wire are used with FFTF. One is placed below the fence fabric and the other is placed above the fence fabric. The barbed wire consists of a No. 12 ½ gauge galvanized or aluminum coated steel wire with 4 round, 14-gauge barbs placed at 5" spacing. Barbed wire No. 15 ½ gauge or high tensile strength line wires with No. 16 ½ gauge barbs may be substituted. The barb points and spacing are the same as No. 12 ½ barbed wire.

Placement of the barbed wire has several factors to consider during inspection:

1. The tension required to stretch the wire is applied with single wire stretchers.
2. All slack is removed before making permanent attachments elsewhere.
3. Line wires are fastened to end, corner, or pull posts by wrapping the wire back on itself with no less than 1 ½ tightly wrapped twists.
4. All splices in the wire are securely made with the best practice and the recommendations of the manufacturer.
5. The barbed wire is placed on the side of the post facing the pavement.
6. The top barbed wire is placed 2" above the fence fabric. The lower barbed wire is placed 1 ½" to 2" below the fence fabric and 1" to 1 ½" above the ground line.
7. The barbed wires are attached to each line post.

Additional barbed wire may be required at small stream crossings and ground depressions. The space below the fence fabric is required to have barbed wire as shown on Standard Drawing **E 603-FFTF-03** unless the installation may collect drift in the channel. The wires are stretched taut between posts and fastened such that vertical movement is prevented.

CHAIN LINK TYPE FENCE

Standard Drawing **E 603-CLTF-01** details the nine individual parts of CLTF:

1. End, corner, and pull posts
2. Braces
3. Line posts
4. Truss rod
5. Chain link fabric
6. Stretcher bar
7. Tension Wire
8. Concrete
9. Fasteners

End, corner, and pull posts are the same material as used for FFTF, placed in the same manner. Line posts are placed in concrete anchors in the same manner as end, corner, and pull posts, so these are all placed at the same time. The line post is required to be 1 ¼" tubular and to be:

1. Galvanized.
2. Set on 10 ft maximum centers.

3. Spaced as uniformly as practicable.
4. Placed in concrete class B.
5. Placed at the required grade and alignment.
6. Placed at each abrupt change in grade.
7. Fitted with a cap to exclude moisture.

Bracing for CLTF at end, corner, or pull post differs from FFTF. Bracing includes:

1. The first line post.
2. A 1 ¼" nominal brace.
3. A truss rod.
4. A turnbuckle with 4" of take up.
5. Necessary fittings.

The assembly of CLTF bracing is detailed on Standard Drawing **E 603-CLTF-01**. The Technician is required to inspect the bracing to verify correct assembly. The truss rods, turnbuckles, and fittings are required to be commercial quality steel, malleable iron, or wrought iron that is galvanized.

Tension wire is used at the top and bottom of chain link fence. These wires are required to be No. 7 gage spring coil or crimped steel, zinc or aluminum coated, and have a minimum breaking load of 1950 lb.

The placement procedures for the tension wires include the following requirements:

1. Be placed prior to fence fabric.
2. Be stretched taut by single wire stretchers.
3. Be secured at the ends in a satisfactory manner.
4. Be secured to all posts.
5. Not be placed until the concrete anchors have cured 4 days.

The fence fabric used for C.L.T.F. is a series of bent wires woven together. This weaving creates a 2" mesh pattern. After the wires are weaved, they are twisted together at the top and bottom. The twisting creates a barbed finish that is called "selvage".

The chain link fence fabric is required to have the following qualities:

1. A height of 48" (unless otherwise specified).
2. Be made of No. 9 gage wire.
3. Have a woven mesh of 2".
4. Be galvanized or aluminum coated (coated after weaving) or be aluminum fabric.

Placement of the fence fabric has several general factors to consider during the inspection procedure:

1. The fabric is attached to the terminal ends with a stretcher bar. This bar is flat and measures $^{3}/_{16}$" x ¾". The stretcher bar is threaded through the loops of the fabric and is secured to the posts by means of clamps with bolts and nuts. The number of clamps is indicated on Standard Drawing **E 603-CLFT-01** in ***Figure 12-3***.
2. The fabric is stretched using mechanical fence stretchers.
3. All slack is removed before making permanent attachments elsewhere.
4. The fabric is fastened to the line posts with ties or clips. The ties are spaced 12" center to center. Therefore, 5 ties are required on 48" fabric.
5. The fabric is fastened to the tension wires with ties. These ties are made of aluminum wire. Galvanized steel wire ties may be used and are required to be no smaller than No. 12 gage. All ties are spaced 24" center to center along the tension wires.
6. Fence fabric is placed 3" above the ground level and 3" below the top of the posts.

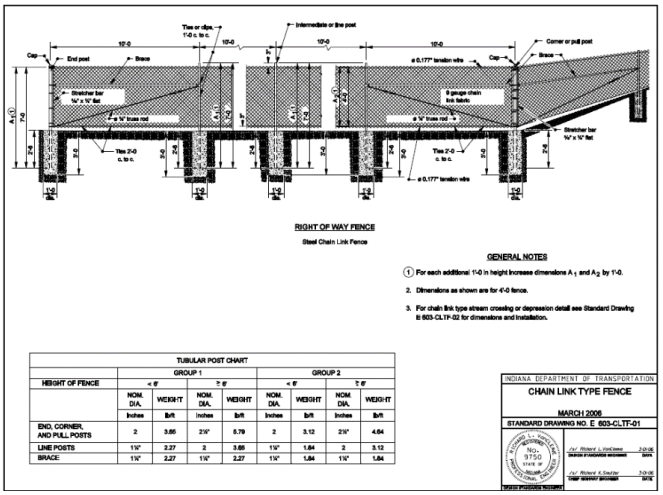

Figure 12-3 Chain Link Type Fence

GATES

Gates used in fence are detailed on Standard Drawing **E 603-CLFT-03** shown in ***Figure 12-4***.

Gates may be single or double swing. Single gates may be as wide as 32 ft and double swing gates may be as wide as 64 ft. The width of the gate opening determines the diameter size of the gate post. Gate post sizes are indicated on a table in Section **910**.

The materials required for a gate are as follows:

1. Galvanized gate post.
2. Galvanized 1 ¼" nominal gate frame with weld joint, riveted construction, or malleable fittings.
3. ⅜" round truss rod.
4. Stretcher bar with fittings.
5. Galvanized standard hinge.
6. Galvanized standard lock.
7. Fence fabric.

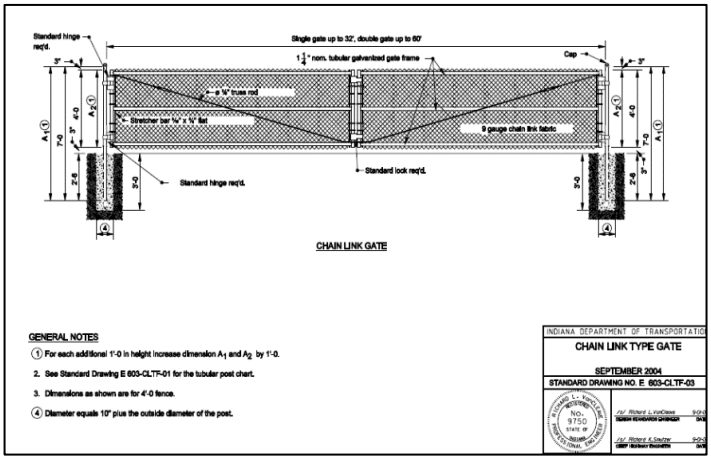

Figure 12-4 Chain Link Type Gate

MEASUREMENT AND PAYMENT

Fence and resetting fence are measured and paid for by the linear foot for the type specified complete in place. Measurement is made along the top of the fence. Measurements begin from the outside of an end post, continue to the outside of another end post for each

continuous run of fence. Measurements are recorded in a systematic method and retained for the final record.

Gates are measured and paid for at the contract unit price for each fence gate for the type and size specified complete in place.

The cost of fence, and corner, end, line, and pull posts shall be included in the cost of the fence.

The cost of fence, post and miscellaneous hardware shall be in the cost of the gate.

The cost of all miscellaneous hardware related to the type of fence including brace connections, caps, clips, clamps, hinges, rivets, ties, truss rods, diagonal braces and stretcher bars shall be included in the cost of the fence.

The cost of concrete for posts, braces or anchors shall be included in the cost of the fence and gates.

MATERIAL ACCEPTANCE

Fencing materials are inspected by INDOT Testing. Once inspections are complete, tags with "seal" numbers are attached to the materials. Rolls of fence fabric, barbed wire, and tension wire are required to have tags on each roll. Groups of individual items may have only one seal number. For example, a bundle of 100 "T" posts has one number. Miscellaneous materials and gates are visually accepted.

The seal numbers indicate that the materials have been tested and are acceptable for use. Damaged material from shipment or placement may not be used or corrected before used. Seal numbers are required to be recorded and given to the PEMS.

In addition, farm field fence and chain link fence woven wire fabrics along with tension wires and barbed wires require a Type C certification in accordance with Section **910** of the specification.

CHAPTER THIRTEEN: *BENCHMARK POSTS AND TABLETS, MONUMENTS, & RIGHT-OF-WAY MARKERS*

This chapter discusses furnishing and setting, setting only, or resetting of right-of-way markers, monuments for marking section or other lines, and bench-mark posts and tablets in accordance with Section **615.**

MATERIALS

BENCHMARK POSTS AND TABLETS

Benchmark posts in accordance with Section **615** and as shown in ***Figure 13-1*** are required to be of the dimensions indicated on the plans and cast in accordance with applicable provisions of Section **615**, except the strength is determined by concrete cores taken from the finished product. At least two concrete cores are taken from each unit and the average strength of the unit is required to be at least 4000 lb/in² with no individual core strength less than 3600 lb/in². Tablets are furnished by INDOT and are set in the posts as indicated on the plans.

Figure 13-1 Benchmark

MONUMENTS

Monuments in accordance with Section **615** and as shown in ***Figure 13-2*** are required to be of the type specified in the contract. Any portion extending above the ground is finished in accordance with Section **702**.

Where concrete is required, Class A concrete is used in accordance with Section **702**. When placed in the forms, the concrete is tamped in layers until mortar covers the outer surface. The tops of the monuments are floated smooth. Monuments may be cast-in-place or precast.

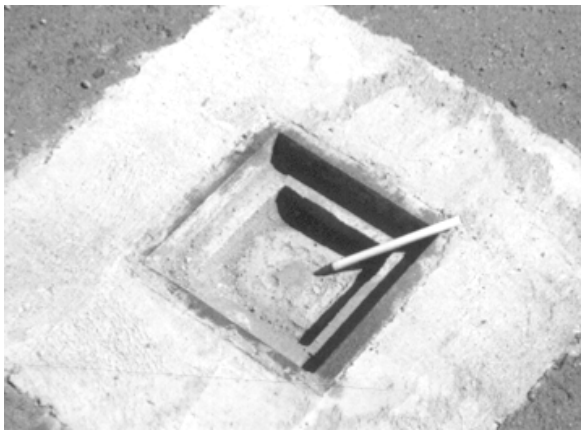

Figure 13-2 Type B Monument

The pin in the monument is set perpendicular to and flush with the top of the monument while the concrete is plastic and left undisturbed until the concrete has set. The pin is steel and is required to be 1" in diameter and 5" long. For type D monuments, the hole is drilled in the center with a ⅛" drill for a depth of 1.5". The hole is filled with lead flush with the end of the pin. Castings for protected monuments are required to be in accordance with Section **910**.

RIGHT-OF-WAY MARKERS

Reinforced concrete right-of-way markers in accordance with Section **615** are required to conform to the dimensions and lettering indicated on the plans. The reinforcement is securely held in place by at least four spacers of an approved design. Testing for both strength and absorption shall be in accordance with the Specification.

The markers are required to have a smooth workmanlike finish free from cracks, patches, honeycomb, exposed reinforcement, and excessive bubble holes. Each marker is plainly marked near the bottom with the trademark or initials of the manufacturer and the date of manufacture. These letters and figures are no less than 1" in height and indented ⅛". Right-of-way markers require a Type C certification in accordance with Section **916**.

CONSTRUCTION REQUIREMENTS

SETTING RIGHT-OF-WAY MARKERS

The required details for setting right-of-way markers are shown on Standard Drawing **E 615-RWPB**. The back face of right-of-way markers as shown in ***Figure 13-3*** are required to be set on right-of-way lines approximately 1000 ft apart. Markers are set at all corners of irregular right-of-way lines, opposite each Point of Curvature, or *P.C*, and Point of Tangency, or *P.T*, of curves, and to be no more than 500 ft apart on the inside and outside of curves. Markers on tangents are located so that the marker is plainly visible from each of the adjacent markers.

Figure 13-3 Right-of-Way Marker

All markers should be set with the rear face of the marker on the right-of-way line and should extend 18 inches above the ground. However, discretion should be used when placing right-of-way markers at the edge of lawns. It may be desirable to set them flush with the ground in those areas.

Right-of-way markers must not be placed where the limits of the State's right-of-way is defined and identified by right-of-way fence. In general, right-of-way markers must define all purchased right-of-way, unless fenced, or otherwise noted on the plans.

Figure 13-4 Flush R/W Marker

Markers are set plumb to the depth required on the plans and with the letters facing the pavement. Portions of the holes not occupied by markers are backfilled and compacted in layers with suitable material to the level of the original ground. The markers may not be displaced during backfilling.

Markers are typically set with 18" of exposed face except for lawns in urban areas where the marker is set flush with the ground as shown in ***Figure 13-4***.

RESETTING RIGHT-OF-WAY MARKERS

When the contract provides that existing right-of-way markers be reset, the existing markers are required to be removed and reset at designated locations in accordance with Section **615**.

SETTING MONUMENTS

INDOT sets monuments in accordance with Section **615** to define section lines and to permanently establish vital survey points. The required details for setting monuments are shown on Standard Drawings **E 615-SCMN-01** and **E 615-SLMN-01**. These monuments are Section Corner Monuments and Survey Line Monuments as listed below. Such monuments are often marked with a sign as shown in ***Figure 13-5***.

Monument types are as follows:

1. Monument Type "A" for vitrified brick or HMA surface on concrete base.
2. Monument Type "B" for HMA pavement.
3. Monument Type "C" for outside the pavement area.
4. Monument Type "D" for concrete pavement.

All section corners and quarter section corners that fall within the right-of-way for a new or re-constructed facility are required to be established. Approximately ten days before the monuments are to be set, the County Surveyor is to be contacted by the PEMS and given the opportunity to be present during placement or to check the monument shortly thereafter. The inspector should document monument details on daily reports and with respect to contacts made with the County Surveyor.

Figure 13-5 Survey Monument Sign

In order to accurately re-establish the original survey line after construction, any original survey points listed below are monumented:

- Point of Intersection of tangents, or *P.I.*
- Point of Curvature, *P.C.* or *P.o.C.*
    - The beginning of a curve
- Point of Tangency, *P.T.* or *P.o.T.*
    - The end of a curve

Intermediate points are monumented so that a surveyor may see a range pole set on an adjacent monument in at least one direction. Also, monuments are located so that the line of sight between adjacent monuments falls within the right-of-way.

If the location of a monument falls within the limits of a concrete pavement, a steel pin, the details of which are indicated on the plans, is required to be set perpendicular to and flush with the top of the finished pavement. The pin is placed just before the concrete takes initial set and then left undisturbed until the concrete has set. Other monuments are required to be of the type shown on the plans, depending on the type of surface of the pavement in which they are placed or if they are placed outside the pavement. Necessary excavation is done to the required depth. The bottom of the excavation is required to be firm and true to line and grades

given. After a monument is in place, the remaining excavated areas are backfilled with suitable material firmly tamped in layers, ensuring the monument is not disturbed.

Existing monuments, which are not required to be disturbed but which *are* disturbed during construction operations are required to be re-established.

RE-ESTABLISHED MONUMENTS

Existing monuments may need to be re-established in pavements or bases which are disturbed unavoidably or covered by operations done in the contract.

If the existing monument contains a brass or copper pin, the pin is extended to the surface of the new pavement by attaching a brass or copper pin of at least a 1" diameter and of the length required. These extensions are attached by tapping the original pin and providing a necessary screw attachment such that the extension may be fastened securely to the original pin. The tapped hole is at least 0.25" in diameter and no less than 1" deep. The screw attachment is required to have the same diameter as that for the hole in the original pin and be no less than 1" in length. Where an existing monument has not been re-established on a previous contract, the monument is re-established in the same manner.

Where existing monuments are protected and encased in cast iron, the castings are adjusted to meet the elevation of the proposed surface by means of an asphalt coated, cast iron, adjustment casting. The size is the same as the original casting, and of the depth necessary to meet the elevation of the proposed new surface.

SETTING BENCHMARK POSTS AND TABLETS

The required details for setting benchmarks are shown on Standard Drawing **E 615-SLBM**. Benchmark posts are required to be set at locations indicated on the plans or as directed. Excavation is made to the depth indicated and to dimensions sufficient to provide for the concrete backfilling. This concrete is Class A and extends for 6" around and below the post. The bottom is required to be monolithic with the sides. The remainder of the excavation up to the original ground line is backfilled with suitable material that is well tamped in layers. Care is taken not to disturb the post. When specified on the plans, or directed, benchmark tablets furnished by INDOT are placed in newly constructed or existing drainage structures located within the limits of the contracts.

RESET BENCHMARK POSTS

When the contract provides that existing benchmark posts be reset, the existing benchmark posts are removed and reset at designated locations in accordance with Section **615**.

The contract will include the item "Reset Benchmark Post" if relocation of an existing benchmark post is necessary. Resetting is handled the same as for a new benchmark post. Other permanent benchmark systems are required to be saved, including benchmarks for:

1. U.S. Coastal and Geodetic Survey
2. U.S. Geological Survey
3. U.S. Army Engineers
4. Indiana Flood Control & Water Resources System

The appropriate agency is notified by INDOT Design when a benchmark is found during the original survey that construction for the contract may disturb. A new benchmark tablet along with relocation instructions is available in advance of construction.

If an existing benchmark is discovered and may be disturbed during construction, a letter is required to be sent to the agency involved, stating the necessity for moving the mark and giving its designation. The DCD, AE, DDC, and PM should be copied on this correspondence. The designation consists of the letters and numbers that have been stamped with dies on the disk. The agency involved is required to send a new tablet properly stamped and the necessary instructions for setting.

MEASUREMENT AND PAYMENT

Right-of-way markers, reset right-of-way markers, monuments, re-established monuments, castings adjusted to grade monuments, benchmark posts, and reset benchmark posts are measured by the number of units installed and paid for at the contract unit price per each complete in place.

CHAPTER FOURTEEN: *GEOSYNTHETIC MATERIALS*

Prior to 1988, geotextiles were commonly referred to as plastic filter cloth or filter fabric. Because of the increase in the number of products being manufactured, the Specifications were revised. This material and similar materials such as geomembrane, geocell, and geogrid are now identified as "Geosynthetic Materials" and the material requirements for utilization may be found in Section **918**. Geosynthetics are polymer-based products used for separation, filtration, reinforcement, liquid containment, soil and aggregate confinement and many other soil related purposes within many conventional engineered structures. The requirements for furnishing and installing Geosynthetics may be found in Section **214**.

STORAGE AND HANDLING

Storage and handling of Geosynthetic materials are required to be in accordance with the manufacturer's recommendations. INDOT also requires that the geosynthetic materials be protected from any of the following, as it may affect the permeability, toughness, and strength of the material:

1. Direct sunlight
2. Ultraviolet rays
3. Water
4. Temperatures > 140° F
5. Mud, dirt, and dust
6. Debris

Exposure of geosynthetic materials to the elements between installation and covering shall be handled in accordance with manufacture's recommendation. At the time of installation, the geosynthetic material may be rejected and replaced if defective, ripped, flawed, deteriorated, or damaged. These problems may occur during construction, manufacturing, transportation, or storage of the geosynthetic materials.

GEOTEXTILES

Geotextiles will be either non-woven or woven as shown in ***Figure 14-1***, and consist of at least 85% long-chain synthetic polymers. The Geotextile's category depends on its application:

1. Riprap and Revetment
2. Underdrain and Drainage
3. Pavement or Subgrade Stabilization
4. Silt Fence

These categories are then broken down even further into Types. Each Type of geotextile has a specified testing requirement. These testing requirements are found in Section **918.**

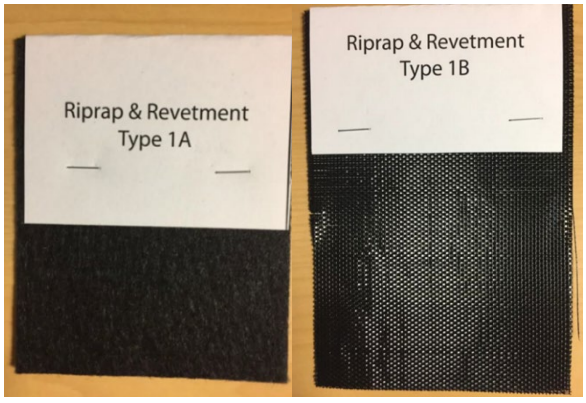

Figure 14-1 Geotextile Samples
***Type 1A** – Non-Woven Geotextile*
***Type 1B** – Woven Geotextile*

PLACEMENT

The ground surface that receives the geotextiles is required to be prepared to a condition that is free of obstructions, depressions, or debris. Geotextile shall be placed taut, without wrinkles and stretched in tension.

Geotextiles used along channels are required to be placed with the machine direction of the material parallel to the channel. If successive sheets are required, they are overlapped so that the upstream sheet is placed over the downstream sheet. If additional sheets are required to reach the top of the channel, the upslope sheet overlaps the downslope sheet.

Geotextiles used for 2 to 1 slopes or greater are required to be placed with the machine direction of the geotextile sheets perpendicular to the toe of the slope. The geotextile sheets are overlapped in the direction of the anticipated movement of the water. For example, on a fore slope the movement of the water is from the pavement and the geotextile sheets start at the bottom of the slope and proceed upslope.

Any damage to geotextile shall be repaired in accordance with Section **214**.

RIPRAP AND REVETMENT

The geotextile is required to be placed such that the placement of the overlaying materials does not excessively stretch the geotextile, tear the geotextile, or pull the overlap or seam apart.

The following requirements are also verified by the Technician:

1. Construction equipment is not allowed on the exposed geotextile.
2. Placement of riprap or stone is required to start at the base of the slope and move upward and from the center outward.
3. Riprap is not allowed to roll downslope.
4. The height drop for riprap is required to be less than 2 ft.

OVERLAPPING AND PINNING

Geotextiles shall be used in accordance with Section **214**. Adjacent pieces of geotextile may be joined by sewing or by overlapping. Most Contractors prefer overlapping. When geotextile sheets are overlapped, they are required to be pinned. The minimum overlap is 18". When the geotextiles are placed under water, the minimum overlap is 3 ft. If an overlap is periodically subjected to being under water, the overlap is required to also be 3 ft.

The overlaps are secured by pinning and the securing pins are required to be:

1. Steel
2. $^{3}/_{16}$" in diameter
3. 18" long
4. Pointed at one end
5. Fabricated with a head to retain a steel washer. The washers are required to have an outside diameter of at least 1 ½".

Securing pins are required to be inserted through both strips of overlapped geotextile. The pins are placed through the midpoint of the overlap. The spacing intervals of the pins are determined by the slopes the geotextile is being placed on in accordance with the following:

SLOPE	PIN SPACING PER ROW
(Horizontal: Vertical)	(Center: Center)
Steeper than 3:1	2 ft
3:1 to 4:1	3 ft
4:1 or flatter	5 ft

The pins are driven until the washer bears against the geotextile so that the geotextile is secured firmly to the ground. Additional pins are installed as necessary to prevent any slippage of the fabric.

UNDERDRAIN AND DRAINAGE

Geotextiles used for underdrains shall be based on plans. Underdrain geotextiles are divided into five types. The geotextiles for underdrains are required to be inspected and handled in the same manner as the geotextiles for riprap. The overlap for geotextiles for underdrains is 1 ft and the upstream geotextiles always overlap the downstream geotextiles. As soon as the geotextile for the underdrains is placed, the trench is backfilled with the aggregate for the underdrains. Geotextile shall be placed in accordance with Section **718**.

PAVEMENT OR SUBGRADE STABILIZATION

Geotextiles for subgrade shall be placed in accordance with Section **214**. Proofrolling is required to be performed prior to the placement of geotextiles and any defect or rut will need to be repaired. Geotextile will be placed taut and without wrinkles as it is stretched in tension. Coarse aggregate should be placed in order to limit disturbance to the grade. Any damage to geotextile during aggregate placement is required to be repaired in accordance with Section **214**. Geotextile for pavement or subgrade is required to meet the standards in Section **918**.

SILT FENCE

Geotextiles for silt fence shall be placed and maintained in accordance with Section **205.**

GEOMEMBRANE

Geomembrane material (***Figure 14-2***) consist of high-density polyethylene, HDPE. The material is strong, rot resistant, and chemically stable.

Geomembrane transportation applications could include waterproofing tunnels, maintenance of water content in frost sensitive soils, waterproofing walls and bridge abutments, and lining storm water retention & detention ponds.

Geomembrane shall meet the material requirements listed in Section **918**.

Figure 14-2 Geomembrane Material

GEOCELL CONFINEMENT SYSTEM

Geocell confinement systems are three-dimensional honeycomb-shaped soil reinforcing Geosynthetic composed of high-density polyethylene strips (***Figure 14-3***). Geocell is primarily used for confinement of granular material.

Figure 14-3 Geocell

Geocell are placed at-grade, in filled with granular material, and compacted. Requirements for geocell application shall be in accordance Section **214**. Material requirements for Geocell confinement systems are listed in Section **918**.

GEOGRID

Geogrid, as in ***Figure 14-4*** and ***Figure 14-5***, are Geosynthetics with large openings or apertures. Geogrid can be biaxial or multi axial of a rectangle network of connected polymer tensile elements. Geogrid applications include soil reinforcement, paving overlay reinforcement, or reinforcement for retaining walls. Requirements for geogrid application shall be in accordance Section **214.** Material requirements for Geogrid confinement systems are listed in Section **918**.

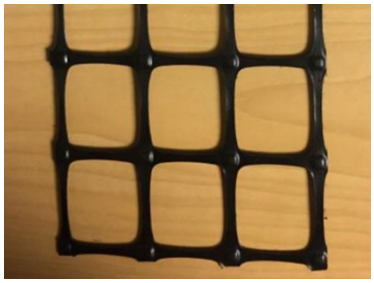

Figure 14-5 Biaxial Geogrid

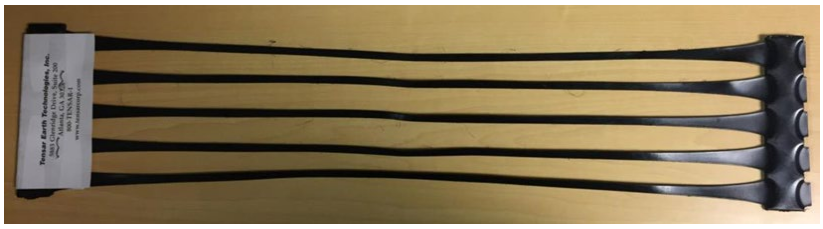

Figure 14-4 Uniaxial Geogrid

ACCEPTANCE OF MATERIALS

The Geosynthetic material must be in accordance with Section **918**. Only Geosynthetic material listed on the Departments QPL of Geosynthetic Materials shall be accepted.

MEASUREMENT AND PAYMENT

Geosynthetic materials are measured and paid for by the square yard for the type specified completed and in place. Geosynthetic utilized as part of a subgrade treatment will be measured and paid for in accordance with Section **214**. The unit price includes furnishing, placing, establishing grade, sewing, overlapping, pinning, staking and all other incidentals required to complete the work including repairing or replacing damaged geosynthetic.

CHAPTER FIFTEEN: *RIPRAP*

Riprap is used to protect a slope against erosion or scour per Section **616** and is placed where vegetation or other methods are ineffective or impracticable. Types of riprap include:

1. Dumped Riprap
2. Revetment Riprap
3. Class 1 or 2 Riprap
4. Grouted Riprap
5. Precast Concrete Riprap
6. Uniform Riprap

Regardless of the type used, it must be placed on a stable slope over an appropriate geotextile for it to be effective. Careful investigation should be made prior to staking out the proposed riprap area to determine the exact locations where it must be placed to be most effective.

DUMPED RIPRAP

Dumped riprap may consist of several different types of material. Often the riprap is waste material from the contract. Dumped riprap may consist of any of the following:

1. Broken concrete, masonry, or stone removed from an old structure.
2. Broken pieces removed from concrete pavement, base, or monolithic brick pavement.
3. Broken rock from Class X or Class Y, unclassified excavation.
4. Broken rock from solid rock excavation.
5. Material produced from sources outside the right-of-way. These materials are required to be coarse aggregate, class F or higher.

Dumped riprap is placed at locations shown on the plans or as directed by the PEMS. The placement is required to have the following characteristics:

1. A finished surface of approximate regularity.
2. A finish surface varying no more than 9" from a true plane.
3. A thickness or no more than 2 ft nor less than 1 ft. The thickness is measured perpendicular to the material surface.

REVETEMENT, CLASS 1 AND CLASS 2 RIPRAP

Revetment riprap is the most commonly used riprap. Revetment riprap, Class 1 riprap, and Class 2 riprap are required to consist of coarse aggregate Class F or higher. Gradation of this material is required to be in accordance with Section **904**. The maximum dimension of an individual piece is required to not be greater than three times the minimum dimension. Stone containing shale, unsound sandstone, or any other material which readily disintegrates may not be used.

Revetment riprap, Class 1 riprap, and Class 2 riprap may be placed by dumping. The finished surface may vary no more than 9" from a true plane for revetment riprap or 18" for class 1 or class 2 riprap and shall not be less than the minimum depth specified in Section **904**. The finished surface shall also be free from clusters of small or large stones. These materials are placed at locations as indicated on the plans or as directed by the PEMS.

GROUTED RIPRAP

Grouted riprap is required to have the same aggregate, preparation of slope, and method of placement as that required for Revetment, Class 1, and Class 2 riprap.

After the aggregate has been placed and accepted, all openings are filled with a cement grout. The grout is composed of 1 part Portland cement to 4 parts fine aggregate. The portland cement and dry fine aggregate shall be dry mixed to a uniform mixture. Water is added as the mixing continues until the grout attains a consistency that allows the material to flow into the openings.

The finished surface of the grouted riprap is required to be smooth, solid, and true to line, grade and section.

PRECAST CONCRETE RIPRAP

Precast concrete riprap in accordance with Section **904** consists of unreinforced concrete units. The nominal thickness is detailed on the plans or proposal. An example of precast concrete riprap is shown in ***Figure 15-1***.

The slope on which riprap is placed is required to be the cross section as indicated on the plans. The laying procedure follows the following format:

1. Laying begins in a trench below the toe of the slope and progresses upward.
2. Pieces are laid by hand perpendicular to the slope.
3. Each piece is firmly embedded against the slope in such manner that the vertical joint space between individual units does not exceed ⅜".
4. Half blocks, odd shaped blocks, or class A concrete is used to fill the voids at the ends of sections to be placed or on curved shape sections.

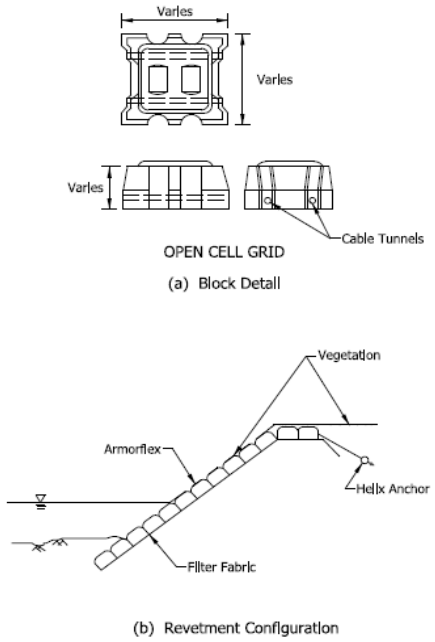

Figure 15-1 Precast Concrete Riprap

The top course is required to conform to the prescribed berm or shoulder elevation. Any adjustment necessary to achieve this is obtained by constructing a wedge course near the top of the slope. This wedge course is Class A concrete or a 1:2 mixture of mortar. When required, the toe wall will consist of class A concrete.

Standard Drawings **E 616-SWRR-01** and **02** provide additional requirements on the acceptable construction of a precast concrete riprap slope wall.

UNIFORM RIPRAP

Uniform riprap is placed to produce a surface of approximate regularity with the edges having projections no more than 3" above the required cross section. This material is hand placed, and the gradation is required to be in accordance with Section **904**.

ACCEPTANCE OF MATERIALS

Dumped riprap shall meet the material requirements of Section **904**.

Uniform, Revetment, Class 1, and Class 2 riprap shall meet the material requirements of Section **904** and the supplier shall be listed on the Departments QPL of Certified Aggregate Producers.

Precast Concrete riprap shall meet the material requirements of Section **904** and the supplier shall be listed on the Departments QPL of Certified Precast Concrete Producers.

Grouted riprap shall meet the acceptance requirements noted above for either dumped or revetment riprap as applicable based on the specific contract requirements.

MEASUREMENT AND PAYMENT

Measurement and payment will be in accordance with Section **616**.

Dumped, revetment, class 1 and class 2 riprap obtained from outside the right-of-way will be measured and paid for by the ton. If obtained from inside the right-of-way, no measurement will be made if placed as shown on the plans unless direct payment is specified. If placed at locations not shown on the plans, measurement and payment will be made by the square yard.

Grouted riprap and precast concrete riprap, including the area occupied by the wedge course, will be measured and paid by the square yard, parallel to the slope.

Precast concrete slope wall will be measured and paid by the square yard.

Geotextiles used under riprap will be measured and paid by the square yard by the type specified, complete in place.

Uniform riprap will be measured and paid by the ton.

CHAPTER SIXTEEN: *SEEDING*

Seeding is considered a beautification process and often is the last item of the contract to be completed. However, beautification is the secondary purpose for seeding. The primary purpose of seeding is erosion control. Erosion control is done by scheduling seeding and sodding operations as early as possible. Stage seeding is required to also be done. Large cut and fill slopes are required to be seeded as soon as they are finished. Seeding for the prevention of soil erosion is not only one of the major items in road construction but is also an important maintenance factor.

The construction requirements for appropriate seeding are described in Section **621** of the specification. The Technician is required to inspect all seeding operations to insure the correct quantities, proper mixing of seed, and correct preparation of the seed bed.

TYPES OF SEEDING

The two types of seeding are plain seeding and mulched seeding. The only difference between these two types of seeding is that mulching material is placed on the areas where necessary for mulched seeding. The amount of seed and fertilizer and method of preparation and placement for the two kinds of seeding are the same. Plain seeding is seldom used.

PREPARATION

Prior to the placement of seed, the soil must be prepared.

The area to be seeded shall be made smooth and uniform and shall be in accordance with the finished grade and cross section shown on the plans or as otherwise designated and shall be trimmed in accordance with Section **210**.

The seed bed shall be loosened to a minimum depth of 6" before fertilizer or seed is applied. In areas that have seen heavy traffic and significant compaction has occurred, the soil shall be loosened to a minimum depth of 6".

Areas that are to be covered with topsoil shall be milled or disked slightly before the topsoil is placed. Such loosening is required to ensure bond of the topsoil with the surface on which it is put and to form a uniform surface. The topsoil is then spread to a sufficient depth to produce the thickness specified after it has been compacted lightly with an approved roller, tamping device, or other method. The topsoil shall be loose enough that the tread of a person's boot shows when walking on the soil but shall not be so loose as to allow more than 1/2 in. of total compaction.

APPLICATION OF FERTILIZER

After preparation, fertilizer is spread uniformly at the rate of 400 lb/acre. Fertilizer should be standard commercial fertilizer with an analysis of 12-12-12. While testing is not required, fertilizer standards are governed by the rulings of the Indiana State Seed Commissioner.

APPLICATION OF SEED

Seed shall be applied in a manner that results in uniform distribution of seed in which seed to soil contact at the optimal seed depth is attained necessary for the germination of the species being planted.

Leguminous seeds, unless otherwise specified, are required to be inoculated with a culture. Their purpose is as follows:

1. The massive root system helps prevent future erosion of embankments.
2. The biological activity is important.
3. Changing nitrogen from the air into forms that may be used by other plants.

The culture is a nitrogen fixing bacteria that enhances the germination of the seed. The culture (inoculant) is mixed with sufficient water to distribute the material. The seed is wetted thoroughly with the solution. Once the inoculation is complete the seed is allowed to dry sufficiently. The inoculated seed is sown within 30 hours after the treatment. Often leguminous seed are hydraulic applied, and the inoculant is added to the water in the spray tank. The inoculant is not used if more than one year old.

Seeding is usually indicated by a "Seed Mixture Type" item. A contract may have several different Seed Mixture Types. When different mixtures are used, the Technician must know the type of seed mixtures to be used and the proposed rate of application of each mixture.

The type of seed is generally indicated in the Proposal quantity items but may be found on the plans if different types are to be used. INDOT uses five types of seed mixtures:

1. Seed Mixture "R"
2. Seed Mixture "U"
3. Seed Mixture "P"
4. Seed Mixture “Shade”
5. Seed Mixture “Floodplain”

The letter notation (R, U, P) indicates the general area where the seed is to be placed.

Seed Mixture R is a general-purpose seed mixture, generally for rural areas. The application rate for Mixture R is 202.5 lb/acre, and consists of the following grasses:

- 100 lb/acre .....low endophyte Tell Fescue
- 50 lb/acre ..... turf type Perennial Ryegrass
- 50 lb/acre ..... Creeping Red Fescue
- 2.5 lb/acre .....White Dutch Clover

Seed Mixture U is applied at specific locations normally in urban areas. The application rate is 196.5 lb/acre, and consists of the following grasses:

- 100 lb/acre ..... a 4-way blend of turf type Tall Fescue
- 50 lb/acre .....Creeping Red Fescue
- 45 lb/acre .....Perennial Ryegrass
- 1.5 lb/acre .....White Dutch Clover

The application rate for *Seed Mixture P* is 130 lb/acre and consists of the following grasses:

- 35 lb/acre ..... Weeping Alkali grass
- 35 lb/acre ..... Creeping Red Fescue
- 35 lb/acre ..... Slender Creeping Red Fescue
- 25 lb/acre ..... Perennial Ryegrass

Seed Mixture "Shade" is applied in shaded areas that do not receive sufficient sunlight. Seeds in this mix are shade tolerant varieties or cultivars. Fertilizer and mulching, where specified, is applied per Section **621**. The application rate is 145 lb/acre and consists of the following grasses:

- 35 lb/acre ..... Fine Fescue
- 40 lb/acre ..... Perennial Ryegrass
- 40 lb/acre ..... Tall Fescue
- 10 lb/acre ..... Kentucky Bluegrass
- 15 lb/acre ..... Timothy
- 3 lb/acre ..... Redtop
- 2 lb/acre ..... Alsike Clover

Seed mixture "Floodplain" is intended for areas that require natural habitat restoration below the 100-year floodplain in conjunction with IDNR construction in a floodway permit. If certain species in this mix are unavailable, substitutions may be allowed when approved by the Engineer. This mix quantity shall be measured in pure live seed, or *PLS*, lb/acre. This mixture shall be applied at a rate of 20 PLS lb/acre. Fertilizer shall not be applied with this seed mixture. This mix shall include seasonal cover crop including the following grasses:

- 2 PLS lb/acre ..... Virginia Wild Rye
- 2 PLS lb/acre ..... Virginia Canada Wildrye
- 2.5 PLS lb/acre ..... Virginia Rough Dropseed
- 8.4 PLS lb/acre ..... Virginia Little Bluestem
- 0.4 PLS lb/acre ..... Virginia Purpletop
- 0.2 PLS lb/acre ..... Virginia Upland Bentgrass
- 0.8 PLS lb/acre ..... Virginia Partridge Pea
- 0.6 PLS lb/acre ..... Virginia Illinois Bundleflower
- 0.6 PLS lb/acre ..... Virginia Black-eyed Susan
- 0.4 PLS lb/acre ..... Virginia Showy Tick Trefoil
- 0.6 PLS lb/acre ..... Virginia Foxtail Barley Hordeum
- 0.6 PLS lb/acre ..... Virginia Purple Coneflower
- 0.4 PLS lb/acre ..... Virginia False Sunflower
- 0.2 PLS lb/acre ..... Virginia Common Milkweed
- 0.2 PLS lb/acre ..... Virginia Yellow Coneflower
- 0.1 PLS lb/acre ..... Virginia Wild Bergamot

A seasonal *cover crop* shall be applied with Seed Mixture Floodplain. The Spring Summer Cover Crop mix is applied during spring and summer months, no later than July 31. The Fall Cover Crop mix is applied in fall months and no earlier than August 1.

Cover crops shall be applied at 50 PLS lb/acre, and include:

a. Spring Summer Cover Crop
   - 35 lb/acre.....Common Oat
   - 15 lb/acre.....Annual Ryegrass
b. Fall Cover Crop
   - 35 lb/acre.....Cereal Rye Secale cereal
   - 10 lb/acre.....Austrian Winter pea Pisum sativum
   - 5 lb/acre..... Crimson Clover Trifolium incarnatum

Do Not Spray" signs shall be placed near the beginning and end of this work, at 200 ft intervals, or as otherwise directed. The sign shall be 16-gauge aluminum. The size and message arrangement shall be as shown on the plans. The sign background shall be white. The sign lettering shall be black. The sign shall not be reflectorized. Paint and primer shall be in accordance with **909**. The signpost shall be placed as shown on the plans. The post shall otherwise be in accordance with Section **910**.

SEASONAL LIMITATION

The Contractor is required to post a warranty bond for all permanent seeding done from October 16 through January 31. Only completed seeding with seed mixtures R, U, or P require the warranty bond. Mulchless seeding may not be done from May 1 to August 15.

APPLICATION OF MULCHING MATERIAL

The next step in the process of seeding is the placement of a mulching material. Mulch for seeding may consist of:

1. Straw
2. Excelsior mulch
3. Excelsior blankets
4. Paper mat
5. Straw mat
6. Wood cellulose fiber mulch

Sections **621** and **914** contain requirements for manufactured mats.

Excelsior mulch is wood fiber cut from sound green timber. The fibers are required to have an average length of 4" to 6" and cut at a slight angle to the natural grain, causing the fibers to splinter. The splintering in turn provides adherence of the fibers to the soil during weathering.

Wood cellulose fiber mulch is made from wood chip particles. These particles are manufactured such that they may be discharged uniformly. The placement is done by a hydraulic water sprayer. The sprayer is required to agitate the particles to keep the material suspended in the water, thus yielding a uniform cover. The wood cellulose mulch fibers intertwine physically to form a strong moisture holding mat on the ground surface. The wood cellulose mulch is placed at a rate of 1 ton/acre within 24 hours after seeding.

PLACEMENT OF MULCH

Mulching material is applied uniformly in a continuous blanket at the rate of 2 tons per acre. Too much mulch is not only wasteful but will retard the growth of the vegetation. Too little mulch does not afford sufficient protective cover for the seed. Mulch is required to be placed within 24 hours after seeding. The percent of moisture in the mulch is determined in accordance with Section **621.**

Adequate provisions for holding the mulching material in place is important. Unless the mulching material is retained, winds or traffic blasts adjacent to the pavement may displace the mulch. Satisfactory and approved methods include Punching and Methods A through E, covered below. Methods A, B, C, D, and E are permitted on slopes steeper than 3:1 and may otherwise be specified by the contract proposal or the PEMS.

PUNCHING

The most common method is punching. The punching operation partially covers the mulch with soil. The tool used for the punching is required to have:

1. Disks that are notched.
2. Disks with 16" minimum diameters.
3. Disks that are flat or uncupped.
4. Disks spaced a maximum of 8" apart along the axle.
5. Disks performing longitudinally with the mulch tiller.
6. Axle sections not exceeding 8 ft in length.
7. The capabilities to have weight or hydraulic force push the disks into the ground.

METHOD A

In Method A the mulch is held in place by use of a mulch binder in accordance with applicable State and Federal regulations and applied according to the manufacturer's instructions. The product contains a coverage indicator to aid in visual inspection for evenness of application. If the mulch fails to stay in place, the Contractor is required to repair all damaged areas.

METHOD B

In Method B, the mulch is held in place by spraying the mulch with a satisfactory liquid asphalt or asphalt emulsion. This material may be applied immediately after the mulch is placed or may be injected into the mulch as the mulch leaves a power-driven mulch spreader.

If applied to the mulch surface, the asphalt is applied at a rate of approximately 0.06 gal. per square yard. If applied with the mulch through the spreader, the rate is approximately 60 gal. per 1 ton of mulch. The exact amount is required to be as directed.

METHOD C

Method C utilizes binder twine and wooden pegs to hold the mulch in place. The pegs are required to be not less than 6" and spaced 4 ft apart. The twine is placed parallel to the pavement. Additional twine is placed at 60 degrees with the pavement edge in both directions. The diagonal strands are spaced 12 ft center to center along the parallel strands. The next parallel strand is spaced at the intersections of the diagonal strands. This intersection is 12 ft from the previous parallel strand intersection measured along the diagonal strand.

METHOD D

In Method D the mulch is held in place with a polymeric plastic net. During placement, it should:

1. Be unrolled such that the mulch lays out flat, evenly, and smooth. The mulch is not stretched.
2. Be held in place by wire staples, spaced 4 ft apart with alternating spacing.
3. Be secured at top and bottom of the slope with staples 1 ft on centers.
4. Be overlapped 4" and stapled on the ends and edges.
5. Be placed with the material length running from top of slope to toe of slope or the length running horizontally or parallel to the contour.
6. Be stapled 1 ft on center along overlaps parallel to the slope.
7. Be stapled 3 ft on center along overlaps perpendicular to the slope.

METHOD E

For Method E the area is covered with erosion control blankets. The Contractor is allowed to use excelsior blanket, paper mat, or straw mat where mulched seeding or erosion control blanket is specified. Wood cellulose fiber mulch may be used where mulched seeding is specified. Section **621** includes information on applying fertilizer, seed, and mulch.

ACCEPTANCE OF MATERIALS

Grass seed is required to be received:

1. Bagged proportionately.
2. Fully tagged. The tag contains the following vital information:
    a. Mix composition which match the Specifications.
    b. Source of supply. The source of supply is required to hold an approved and accepted Indiana State Seed Permit, be tested by a USDA accredited seed laboratory or Indiana State Seed Laboratory and provide test results, and provide a type Other (ITM 804) certification.
    c. Seed will be considered expired 15 months after the date it was tested. Seed beyond the expiration date is not used or may be retested. If retested, the new germ date will be used, the 15-month window will be reset and the label updated.

The acceptance of mulch is dependent upon the mulch being used and the purpose of use. Material acceptance will be in accordance with the Frequency Manual. The following are specific types of mulches that may be used:

1. Wood cellulose fiber
2. Excelsior blankets
3. Paper mats
4. Straw mats

In accordance with the Frequency Manual, some mulches are tested to verify the moisture requirements. One test is required for each 40 tons of mulch. Additional tests may be required if visual inspection indicates a significant amount of moisture in the mulch.

Fertilizer standards are covered by the guidelines of the Indiana State Seed Commission. The Technician is only concerned about the analysis of the fertilizer. If fertilizer is bagged, the bag is required to contain the analysis of 12-12-12. Acceptance of fertilizer will be in accordance with the Frequency Manual. A visual inspection is made of the bulk material to assure that the fertilizer has never been extremely wet. This may be detected by many large, discolored clumps.

MEASUREMENT AND PAYMENT

The measurement and payment of seeding items are per the contract unit by specified type completed and in place. The contract list of pay items may specify separate items for seeding and mulching or may utilize only one item such as “Mulched Seeding, Class____, Type____”.

If seeding is paid by separate bid items, the units normally are as follows:

1. Seed Mixture — per Pound
2. Fertilizer — per Ton
3. Mulching Material — per Ton

If seeding is paid for by separate bid items, the Technician is required to verify that the seed is weighed each day and the proper reports are made. If fertilizer is paid for by separate bid items, counting sacks of fertilizer used each day then multiplying by the weight of one sack to obtain the daily record of fertilizer is allowed.

If mulching is paid for by separate bid items, the material is paid for by the ton; therefore, each truck load is required to be weighed and a weigh ticket made. Representative samples are required to be taken from the mulching material to determine the amount of moisture in the material in accordance with Section **621**. This sample is weighed at the time of delivery, then re-weighed when the mulching material is dry to determine the moisture content. To determine the moisture, this sample is placed in a large burlap sack then placed in a suitable location to dry. The number of samples required depends on the total amount of mulching required, weather conditions, and the sources of supply.

If the contract proposal has an item of "mulched seeding", then measurement and payment is different. The item "mulched seeding" includes all ingredients needed to complete the seeding operation. (i.e., the seed, fertilizer, water, and mulching material.) Mulched seeding is measured and paid for by the square yard.

CHAPTER SEVENTEEN: *SODDING*

Sod is grass which is cut from a well-established field of grass and placed at other locations. The locations at which sod is placed is determined by the plans and as directed by PEMS.

Nursery sod and sod are the two types of sod listed in the Specifications Section **621**. Nursery Sod is required to meet the requirements for sod. Nursery sod is a variety or blend of Kentucky bluegrass and is required to comply with nursery inspections and plant quarantine regulations of the States of origin. Nursery sod is required to comply with Federal regulations governing interstate movement of nursery stock. A valid copy of the certification of nursery inspection is required to accompany each shipment. Sod and/or nursery sod are generally placed at the following locations:

1. Slopes steeper than 3:1.
2. Slopes where runoff from the adjacent property may cause erosion.
3. In front of dwellings.
4. In ditches with a grade of 1% to 3%.
5. Adjacent to curbs, sidewalks, inlets, end sections, paved side ditch, etc.
6. In areas where mulch seeding does not serve satisfactorily.

PREPARATION OF GROUND BEFORE SODDING

The area to be sodded is required to be smooth, uniform, and in accordance with the required cross section. Surfaces prepared for sod are required to be of sufficient depth below unseated areas so that newly laid sod is level with the surrounding surface. For those areas which are covered with topsoil, the procedure for the application of topsoil is required to be in accordance with Section **621**.

After the area has been prepared for sod, fertilizer is applied at the rate of 400 lb/acre. The surface is loosened to a depth of 1" to 2" and then raked before the sod is placed. All clods, lumps, boulders, or waste material are removed. In areas where the above method of preparation is impracticable, a different method may be approved.

Notching for sod is required to be of sufficient depth that newly laid sod is level with the surrounding soil surface. Notching reduces the possibility of the sod edges from drying out and dying. Notching is required to be done when sodding is layed adjacent to:

1. Surrounding soil
2. Sidewalk and curb
3. Existing sod
4. Pavement

Notching is not required along paved side ditch, end sections and graded box end sections, or curbs along slope walls.

LAYING SOD

Sod strips are required to be laid by hand in the designated direction. The sod is fitted to the surrounding grade and fixed objects and is butted together closely to avoid open joints.

Overlapping of sod is not permitted. After laying and initial watering, the sod is tamped or rolled to ensure contact with the soil underneath and to be level with the surrounding surface. After compaction, the sod is required to present a smooth even surface free from lumps and depressions. On slopes of 3:1 or flatter, the use of broken sod strips is permitted. Where broken pieces are laid, no overlaps are allowed.

Sod placed in ditches with grades steeper than 1% and on slopes 3:1 and steeper are required to be pegged. The pegs are spaced not over 2 ft apart in each strip, measured lengthwise of the strip. Pegs are required to be driven down until no more than 1" protrudes above the surface of the sod. Grades and slopes flatter than specified are required to be pegged as directed.

Pegs are required to be wood and be at least 0.5" by 0.75" by 12". Instead of pegs, T-shaped wire pins may be used. T-shaped pins are required to be machine bent from 8 gage low carbon steel with a minimum of an 8" leg, a 4" head, and a 1" secondary drive. Pins are driven flush with the top of the sod.

Sod laid during the months of June, July, and August, is subject to the following conditions:

1. Sod must be in good, live, and growing condition at time of cutting.
2. Sod must be placed within 36 hours after cutting and during that period be protected from damage.

WATERING SOD

Sod is watered immediately after laying. The amount of watering is required to be sufficient to saturate the sod and the upper few inches of the underlying soil. The sod is required to be watered once each day of the first week, once every second day of the second week, once every third day of the third week, and once a week thereafter. Sod is maintained for a minimum of four weeks from the time the sod is laid before being accepted. During periods of ample rainfall, watering may be modified to simulate the above schedule.

Winter sodding is allowed when the temperature is above 35° F. No frozen sod may be laid, and no sod may be laid on frozen soil. Sod is required to be properly protected from drying and be laid within 48 hours after cutting.

MEASUREMENT AND PAYMENT

Sodding will be measured by the square yard. The field measurements are taken to the nearest 0.1 ft. The computation of individual areas is required to be to the nearest 0.1 yd^2. Once individual areas are totaled, the final sum is rounded to the nearest whole square yard.

The sod is required to be free from all primary noxious weeds. Sod is accepted by visual inspection. Acceptance in the field before cutting does not preclude rejection of the sod when delivered to the contract site.

Sodding and Nursery Sodding is paid for at the contract unit price per square yard, complete in place. The accepted quantity of fertilizer furnished and delivered complete in place is included in the price for sodding. The cost of watering, excavating the earth bed, disposal of surplus material, and other necessary incidentals are included in the cost of sodding. Topsoil if specified is paid for at the contract price per cubic yard.