6-601 PIPE CULVERTS—GENERAL

6-601.1 GENERAL

Proper drainage affects a roadway's service life. In addition to providing for existing natural drainage channels through the project, a roadway drainage system provides for the collection and disposal of surface runoff. Runoff that is collected from the roadway is carried to natural drainage channels or existing drainage systems within the right of way. In areas with groundwater that may affect the roadway structural section, groundwater drainage systems are incorporated into the design.

During the design phase, drainage systems are designed to accommodate existing drainage channels and roadway runoff. In urban areas, surface drainage is conveyed underground through a storm drain system. A storm drain system is a network of drop inlets, catch basins, pipes, and box culverts. In storm drain systems, because drainage flows by gravity, culvert grades and elevations must be closely controlled and monitored. Conditions can change from the time when the design was completed until the start of construction. The Resident Engineer should evaluate the adequacy of the designed drainage systems in relation to current field conditions. The Resident Engineer should carefully review the plans and specifications, giving special attention to environmental and right-of-way provisions. The plans and specifications reflect the environmental, right-of-way, and other NDOT commitments made before construction of the project.

To identify areas where drainage may be a concern, the Resident Engineer should observe drainage flows during storms. Observing the flow characteristics of the storm water runoff allows the Resident Engineer to assess the adequacy of existing and proposed drainage improvements. When reviewing drainage flows, observe the sufficiency of openings and the size and alignment of ditches and culverts. NDOT periodically constructs drainage facilities for other governmental entities. Because drainage facilities on a project are part of a larger, more complex drainage system, the Design Division Hydraulics Section plays an active role in decisions affecting drainage facilities. The Resident Engineer should discuss any concerns or proposed changes with the Design Division Hydraulics Section, which must approve any changes.

Culverts used in roadway projects are constructed of several types of materials, such as concrete, steel, and plastic. Common types of culverts used on NDOT projects are nonreinforced and reinforced concrete pipe, corrugated metal pipe, plastic pipe, and metal arch pipe. Culverts may have a variety of treatments at the ends of the culvert. Examples include end sections, headwalls, manholes, drop inlets, or riprap basins.

Figure 6-601.1. Reinforced Concrete Pipe.

Figure 6-601.2. Corrugated Metal Pipe.

Figure 6-601.3. Plastic Pipe.

Figure 6-601.4. Metal Arch Pipe.

Construction and installation of culverts include excavation of trenches. Trench excavation may require shoring or sloping back of the trench walls to reduce the risk of the trench collapsing. Confirm that required shoring or sloping has been completed before entering a trench. If the trench dimensions require shoring or sloping back the trench walls for safety, the inspector should monitor the contractor's operations to verify that activities comply with the approved safety plan. The contractor must comply with the approved safety plan and Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) regulations.

6-601.2 BEFORE CONSTRUCTION

One of the first items of work relating to drainage is staking the culverts and other drainage improvements by the survey crew. Based on the information contained in the plans, field books are prepared consistent with the requirements of the *Documentation Manual.*

The objectives of any drainage improvement are to perpetuate existing drainage conditions and to accommodate modified flows resulting from the roadway project. Typically, the flow line grade and alignment of a culvert should be the same as the channel that it replaces. To meet the objective of perpetuating an existing drainage channel, the grade of a culvert may be changed, and it may also be extended, shortened, or realigned.

Based on information in the plans, and modifications required due to field conditions, the survey crew will stake the culverts. The survey crew chief documents the culvert survey information in a field book called the "pipe book." If the survey stakeout results in changes to pipe lengths, the Resident Engineer will inform the contractor of the modified pipe length quantities for each culvert. As stated in the specifications, the contractor orders pipe after the Resident Engineer furnishes a list of pipe sizes and lengths.

If field conditions require modifying a culvert, the following flow characteristics should be considered:

- A steep grade tends to allow debris and sediments to pass easily through the culvert, but it can increase abrasion along the flow line and increase erosion potential at the outlet.
- A flat grade tends to allow sediment to deposit in the culvert.
- The transition between an inlet channel and a culvert should be smooth without constricting the flow.
- Disturbance of vegetation and riprap may increase erosion around the culvert.
- The channel at the outlet of the culvert is susceptible to damage, even under normal flow.
- Modifying culvert inlets or outlets may require additional channel protection. Protection may extend upstream or downstream. Adjustments to the flow line require approval of the Design Division Hydraulics Section.

Before culvert installation begins, the inspector should review the plans and specifications for the location, type and size of culverts, and bedding required.

When inspecting culverts, consider the following:

- Upon delivery of material, verify receipt of proper material certifications. Inspect pipe material for cracks, defects, and damage that may have occurred during shipping.
- Obtain samples, if required, as indicated in Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.
- Check pipes for proper:
- Class, type, and size
- Thickness, gauge, and schedule
- Coating and lining
- Lengths of sections
- Review the safety requirements for trenching operations and confined space entry.
- Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.
- Check that manholes, inlets, and pipes are properly staked.
- Verify that staked locations and elevations are appropriate for existing field conditions.
- Verify that the contractor has contacted the "Underground Service Alert (USA)," located all underground utilities, and resolved all utility conflicts.

As with all elements of a construction project, safety is an NDOT priority. Construction and installation of culverts includes excavation of trenches that may require shoring or sloping back the trench walls to reduce the risk of trench collapses. The plans contain trenching details. Culvert installations frequently include movement of materials such as concrete and metal pipes being hoisted. Special attention is required to maintain an awareness of safe working conditions. The Resident Engineer and crew should review the contractor's safety plan related to trenching and excavations and be familiar with its requirements. Concerns or questions about the contractor's safety plan should be discussed with the contractor's safety officer.

6-601.3 DURING CONSTRUCTION

Installation of culverts includes excavation of material to construct the trench, preparation of the trench, placement of bedding material, placement of culvert, and backfilling. If a culvert is located in an embankment, the embankment is constructed and then the trenching operation is performed.

6-601.3.1 TRENCHING

If the trench dimensions require shoring or laying back the trench walls for safety, the inspector should monitor the contractor's operations to verify that activities comply with the approved safety plan. During the excavation operations, the inspector should frequently check the survey grade stakes. If discrepancies are noted or questions arise, the inspector should consult with the survey crew. The inspector should also be familiar with the requirements of the plans and specifications for excavating culverts. The inspector must check the excavation for correct depth, width, and alignment. Verify that the bottom of the trench has been properly graded and compacted. Compaction test results should be obtained from the tester to verify that the required compaction is achieved prior to pipe installation. Refer to Section 6-206, Structure Excavation for additional information.

6-601.3.2 BEDDING

The quality of the bedding directly affects the load supporting capacity of a culvert pipe. Bedding material for culverts must conform to the requirements of the specifications. The inspector must check the type and depth of bedding for conformance with the plans and specifications. Culvert installation begins at the downstream end unless otherwise specified in the plans or specifications. When installing culvert pipe, check that the entire length of pipe rests in contact with the bedding material at the proper flow line. Frequently check the alignment and elevation. Be exact in checking grade and alignment for sewer pipes. Because sewer pipes are commonly gravity flow and have a low flow rate, they will have specific elevation and grade requirements.

6-601.3.3 LAYING PIPE

Culvert pipe joints must be placed in conformance with the plans and specifications. Typically, the direction of joint laps is placed so that the bell or grooved end of concrete pipe or the outside laps of metal or plastic pipe are placed in the upstream direction. Placing the joints in this position improves the water tightness of the joint. Check that joints are properly sealed or banded, and snug. Verify that joints are grouted, where required. Any holes in the pipe material that were used for lifting must be plugged in an acceptable manner per the specifications. The inspector must check in-place pipe for damage before backfilling and again before accepting the work. The inspector should also confirm that any damage to coating or lining is properly repaired.

6-601.3.4 BACKFILL

The material around and above the pipe and the manner in which it is placed and compacted influences the culvert's ability to perform as designed and to achieve its design life. In general, the greater the compaction of the backfill under the haunches and along the sides of the pipe, the less the pipe will deform under load. Consistent and uniform compaction reduces settlement. Settlement of the backfill can result in an increased transfer of embankment load onto the pipe. Increasing loading of the pipe could deform the pipe, which weakens the pipe and causes separation of the pipe joints.

For these reasons, the backfill or embankment material adjacent to the pipe should be material free from large rocks and lumps, containing sufficient fines so it compacts to a relatively impervious mass. It must be compacted to a density and width not less than that required by the specifications. Care must be taken to obtain proper compaction under the haunches of the pipe and to place and compact the backfill uniformly on both sides of the culvert. Firm support must be obtained. Over-tamping of the haunches can cause the pipe to lift out of position. Proper backfilling can prevent culvert pipe failures. Backfilling in strict accordance with the specifications is required for the pipe to perform as designed. Refer to Section 6-207, Backfill for additional information.

Figure 6-601.5. Pipe Backfill.

The inspector verifies that the backfill material is placed and fully compacted in lifts of the required thickness. This operation must be performed equally and simultaneously on both sides of the pipe. The area under the haunches of the pipe is critical during the backfilling and compaction operation. Refer to Figure 6-601.5. Note that the required compaction must be obtained prior to placing successive lifts. Observe the operation to confirm that the compaction method does not cause pipe damage or displacement. The inspector should request compaction testing whenever the contractor's compaction methods change or appear inadequate.

The construction method of the embankment around and above the culvert largely affects the load that will be imposed on a culvert pipe. The plans show the maximum fill height allowed over various sizes and types of pipe. Equipment is not permitted to operate across the culvert until the embankment has been constructed to a safe minimum depth above the culvert, typically two feet. Concrete headwalls should be constructed as soon as the embankment is constructed to the height of the headwall so the ends of the culvert are protected during storms.

6-601.3.5 PIPE JACKING

Pipe jacking is a technique for installing underground pipelines and culverts, usually concrete pipes, by jacking, or pushing, pipes through the ground. Pipes can be jacked with little or no surface disruption. For large diameter pipes, excavation takes place as the leading edge of the pipe is pushed through the ground.

To install a pipeline using this technique, construct jacking pits at the beginning and ending points. The dimension and construction of a jacking pit depends on the equipment selected by the contractor.

A thrust wall is constructed to provide a support against which to jack. High-pressure hydraulic jacks provide the forces required for jacking concrete pipes. The ram diameter and stroke of the jack may vary according to a contractor's technique. To ensure that the jacking forces are distributed around the circumference of a pipe being jacked, a thrust ring is used based on the number of jacks being used. The jacks are interconnected hydraulically to ensure that the thrust from each is the same. The number of jacks used may vary because of the pipe size, the strength of the jacking pipes, the length to be installed, and the anticipated frictional resistance.

During the jacking operation, the pipe may veer off-line. The contractor should monitor the pipe alignment. Check the roadway surface for signs of upheaval or failure, and require immediate corrective action. When the plans and specifications designate jacking, proposed alternative methods require written approval by the Resident Engineer in coordination with the Design Division Hydraulics Section.

6-601.4 MEASUREMENT AND PAYMENT

Pipe used for culverts and other drainage improvements are typically manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If end treatments are to be constructed with the culvert, consult the specifications for measurement and payment for the end treatment. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-603 REINFORCED CONCRETE PIPE

6-603.1 GENERAL

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to reinforced concrete pipe. The guidelines in this section clarify the installation of reinforced concrete pipe. Reinforced concrete pipe may have circular or elliptical cross sections. The plans and specifications will specify the type of reinforced concrete pipe. When nonreinforced concrete pipe is specified, follow the guidelines for reinforced concrete pipe.

Following are the basic shapes of reinforced concrete pipe joints:

- Modified tongue and groove
- Tongue and groove
- Bell and spigot

Generally, use a rubber gasket for sealing concrete surfaces with opposing shoulders on both ends, such as the bell and spigot and the modified tongue and groove joints. Use preformed flexible joint sealants or mortar joints where lesser joint performance is required or where the product shape dictates the type of seal. Joints using flexible sealants typically perform as a soil-tight system unless the specifications describe higher performance expectations.

6-603.2 BEFORE CONSTRUCTION

Review the following guidelines before installing reinforced concrete pipe:

- At the contractor's option and expense, the contractor can use pipe that exceeds specified strength requirements.
- Inspect the pipe for damage. Minor hairline cracks and chips are not reasons to reject the pipe. However, the following problems are unacceptable:
    - Pipe with cracks through the wall
    - Exposed reinforcing steel
    - Damaged bells, spigots, or joint grooves
- Monitor the contractor's method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments according to the plans and specifications. Before the contractor installs pipe, the inspector determines the acceptability of excavations and any required bedding. For pipes with bell ends, confirm that the excavation and bedding uniformly support the pipe.

- For elliptical pipe, the top of the pipe must be marked.
- Store rubber gaskets in a cool place away from sunlight. If lubrication is required before installation, the contractor must follow the manufacturer's instructions.
- Before using joint mortar, the mortar aggregate must be approved.
- Ensure that certification of casting yard complies with specifications.

6-603.3 DURING CONSTRUCTION

The inspector should be familiar with the following guidelines before installing reinforced concrete pipe:

- Confirm that pipe of the specified size, type, and class is installed at the proper locations.
- Observe that pipes are placed with belled ends upstream. Where possible, lay pipes from lower to higher elevations. Laying pipe from the downstream end facilitates tight joints, particularly on steep grades. When extending an existing pipe downstream, the new pipe can be placed beginning at the existing pipe, continuing downstream, or beginning downstream and connecting at the existing pipe with a special connecting structure.
- When a section of pipe is placed, verify that the pipe elevation and alignment conforms to the plans.
- Ensure that joints have smooth, uniform interior surfaces. Unless otherwise required, joints must be sealed completely with mortar, rubber gaskets, resilient materials, or liquid sealing materials. Reject gaskets that have cracks or splits.
- Before the contractor places the backfill, confirm that lift holes are plugged.
- Use mortar within 30 minutes after adding water.
- Refer to Section 6-207 Backfill for additional guidance on backfill.
- Complete backfill while the mortar in joints is still plastic. However, after the mortar sets, backfill is prohibited until 16 hours after mortaring the joints and the mortar is cured in accordance with the specifications.
- Water cannot contact the interior of the pipeline until seals containing portland cement have aged 24 hours.
- Require backfilling in a manner that will not damage seals.
- For siphons and pressure pipes, perform hydrostatic testing required by the specifications before backfilling. Repair all leaks and other defects. If the pipe sweats but no flow develops, repair is not needed.
- Require minimum cover for construction loads, as shown in the plans and specifications.

- Protect pipes from damage during construction operations.
- Do not permit the pipe to be dropped onto the bedding to consolidate and mold the bedding. This is commonly called "battering" and is not allowed because of the potential to damage the pipe.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris.

6-603.4 MEASUREMENT AND PAYMENT

Reinforced concrete pipe is manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If culvert end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual.*

6-604 CORRUGATED METAL PIPE AND METAL ARCH PIPE

6-604.1 GENERAL

The discussion of pipe culverts in Section 6-601, Pipe Culverts – General, applies to corrugated metal pipe and metal arch pipe. The guidelines in this section clarify the installation of corrugated metal pipe and metal arch pipe. Corrugated metal pipe and metal arch pipe may have circular or near-circular cross sections. The plans and specifications will specify the type of corrugated metal pipe and metal arch pipe. When using slotted corrugated pipe to allow surface drainage to enter the pipe, install it flush with the top of dense-grade pavement before placing the open-graded surface.

6-604.2 BEFORE CONSTRUCTION

The inspector should review the following guidelines before installation of corrugated metal pipe:

- Inspect the pipe for damage. Damaged corrugated metal pipe should not be incorporated into the work.
- Monitor the contractor's method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments in accordance with the plans and specifications. Before the contractor installs pipe, determine the acceptability of excavations and any required bedding.
- If rubber gaskets are used, verify that the contractor stores the gaskets in a cool place away from sunlight.

6-604.3 DURING CONSTRUCTION

Be familiar with the following guidelines relating to installing corrugated pipe:

- Confirm that pipe of the specified size, type, and class is installed at the proper locations.
- Where possible, lay pipes from lower to higher elevations. Laying pipe from the downstream end facilitates tight joints, particularly on steep grades. When extending an existing pipe downstream, the new pipe is connected to the existing pipe, continuing downstream.
- When placing a section of pipe, verify that the elevation and alignment of the pipe conforms to the survey crew's stakeout.
- Corrugated metal pipe sections are joined with a coupler that is firmly bolted in place.
- Refer to Section 6-207, Backfill, for additional guidance on backfill.
- Require backfilling in a manner that will not displace joints.
- When used as siphons, corrugated metal pipe seams are soldered and couplings incorporate a rubber or other approved gasket material. Fill the siphon pipe with water and repair leaks before backfilling.
- Require minimum cover before any loads are placed on the pipe.
- Protect pipes from damage during construction operations.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris. Verify that the pipe has not been deformed.

6-604.4 MEASUREMENT AND PAYMENT

Corrugated metal pipe and metal arch pipe are manufactured in standard lengths. The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If culvert end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-605 PLASTIC PIPE

6-605.1 GENERAL

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to plastic pipe. The guidelines in this section clarify the installation of plastic pipe. Plastic pipe can have a solid wall or it can be perforated to allow water to enter or exit the pipe. The plans and specifications will specify the type of plastic pipe.

6-605.2 BEFORE CONSTRUCTION

Review the following guidelines before installation of plastic pipe:

- Inspect the pipe for damage. Do not incorporate damaged plastic pipe into the work.
- Review manufacturer's recommendations on exposure of pipe to the elements.
- Monitor the contractor's method of handling pipe to confirm that the pipe is not damaged.
- Before structure excavation, the contractor constructs embankments in accordance with the plans and specifications. Before the contractor installs pipe, determine the acceptability of excavations and any required bedding.

6-605.3 DURING CONSTRUCTION

Be familiar with the following guidelines before installation of plastic pipe:

- Verify that pipe of the specified size, type, and class is installed at the proper locations.
- Lay pipes from lower to higher elevations.
- When a section of pipe is placed, observe that the elevation and alignment of the pipe conforms to the survey crew's stakeout.
- Refer to Section 6-207, Backfill, for additional guidance on backfill.
- Require backfilling in a manner that will not displace plastic pipe or cause the pipe to float.
- Require minimum covers, as required by the manufacturer or as shown in the plans and specifications.
- Protect pipes from damage during construction operations.
- After the pipes have been installed and before the project is completed, the inspector should verify that the pipes are clean and free of dirt and other debris, and undamaged.

6-605.4 MEASUREMENT AND PAYMENT

The length of pipe measured for payment is the total length necessary to be placed before cutting, if cutting is necessary. If plastic pipe end sections are incorporated into the work, structure excavation and backfill associated with the end sections are not paid, but included in the cost of the end section. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-606 STRUCTURAL PLATE CULVERTS

6-606.1 GENERAL

Figure 6-606.1. Structural Plate Culvert.

When the size and shape requirements of a culvert exceed the capabilities of corrugated metal pipe, structural plate culverts can be used. Structural plate culverts are manufactured and transported to the jobsite where the components are assembled to construct the culvert. Structural plate culverts are fabricated based on the requirements of the plans and specifications.

The contractor develops shop drawings based on the requirements of the plans and specifications. The contractor submits the shop drawings to the Resident Engineer. The Resident Engineer submits the shop drawings to the Structures Division for review and approval. Based on the approved shop drawings, the structural plate culvert is manufactured. The manufacturer provides assembly instructions showing the position of each plate and assembly sequence. The inspector should be familiar with the plans and specifications relating to the structural plate culvert. Verify that anchorage assemblies are installed according to the plans and the manufacturer's recommendations. The discussion of pipe culverts in Section 6-601, Pipe Culverts – General, and in Section 6-604, Corrugated Metal Pipe and Metal Arch Pipe, also apply to structural plate culverts.

6-606.2 MEASUREMENT AND PAYMENT

The length of structural plate culvert measured for payment is the average of the top and bottom centerline lengths. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-607 UNDERDRAINS

6-607.1 GENERAL

Underdrains are pipes that intercept underground flow and seepage to drain the roadway structural section. The most common use of underdrains is to intercept subsurface water moving toward the roadway. A system of interconnected underdrains can be used to remove the groundwater when drainage of a large area is necessary. Typically, a system of interconnected underdrains may include a drain backfill with a geotextile fabric to prevent sediment from entering the underdrains. Cleanouts are constructed at regular intervals and other locations, such as junctions. Cleanouts provide access to the underdrains for maintenance.

The discussion of pipe culverts contained in Section 6-601, Pipe Culverts, and related sections pertaining to the specific pipe material apply to underdrains.

6-607.2 MEASUREMENT AND PAYMENT

Pipe connector pieces, such as bends, wyes, and tees, are measured as pipe along centerlines and included in the quantity of underdrain pipe length. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-608 DOWNDRAINS

6-608.1 GENERAL

Downdrains are drainage systems that convey water down roadway slopes in a manner that prevents slope erosion. Downdrains are constructed to allow drainage from fill embankments, benches in cut sections, and other steep or long slopes. Downdrains are often placed near bridges to remove runoff from the roadway before reaching the structure. A downdrain system consists of a catch basin (embankment protector), downdrain pipe and anchors, end section, and riprap. Downdrain placement is important to ensure that drainage is collected and passed down the slope. Metal corrugated pipe and plastic pipe are the most commonly used downdrain pipes. Downdrain pipes are constructed so that the outlet end of the pipe extends to or beyond the toe of the slope to prevent erosion. Observe that anchorage assemblies are installed according to the plans and the manufacturer's recommendations. The discussion of pipe culverts contained in Section 6-601, Pipe Culverts – General, applies to downdrain pipes. Consult the plans and specifications regarding the type of inlet and outlet structure for each downdrain.

6-608.2 MEASUREMENT AND PAYMENT

The length of downdrain pipe measured for payment is the total length placed. Structure excavation, backfill, and riprap are not measured for payment in downdrain systems, but are included in the cost of other items. Pipe connector pieces are not directly paid for, but are included in the quantity of underdrain pipe length. Anchor assemblies are paid individually. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-609 CATCH BASINS, MANHOLES, AND INLETS

6-609.1 GENERAL

Catch basins, manholes, and inlets are structures that connect to pipes and culverts. Section 609 of the specifications describes the requirements of materials and construction. Unless otherwise specified in the plans or specifications catch basins, manholes, and inlets may be precast or cast-in-place. The traffic control requirements of the project influence the structure type selection, construction materials, and construction method. For example, if disruption of traffic must be kept to a minimum, pre-cast structures and quick-setting concrete could be used to reduce construction time and allow traffic to return to the roadway.

6-609.2 BEFORE CONSTRUCTION

Before starting work on drainage structures, review the plans and specifications. Verify existing drainage conditions, and check that the structures are staked at the proper location and elevation. Consider the following:

- Review safety requirements for trenching operations and confined space entry. Do not enter manholes, inlets, vaults, trenches, or other confined spaces without taking the proper safety precautions.
- Conduct periodic field inspections at the precast yard to verify that structures are constructed as detailed in the plans. Upon delivery of precast structures, verify receipt of proper material certifications. Check the type and dimensions of precast items for conformance. Where applicable, check the spacing of stair rungs for compliance. Pay particular attention to defects and damage that may have occurred during shipping.
- Where cast-in-place structures are used, check forms and reinforcing steel for proper condition and dimension.
- Verify the contractor has provided all survey tie records, including permanent reference ties, to all covers to be adjusted and submits the documentation to the Resident Engineer before paving or making any adjustments.
- Clearly mark frames and matching lids as matched pairs to ensure that each lid is placed on its matching frame.

6-609.3 DURING CONSTRUCTION

Consider the following during construction of catch basins, manholes, and inlets:

- Verify receipt of proper certificates of compliance.
- Check pipe invert and flow-line elevations.
- Provide a smooth flow line between manholes and pipes. Check that a watertight union with pipes is achieved. Where precast sections are used, check that clean joints are constructed. Verify the proper use of concrete adjustment rings and mortar to make field adjustments. Verify that special coatings that may be required by the specifications are applied.
- Check for proper dimension, formwork, concrete placement, and curing.
- Check grates for acceptability with respect to type, dimension, orientation, and galvanization. Grates and their matching frame must be delivered to the project together.
- Check the type, label, dimension, and utility company marking of manhole covers for compliance with specifications. Where located within pavements, check the slope and elevation of covers.
- When adjusting existing covers:
    - Verify adjustments are made by one of the methods described in the specifications.
    - Confirm that frames and lids are installed as matched pairs.
    - Verify that the material around the structure has been compacted prior to placing concrete for collars
    - Replacement collars must be the same diameter as the original collar. If a smaller diameter collar is used, the structural section must be replaced. The patched roadway structural section must match the thickness of the adjacent section, prior to placement of the smaller diameter collar.
- Review the specifications for mortar or grout requirements. Verify that any needed mortar repairs and grouting around pipe and grade rings are properly performed.
- Verify concrete and reinforcement in the manhole collars comply with plans and specifications.
- Concrete patching material must be approved for use.
- Obtain local agency or utility company acceptance after covers are adjusted.

6-609.4 MEASUREMENT AND PAYMENT

Because third parties may reimburse NDOT for the costs of manholes or manhole adjustments, accurately document the ownership of the manholes in the appropriate field book. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-610 RIPRAP

6-610.1 GENERAL

Figure 6-610.1. Riprap.

Erodible slopes within the right-of-way are typically treated with an erosion control measure. A common type of erosion control is riprap. Riprap is the careful placement of relatively large stone on the erodible slope. Riprap is also used at culvert inlets and outlets to protect natural ground from erosion and as a means for dissipating energy from flowing water. Because conditions that require riprap are variable, different types or classes of riprap are required. The classes of riprap are described in the specifications. For additional erosion control protection, riprap may be grouted.

6-610.2 BEFORE CONSTRUCTION

Before construction begins, consider the following guidelines:

- Review the plans and specifications with respect to the location, limits, and type of material required. Pay particular attention to the nominal size and material requirements of the stone, and placement depth.
- Review the requirements for riprap with respect to nominal size, shape, specific gravity, gradation, abrasion resistance. To reduce the likelihood of riprap stones moving under flowing water, specific gravity of the riprap is specified. The inspector should confirm the specific gravity of the riprap to be used by verifying that the source of the riprap has been approved. Visually observe the required material samples from the material source and jobsite for compliance with specification requirements. Where the material is suspect, request lab results for verification or require the contractor to provide the necessary equipment for gradation testing.
- Verify the acceptability of the slope after it is prepared, including the bedding for riprap if required. Check the excavation for the toe or cut-off wall, where required, to confirm that it conforms to the lines designated in the plans.

6-610.3 DURING CONSTRUCTION

The stone for riprap is generally placed and spread using a combination of mechanical and hand methods. Before the riprap is placed, observe the placement of bedding material to confirm that the bedding is placed as stated in the plans and specifications. The contractor should place riprap so that it is tight, stable, and closely conforms to the details shown in the plans. Verify the depth of the riprap. Regardless of the contractor's placement method, the final surface should appear relatively smooth with interlocking faces of adjacent stones. Riprap is typically placed in a single layer by a means that does not cause segregation.

6-610.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-611 CONCRETE SLOPE PAVING

6-611.1 GENERAL

Concrete slope paving is used primarily for erosion control and is typically used on slopes around major structures. Concrete slope paving is typically a Class A or a Class AA portland cement concrete with fiber reinforcement. Section 501, Portland Cement Concrete, of the specifications describes the concrete requirements. Guidance on concrete inspection is provided in Section 6-501, Portland Cement Concrete.

6-611.2 BEFORE CONSTRUCTION

Before concrete slope paving begins, consider the following guidelines:

- Review the plans and specifications. Pay particular attention to the location, limits, depth, and type of slope paving required.
- Review Section 6-501, Portland Cement Concrete.
- The contractor must have an approved mix design for concrete used in the slope paving. The concrete materials, including reinforcing fibers and color pigmentation, are described in the plans and specifications. Check the required materials for compliance, including required material certifications.
- Confirm that the area to receive slope paving is properly graded, compacted, and free of unsuitable materials. Check the toe or cut-off wall excavation for conformance to plans and specifications. Figure 6-611.1 shows a slope paving cut-off wall excavation. Where unsuitable soil material is encountered, it may be necessary to replace the material. The grading of the slope may need to be adjusted in the field to match the ditch line or other boundaries. If the grade of the slope paving is adjusted in the field, the adjustment must be to flatten the grade, not to make the grade steeper.

Figure 6-611.1. Slope Paving Cut-Off Wall Excavation.

6-611.3 DURING CONSTRUCTION

Review the plans and specifications to confirm that the contractor mixes and places concrete as required. Where forms and reinforcement are required, check the acceptability of forms and the placement of reinforcement. Verify that header boards are anchored. Monitor the depth of paving for compliance, and confirm that expansion joint materials, where required, are placed at the proper thickness and location.

Concrete consolidation is more effective with manual consolidation techniques, such as using a hand-tamping tool, rather than with mechanical internal vibrators, which may cause the wet concrete to flow out of the forms. Concrete slope paving is placed, starting at the bottom, moving up the slope. Verify compliance with requirements for slope paving during inclement weather, curing method and material, surface moisture, and curing period. The surface to receive concrete slope paving must be pre-wetted before placing concrete to reduce moisture loss in the concrete.

6-611.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-612 COATINGS

6-612.1 GENERAL

This section relates to graffiti resistant coatings applied to surfaces. Graffiti resistant coatings are proprietary. Therefore, follow the manufacturer's instructions. Before beginning application of the coating, the inspector should become familiar with the specifications and manufacturer's recommendations.

6-612.2 BEFORE CONSTRUCTION

Consider the following:

- The Resident Engineer should verify with the District Engineer the limits of the coating to be applied.
- Understand the specifications and manufacturer's recommendations related to coatings.
- When applying coatings to new concrete surfaces, confirm that the concrete has cured for at least 30 days, or as recommend by the manufacturer.
- When applying coatings to stained or painted surfaces, diligently follow the manufacturer's recommendations. Special consideration may be needed for freshly stained or painted surfaces.
- Be aware that graffiti-resistant coatings include several components that must work together as specified by the manufacturer. Therefore, the success of the coating depends strongly on proper surface preparation and application, including appropriate cure times of the individual component materials.
- Confirm that the technical representative for the manufacturer has been notified of the application schedule.

6-612.3 DURING CONSTRUCTION

Be familiar with the following:

- Confirm that the manufacturer's technical representative is on-site and has verified that the application process complies with the manufacturer's recommendations.
- Observe that the surface to receive the graffiti-resistant coating is prepared consistent with the manufacturer's recommendations.
- Document the surface preparation with sufficient detail to provide information if the coating does not perform as anticipated.
- Monitor the application of the graffiti-resistant coating, noting the application rate and the cure time between coats.

6-612.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-613 CONCRETE CURBS, GUTTERS, AND SIDEWALKS

6-613.1 GENERAL

This section covers concrete curbs, gutters, and sidewalks. Concrete curbs, gutters, and sidewalks are constructed on a solid foundation, typically base course material, which has been graded and compacted. Curb and gutter systems must be constructed so that water will not pond on the roadway or flow randomly over fill slopes. For additional information, refer to the following sections: Section 6-501, Portland Cement Concrete, Section 6-501, Concrete Structures, and Section 6-505, Reinforcing Steel.

Curbs and gutters have two purposes: first as a gutter to direct drainage from the roadway, and second for safety, to keep motorists on the roadway. A gutter guides water from rain and melted snow and ice into the storm drains, so that it does not accumulate on the surface. A curb channels the movement of traffic and redirects vehicles. Since curbs, gutters, and sidewalks add to the cost of a road, they are generally limited to urban areas, and they are rarely built in rural areas except where certain drainage conditions make them necessary.

6-613.2 BEFORE CONSTRUCTION

Before the contractor constructs curbs, gutters, and sidewalks, the inspector should do the following:

- Review the plans and specifications for details about the project's concrete curbs, gutters, and sidewalks, and compare these details with conditions in the field.
- If the Resident Engineer decides that curbs, gutters, or sidewalks are required, in addition to those shown on the plans, the Resident Engineer should consult with the District Engineer and the Design Division. When adding curbs, gutters, or sidewalks, the Resident Engineer should confirm the following:
    - Conformance to the current policy of replacing existing facilities.
    - Compliance with requirements of the Americans with Disabilities Act (ADA).
    - Compliance with agreements.
    - Placement that provides proper drainage.
- Discuss the construction operation with the contractor. Determine whether the contractor has considered the public's convenience. The contractor must accommodate vehicle and pedestrian traffic in conformance with the specifications. Advise the contractor of any necessary modifications to the operation.
- Make a general check of the layout as staked, including the location of gutter depressions, curb ramps (wheelchair ramps), and driveways. Also, review the survey stakeout for accuracy.
- Mark and measure sections identified for removal before removal operations begin. Coordinate with the contractor regarding removing sections to the nearest existing joint.

- Review the location and construction details of curb ramps that are designated in the plans. Pay particular attention to the slope and surface finishing requirements of curb ramps. A textured surface finish or detectable warning devices are used, and field adjustments may be needed to meet slope requirements. Confirm that adjustments comply with ADA requirements.
- Review the locations of drainage structures to confirm that no new drainage structures are aligned with curb ramps.
- Verify that there is an approved concrete mix design for the curbs, gutters, and sidewalks.
- Examine the base material to verify the following:
  - The base has been constructed to the proper elevation and cross section.
  - The foundation has been watered and compacted.
  - The appropriate density tests have been taken and meet the minimum density requirements.
  - The base is wet immediately before placing concrete.
- Check that the contractor has adequate materials on hand to cure and, as needed, protect the concrete during inclement weather.
- Verify the contractor has implemented appropriate measures for washing out concrete mixer trucks.
- Confirm that gutters will drain. When new curbs or gutters are to join existing facilities, confirm that the survey crew has checked the existing elevations against the planned grades.

6-613.3 DURING CONSTRUCTION

Once work begins, take these steps:

- Examine the forms to verify the following:
  - Forms are placed to the lines and grades staked by the survey crew.
  - The forms are smooth on the side next to the concrete.
  - Forms have a true, smooth upper edge.
  - Forms are full depth.
  - Forms are rigid enough to withstand the pressure of fresh concrete without distortion. Replace forms that will not produce an end product within specified tolerances.
  - Forms are coated with form oil as specified.
- Confirm the contractor adjusts the forms to remove any unsightly changes in vertical or horizontal alignment. Adjustment from staked grades is sometimes necessary near joints with existing curbs or sidewalks.

- Pay particular attention to how forms are set with respect to locations of drop inlets, curb ramps, and driveways; make adjustments where needed.
- Finished appearance is important and is noticeable by the public. Do not directly use existing edges of pavement and sidewalks, or existing pavement surfaces to establish a grade line for curbs.
- Where reinforcing steel is required, check spacing, clearance, and supports for acceptability.
- Confirm that joints are scored as specified.
- If the plans and specifications require adhesive to bond the concrete to the pavement surface, verify that the contractor cleans the pavement as specified and uses the required adhesive.
- Inspect the placement of weakened plane and expansion joints to confirm that they are constructed as specified.
- Refer to Section 6-501, Portland Cement Concrete, for inspection requirements related to concrete placement.
- Observe concrete as it is placed. In the daily construction report, record the reasons for rejecting any concrete and the approximate amount rejected. Confirm that the contractor does not allow concrete to segregate while being placed and consolidated in the forms. Stop the operation if the concrete requires patching with grout or mortar. Inform the contractor to take corrective measures when concrete placement does not meet the requirements of the specifications.
- When corrective measures are necessary, advise the contractor and Resident Engineer, being specific as possible, and document the discussion in the daily construction report.
- Check that transverse expansion joints are located and constructed in conformance to the specifications. Joint types and locations should match those in adjacent concrete. Verify that edging is performed where required.
- Before the forms are removed, confirm that the contractor uses the required trowel to finish the concrete surface as specified.
- Prohibit excessive finishing and addition of water. Confirm that the finishing meets specifications, and measure the finished product to verify it conforms to the required tolerances.
- Verify that concrete cures for the specified curing period. Verify an approved curing compound is applied to exposed concrete surfaces and that the rate and time of application is acceptable. Confirm that the contactor complies with the provisions for concrete protection during cold weather.
- Do not begin form removal and backfill until the concrete is strong enough to prevent damage. Confirm that the edges are adequately shouldered. Watch for damage to the concrete during the backfill operation.
- Verify that the contractor does not place concrete on frozen or ice-coated material and protects the concrete after placement according to the specifications.

Construct curbs and gutters using either forms or equipment, such as a curb and gutter extrusion machine. The inspector must verify that the machine is configured to produce the required cross section. Typically, the extrusion machine uses a guide wire to control the vertical and horizontal alignment. The survey crew should check the guide wires to verify the correct vertical and horizontal alignment before beginning the concrete placement.

Extrusion machines typically require clearance to operate the equipment. The amount of space depends on the type of equipment used by the contractor. Discuss these details with the contractor. Because the concrete is supported for a relatively short time, a low slump concrete is used to retain the desired shape. The extrusion machine should produce a consistent and uniform concrete surface with no major defects. Curing and protection requirements of the concrete remain the same as when forms are used. All exposed surfaces must be cured.

6-613.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-614 PAINTING

6-614.1 GENERAL

This section addresses the painting requirements for steel and concrete structures. Section 714 of the specifications covers specific paint specifications for different surfaces. Paint removal, disposal, and painting requirements are changing because of environmental and personnel safety concerns. The Resident Engineer and crew should thoroughly review the specifications for each project.

6-614.2 BEFORE CONSTRUCTION

Specifications require that the Resident Engineer approve prepared paints. While certificates of compliance are most often required for paint, the Materials Sampling and Testing Checklist issued by the Materials Division provides direction for the specific project.

For structural steel members, an inspector from the Structures Division Nondestructive Testing Section will monitor painting operations on the project and at the fabrication facilities. Painting must be performed under clean, dry conditions. Confirm that the contractor provides adequate protection from paint drift or overspray. Traffic, personnel, and other items that may be damaged by the paint require protection. The contractor may have to tent the structure or portions of the structure or provide traffic detours to provide adequate protection. Moisture on the surface will be trapped by the paint and prevent bonding. Moisture or dust in the air will cause a speckled or blotchy appearance on the painted surface. Cold weather also inhibits bonding of the paint to the steel. Painting should not be conducted on surfaces that are below 32°F. Inspect the surface to be painted to verify it is prepared as described in the specifications and is free of any foreign matter.

Paint systems must be applied in accordance with the paint manufacturer's recommendations utilizing proper mechanical mixers, thinners, pressures, paint guns, nozzles, and safety equipment. Review with the contractor the procedure, system, and safety clothing to be used. The Structures Division Nondestructive Testing inspector discusses with the contractor the surface preparation and paint application process to be used. Painting of structural steel requires that painters and sandblasters be qualified by experience and demonstrated abilities. The Resident Engineer may withdraw the qualification at anytime the performance of the painter, sandblaster, or their equipment is in question.

When painting concrete, the concrete surface must be cured and dried for a minimum of seven days before paint is applied. Painting operations must follow the manufacturer's recommendations.

6-614.3 DURING CONSTRUCTION

When the paint arrives at the jobsite, the inspector must check that the paint formula and system complies with the specifications. If the contractor desires to paint during inclement weather, the Resident Engineer should make certain that the contractor provides suitable enclosures to protect the work. The contractor receives no additional compensation for enclosures to protect the work. A clean surface is one of the most important aspects of a successful painting operation. Refer to the specifications for painted surface requirements.

When paint removal is required, review the specifications to determine submittal requirements. Typically, the contractor is required to submit a paint removal plan that incorporates environmental considerations. The Resident Engineer submits the plan to the Structures Division for review and approval.

The Structures Division Nondestructive Testing Section inspector performs on-site painting inspection of steel girders. The inspector confirms that each coat of paint is of the proper thickness. To verify the proper thickness of paint on the surface, the inspector checks the dry film thickness of the paint using a gauge or meter. The inspector should choose checkpoints that are representative of the painted surface and document the locations of the paint thickness checks. Frequently check difficult to reach areas for coverage.

6-614.4 MEASUREMENT AND PAYMENT

Painting is not paid for directly, unless otherwise provided in the specifications. The cost of painting is included in the cost of other items of work. The inspector verifies and documents the activity, date, and location of the work.

6-618 GUARDRAIL

6-618.1 GENERAL

Guardrail is installed to prevent errant vehicles from leaving the roadway and impacting fixed objects, steep side slopes, and opposing traffic. Different types of guardrail designs exist to address specific conditions.

6-618.2 BEFORE CONSTRUCTION

The Resident Engineer should refer to the current version of the AASHTO *Roadside Design Manual* when reviewing planned guardrail installations. Give attention to the stakeout and construction of required embankments for flared guardrail end sections. After the survey crew stakes the guardrail, the Resident Engineer should review the survey layout. The Resident Engineer should request a guardrail review from the Standards and Manual Supervisor in the Specifications Section of Roadway Design, if the planned guardrail installation appears deficient.

The inspector should consider the following guidelines before installing guardrail:

- Review the plans and specifications.
- Check the type of guardrail system for conformance, including rail sections, hardware, and posts. The specifications require shop drawings to be submitted for guardrail terminals.
- Verify survey stakeout.
- Check lateral offset, longitudinal length, termini location, post spacing, rail curvature, and parabolic flares.
- Confirm planned guardrail locations are consistent with current field conditions.
- Confirm that the embankments for flared guardrail end sections are staked.
- Guardrail identified for removal, removal and replacement, or remove and reset should be measured for payment before guardrail removal begins.
- Verify receipt of proper certificates of compliance.
- Check post layout for conflicts with utilities and drainage structures.

6-618.3 DURING CONSTRUCTION

Consider the following guidelines during the construction of guardrail:

- Unless designated otherwise, drive guardrail posts in place, or set them in dug holes. Check post spacing, elevation, depth, and alignment regularly. Where posts are driven, watch for irregular movement or heaving of the soil, possibly indicating an underground obstruction. Check driven posts for damage such as distortion or splintering.
- Where posts are set in pilot holes, watch for over drilling and require backfilling and compaction as needed to adjust depth and provide a firm foundation. After setting, place and compact backfill material in layers around posts. Compact backfill with an appropriate tool but do not displace the post from correct alignment. Check that all posts are set firm and plumb and that they are within tolerance of the required alignment and elevation.
- Where wood posts are cut in the field, verify that the exposed surface is treated as specified. Post lengths must conform to the plans and specifications for the type and location of installation.
- If posts are installed in loose soil or within two feet of the top of a slope, use longer posts. If unsure about the post length, consult the Resident Engineer and the Standards and Manual Supervisor in the Design Division Specifications Section.
- Verify that connections to bridge railings, retaining walls, abutments, or other flat surfaces comply with plans and specifications.
- Check for correct construction of the embankment for flared guardrail end sections.
- Check that all fittings and metal plates are securely placed in the correct position. Check that rail sections are lapped so that the exposed ends will not face approaching traffic and are smooth and continuous.
- Check bolts for tightness and threaded rods for proper trimming. Make sure bolts are long enough and nuts are threaded completely onto the bolt. One or two threads are insufficient.
- Check for conformance in the rail height and rail face with respect to lateral offset and alignment and inform the contractor of any needed adjustment.
- Pay particular attention to the construction details for end treatments, median terminals, and rail transitions such as post type, post length, post spacing, number of rail sections, lapping direction, splices, method of connecting, fastener type, and reflector tab location. Specialized hardware and designs are commonly used at these locations and require close inspection before acceptance. The inspector should refer to the manufacturer's installation instructions for specialized hardware.
- When the roadway remains open to traffic, the installation of rail sections immediately follows the installation of guardrail posts, unless other protection is provided for in the plans and specifications. At the end of the workday, check to confirm that the termini of exposed rail sections are treated with temporary end treatments such as a temporary impact attenuator.
- Install cable clips in the proper direction and tighten them to the required torque.

- Immediately before placing concrete, verify that holes for concrete anchors and footings are excavated to the dimensions shown on the plans and on the manufacturer's drawings.
- Verify that anchor cables are tight enough to prevent any obvious slack in the cable once the footing concrete has cured for the required period.
- Check that plantmix bituminous dikes are positioned under the guardrail as shown on the plans.
- Check that the construction of flares conforms to the plans.
- Verify that installed guardrail is visually uniform, horizontally and vertically. Require the contractor to adjust posts and rail if necessary.
- Verify each pay item for each guardrail installation.
- Keep accurate records and make sufficient measurements to support both partial and final payment.

At the completion of any project that installs or removes guardrail, the inspector must accurately complete the guardrail inventory sheet. Refer to the Construction Division intranet site (SharePoint), http://sharepoint1/040/default.aspx, for a guardrail inventory sheet and a manual describing how to complete the inventory sheet. The completed guardrail inventory sheet is sent to the Standards and Manual Supervisor in the Specifications Section of Roadway Design. The guardrail inventory sheet is used to evaluate and address federal safety requirements.

6-618.4 MEASUREMENT AND PAYMENT

The limits of measurement for payment are shown in the plans. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-623 SIGNALS, LIGHTING AND INTELLIGENT TRAFFIC SYSTEMS

6-623.1 GENERAL

Traffic signals, street lighting, illuminated signs, and Intelligent Traffic Systems are all part of roadway electrical systems. Intelligent Traffic Systems (ITS) is a general term that includes items such as changeable message signs, communication systems, and traffic monitoring systems. Typically, electrical systems along local roadways, including traffic signals at highway ramp junctions, are maintained by the local agency and built to the local agency's specifications. Electrical systems along highways are constructed to NDOT specifications and maintained by NDOT or the local agency. The technology and materials associated with electrical systems continually evolve. The evolution of the technology for these systems creates advances in equipment. Although equipment advances are common, the basic construction features typically remain the same.

Electrical systems are typically installed in urban areas, although lighting and ITS systems are also common in rural areas. The basic components of electrical systems consist of electrical service, controller, wiring, conduit, and signal/lighting/ITS components. The electrical service is the point at which an electrical utility company furnishes or provides electrical power to a user, typically with a meter to record electrical power usage. A controller is the equipment, similar to a computer, that controls and manages the components of the electrical system. Controllers are typically located in metal cabinets on the project, near the electrical system that they control. Wiring and conductors convey electrical power to the electrical components, including the electrical service. Conduits are plastic or metal pipes in which wiring is placed. Conduits allow for the installation or replacement of wiring underground without trenching after the initial installation. All electrical systems must meet certain standards and codes as detailed in the plans and specifications.

6-623.2 BEFORE CONSTRUCTION

The inspector's work on roadway electrical systems should begin before the contractor arrives at the jobsite. The inspector needs to become familiar with the project; existing conditions should be thoroughly documented to help settle disputes during construction, quality of materials should be verified before use, and the construction schedule should be reviewed to confirm that it is appropriate for the work to be performed. Completing the following tasks before construction begins will help with this process:

- Thoroughly review the project plans and specifications to confirm compliance with regulations and codes and pay close attention to all project notes. Record on the plans any unusual items covered in the specifications but not directly called out on the plans.
- If electrical systems not maintained by NDOT are constructed or modified, contact the local agency that performs the maintenance.
- Check the condition of any existing electrical equipment that is indicated on the plans to remain in place, to be salvaged, or to be relocated; take photographs to document the condition of these items before the contractor arrives at the jobsite.
- Confirm that electrical equipment and materials submittals have been provided by the contractor, and approved by the Resident Engineer. The specifications require equipment submittals for all equipment and materials to be used on an electrical system.
- The inspector should keep a copy of the contractor's submittal to confirm that the proper products are used. As materials are delivered to the jobsite, verify that they match the description on the approved submittal. If the contractor wants to substitute a specified product with a different product of equal quality and suitability that is not listed in the Qualified Products List, a request for substitution must be made in writing. The Resident Engineer approves or denies the substitute. Refer to Section 3-403.3.1.5, Qualified Products List, for additional information.
- If the plans and specifications call for any agency-furnished equipment such as traffic signal controllers and cabinets, confirm with the furnishing agency that these materials will be available when needed, that provisions have been made for testing if necessary, and that all parties have been properly contacted to control the pickup and delivery of these items.

- Review the contractor's schedule of operations and confirm that arrangements are being made to maintain existing electrical systems, or that temporary electrical systems will be provided in accordance with the plans and specifications.
- Certain job-specific electrical equipment such as poles and controllers often require substantial lead-time due to fabrication of specialized materials. Confirm with the contractor that lead-time for the electrical equipment is accounted for in the schedule of operations; partial payment will not be given for these materials until they are delivered to the jobsite. If the specifications allow for suspension of working days due to material lead time, the contractor should still be required to perform underground work such as conduit, pull box, and foundation installations before allowing any suspension of working days.
- Walk the project with the contractor to determine the locations where cranes, pile-driving equipment, or other equipment may be needed, and advise the utility company representatives of overhead clearances necessary to accomplish the work. Also, if overhead wires for temporary lighting or signals will encroach on private property, refer the situation to the Right-of-Way Division.
- Contact the project manager and district utility coordinator to discuss the status of electrical and utility agreements for the project. If an electrical or telephone service connection is needed, the district utility coordinator should submit an application to the utility company. Confirm that this is being provided early enough for the utility company to plan their work in an orderly manner.

6-623.3 DURING CONSTRUCTION

Before installing any underground equipment, the contractor must contact the appropriate underground utility locating service. The Resident Engineer should not allow the contractor to perform any excavations until all underground utilities have been located.

Only journeyman electricians or electrical apprentices directly supervised by a journeyman electrician may perform electrical work or install electrical material. All work performed on traffic signals must be performed or be directly supervised by a journeyman electrician certified as International Municipal Signal Association (IMSA) Level II or higher.

Existing electrical systems should remain in satisfactory operation during construction, except when shutdowns are permitted by the specifications. The contractor may need to provide a temporary system in order to maintain satisfactory operation during construction. Coordinate with the local agency for the operation of the signal system during construction. Any existing facilities damaged by the contactor's operations must be promptly repaired or replaced in accordance with the specifications.

Throughout construction, it is important that the contractor provide adequate warnings and safeguards in the form of signs, lights, and barricades. All temporary traffic control devices used must be in good condition and conform to the latest version of the "Manual on Uniform Traffic Control Devices" (MUTCD) and the NDOT Standard Plans. Any excavated foundation holes, where pedestrians may walk, must be covered with adequately braced plywood or an equivalent.

Underground work such as the installation of conduit and concrete foundations should be inspected while the work is actually being performed, since these items cannot be inspected once the work is complete. If any unexpected underground utilities are encountered while performing underground work, a representative of the utility owner should be contacted immediately.

All electrical equipment and installations must be properly grounded according to the bonding and grounding techniques explained in the plans and specifications. Electrical systems should be tested for system voltages, insulation resistance, ground continuity, and current before final inspection. If detector loops are being installed on the project, they should be tested before and after they are permanently secured in the pavement. The plans and specifications fully explain the testing techniques and acceptable tolerances. The tests should be performed by the contractor, in the presence of the inspector, and documented. Any items that fail to test satisfactorily should be repaired or replaced.

Changes made during construction are recorded using NDOT form 040-056, "Daily Construction Report," and on the as-built plans. Specific details of the changes made should be recorded. Significant changes require a change order.

The specifications will describe the specific components of electrical systems that require inspection during construction.

6-623.3.1 CONDUIT

Conduit is an integral part of all electrical systems as it provides for the installation of the wiring that powers the electrical equipment. The two different types of conduit used for underground installation on electrical systems include metallic (steel) conduit and non-metallic (plastic) conduit. An initial inspection of the conduit should be performed prior to conduit installation to confirm that the conduit is in good condition and that it is of the schedule and size specified in the plans and specifications. Non-metallic conduit used in electrical systems should be gray in color unless otherwise indicated in the plans and specifications. Conduit should also have the manufacturer's name, trade size, and schedule imprinted on the outside. Should the contractor want to use a different conduit size and schedule not conforming to the plans and specifications, it must be approved by the Resident Engineer. Conduit should also be inspected for cracks, dents, excessive weathering, or signs of having been damaged. Any conduit that does not appear to be in acceptable condition must be rejected.

For placing electrical conduit underground, the typical methods of installation are trenching and boring. The contractor can typically choose which method of installation to use, as long as it is in conformance with the plans and specifications. As conduit is being installed, the inspector should monitor the following:

- Verify that conduit is placed at the proper depth, and the trench is properly bedded, backfilled, and compacted in accordance with the plans and specifications. On new construction, all trenching for conduit located under paved surfaces should be placed prior to construction of the base course and pavement
- For clarity, conduit runs as shown on the plans, are schematic. Actual installation of the conduit should be as straight a line as possible between pull boxes or other terminations. Changes made to conduit routing during construction should be reflected on the as-built plans
- When conduit is properly screwed together, all threads should be covered by the coupling, and the ends of the conduit should be butted tightly together. If threads are exposed, generally either the connection is not tight or the threads are crossed in the coupling
- Rigid metallic conduit, when used underground, must be wrapped in accordance with the specifications to protect it from corrosion

- When a conduit run containing signal cables is over 50 feet in length, all bends (sweeps) must be factory-coated PVC rigid metallic conduit. The friction created by the cable being pulled through a sweep on a long run, may 'burn' through the side of a PVC sweep, creating a hole in the conduit
- The total degree of bends (sweeps) used on a conduit run cannot exceed 360°. For example, a conduit run with 90° sweeps can only have four sweeps
- Field bends should be made only with approved tools, and conduit should never be bent to a radius smaller than the minimum bend radius specified by the conduit manufacturer.
- Conduits should be capped to prevent contamination such as dirt, debris, rodents, and water from entering them until the wiring is installed. After the wiring is installed, the ends of the conduit should be plugged with an approved duct seal to prevent contaminants from entering the conduit
- Conduit used on a pole as a riser for power service must conform to the specifications and the power company's standards
- Allow only the number and sizes of cables/conductors in a conduit that is shown in the plans. The size of the conduit specified is based on the fill, or amount of space taken up by the wiring. The National Electrical Code (NEC) limits the number of conductors that are allowed to be installed in a single conduit. If approved, at the contractor's expense, the contractor may use a larger size conduit than specified on the plans, as long as the same size and type is used for the entire length of the conduit run
- Verify that all conduit runs are complete and that all appurtenances such as pull boxes, poles, and controller boxes are connected by conduit runs. Conduits that terminate in pull boxes with multiple runs should be permanently labeled or otherwise identified to determine where they run

For conduit that is to be installed in or on a structure, the inspector should consider the following:

- Refer to the bridge plans for conduit installation details
- Expansion fittings are provided when a conduit passes through an expansion joint on a structure
- Conduit that is hung on structures must have hangers that conform to the specifications, and should be painted the same color as the structure and run straight to provide a suitable appearance

6-623.3.2 PULL BOXES

Pull boxes, vaults, or junction boxes are installed at conduit termination points, and facilitate wire pulling and splicing. The term vault is used for a large pull box and the term junction box is used for a pull box that is located in or on a structure. The size, type, and installation methods for pull boxes will be indicated on the plans and in the specifications. Typically, pull boxes used on NDOT projects are required to be traffic rated with metal lids. Initial inspections of the pull boxes should be performed prior to installation, and any pull boxes that are chipped, cracked, or have more than minor surface blemishes should be rejected. As pull boxes are being installed, the inspector should consider the following:

- Pull boxes should generally be placed at intervals as shown on the plans. The contractor may install additional pull boxes or junction boxes to facilitate operations however, it will be at the contractor's expense
- Pull boxes are typically installed on a minimum of 6-inches of drain rock or as shown on the plans. Additional drain rock may be required around and under the pull box to prevent the soil from eroding around the pull box
- The tops of pull boxes should be set flush with the final grade and slope; whether in pavement, sidewalks, landscaped areas, or in the roadway shoulder
- Verify that steel pull box lids are grounded
- On unpaved slopes, check that pull boxes are kept out of depressions so as not to collect water
- Pull boxes should not be placed in pedestrian ramps
- Pull boxes placed in structures must be constructed and placed in accordance with the plans and specifications. If the formed type of pull box is to be used, confirm that the contractor places properly dimensioned wooden pull box templates at the correct locations and the conduit is stubbed into the pull box before concrete is placed for the structure
- Verify that pull boxes placed on or adjacent to a structure are placed away from where expansion joints will be located

Following construction, a final check of pull boxes should be performed to verify pull box lids are properly fastened, all metal pull box lids are properly grounded, and all lids are properly marked with embossed lettering identifying what the pull box is being used for. Refer to the specifications for additional information on requirements for pull box lid markings.

6-623.3.3 WIRING

Wiring is used in electrical systems to convey electrical power to the system components. The wiring for electrical systems generally consists of conductors and cables. A conductor is a single wire, and a cable is a group of two or more insulated conductors wrapped in a common sheath. Wires are sized based on the standard American Wire Gauge (AWG) system which uses numbers to indicate the size of the wire; in general, the smaller the number, the larger the wire diameter. Since wiring is typically installed underground in conduit, it is important to perform a preliminary check of the wiring prior to installation to make sure the insulation is not damaged. Wiring with damaged insulation must be rejected. During installation of the wiring in conduit, the inspector should consider the following:

- The wiring being installed should match the size and type being called for in the plans and specifications. The symbols for wire sizes, insulation types, and temperature and voltage ratings are imprinted on the insulation of single conductors or the non-metallic sheath of multi-conductor cables
- In general, wiring that is installed in conduit should be pulled through the conduit by hand. Pulling wire by mechanical means may damage the conductors, the insulation, or the conduit. If the specifications permit power pulling of larger conductors or cables, a tension measuring device should be used in accordance with the manufacturer's recommendations
- All traffic signal conductors must be run continuously from terminal to terminal with no splices. (Terminals are the devices located on the poles and in the controller that are designed specifically for joining electrical circuits together)
- When a single conduit or pull box has multiple circuits passing through it, each circuit should be labeled. All traffic signal conductors and cables must be labeled and color coded in accordance with the specifications. Labels should be banded to the conductors or cables with labels specifically designed for wiring
- When possible, high voltage wiring and low voltage wiring should be placed in separate conduit

As the contractor installs the wiring, wire splices will sometimes be necessary. The plans and specifications give specific guidance on what types of wires can be spliced, appropriate splicing methods, and where splicing is allowed. As splicing requirements may be different for different types of wiring, it is important to thoroughly review the plans and specifications to become familiar with these requirements. In general, splices are typically allowed only in pull boxes, junction boxes, or at the bases of lighting standards. Also, splicing is often not allowed on certain types of wiring such as signal interconnect cable and detector loop cable.

6-623.3.4 SERVICE ENCLOSURES

Service enclosures are the cabinets that house the circuit breakers and electrical service equipment. There are two separate sections in a typical service enclosure, a line side and a load side. The line side is the section where the serving utility brings in the wires from the service point. The load side is the section that houses the circuit breakers and where the wires go out to power the electrical equipment.

Service enclosures are typically either pedestal mounted or surface mounted on a pole or cabinet. Pedestal mounted service enclosures are mounted on concrete pads, which can either be cast-in-place or precast. The cabinet is bolted into place on the pedestal and properly sealed in accordance with the specifications to prevent seepage of water into the cabinet. If the service enclosure is mounted on a pole or cabinet, it should be securely fastened in accordance with the plans and specifications. Service enclosures should be placed in a location where utility access can be provided and oriented such that the meter can easily be read. The service address should be embossed onto a metal plate and permanently attached to the front of the enclosure.

Make sure the service cabinet is the type specified in the plans and specifications. The circuit breakers should have their ratings imprinted on them and a nameplate identifying what the circuit breaker controls. A nameplate should be placed adjacent to each circuit breaker. Confirm that these circuit breaker ratings match what is called out for in the plans and specifications. The cabinets should also be inspected for dents or chipped paint. Minor dings or paint chips can be field repaired, but cabinets with more than minor damage must be replaced.

Some service enclosures will also house transformers, which are devices that are used to boost or drop voltage. If a transformer is to be installed in an enclosure, it will be called out for in the plans and specifications. Because transformers generate a certain amount of heat, the enclosure housing the transformer usually needs to be vented and may require a fan. Make sure the venting and screening is accounted for and in accordance with the plans and specifications. Also, check that the transformer is securely fastened and wired in accordance with the plans and specifications.

6-623.3.5 CONTROLLERS AND CONTROLLER CABINETS

Controllers are the equipment that control and manage the components of an electrical system and are typically located in metal cabinets on the project, near the electrical system that they control. Controllers are necessary at all traffic signals, and are needed to operate many ITS components such as changeable message signs, traffic monitoring stations, and closed-circuit television (CCTV) cameras. If a controller is necessary, the type of controller and cabinet to be installed will be called out for in the plans and specifications. The inspector should confirm that the controller and cabinet being installed are in good condition, are of the type that is specified, and include all equipment called out for in the plans and specifications.

The concrete base for the controller cabinet, conduits, and grounding systems is installed before the cabinet. The cabinets are supplied with a gasket that is placed between the clean concrete foundation and the cabinet. The cabinet must be bolted into place using the anchor bolts that are an integral part of the foundation, and properly sealed to prevent seepage of water into the cabinet. The door of the cabinet should be able to open fully without hitting any obstructions, and the cabinet should be oriented in the proper direction. Typically, the cabinet is oriented so that when a technician is working on the controller, the technician can see the system that it controls. Do not allow any electronic equipment, including the controller, to be placed inside the cabinet until the cabinet has been securely bolted into place on the foundation.

A wiring diagram should be provided with each cabinet. Confirm that the power input wiring, signal head (lights) output power wiring, detector wiring, and pedestrian push button wiring are connected to the labeled terminals in accordance with the wiring diagram furnished with the cabinet, and that all wiring is properly labeled in accordance with the plans and specifications. Any stranded conductors smaller than No. 14 should have crimp-on spade terminals installed on them to facilitate attaching them to the terminals. If any modifications are made to a signal system, the cabinet wiring diagram must be modified accordingly. Only certified IMSA Level II personnel should attempt to rewire any portion of the cabinet, or make modifications to any part of a signal system. Verify that the contractor provides documents for all modifications and the reasons for the modifications.

When completed, the cabinet and wiring should be neatly organized. All the wiring should be neatly and firmly bundled together, either laced, bound, or tie-wrapped, and out of the way so that the wire bundles don't inadvertently come into contact with various components, such as the test switches mounted on the inside of the door. The wiring bundles should be arranged so that technicians cannot easily hook them or disturb them when opening the door.

6-623.3.6 POLES

Poles are used on electrical projects for traffic signals, lighting, overhead sign structures, and intelligent traffic systems. In general, all poles and anchor bolts should be inspected prior to installation to confirm that they are of the correct type and are in good condition. The type of pole to be installed at each location will be detailed in the plans. Poles or pole arms with dents should be rejected, and any damaged galvanizing or paint should be properly repaired in accordance with the specifications.

Prior to installation, each pole location should be staked and the locations should be approved by the inspector. As signal pole locations are often dependant upon pedestrian ramp and sidewalk placement, the locations of these items should be staked as well to facilitate pole location approval. Should any underground or overhead utilities prevent the placement of a pole at its specified location, the Safety/Traffic Division should be contacted to provide an alternate location. When laying out pole locations for traffic signals, verify that no obstructions exist that will prevent vehicular or pedestrian traffic from seeing vehicular or pedestrian signal faces, or that will prevent pedestrians from accessing push buttons. Poles with push buttons must be located so that the button is ADA accessible and in accordance with the most recent editions of the MUTCD and the NDOT Standard Plans.

All poles must be mounted on properly prepared foundations with properly sized anchor bolts and be individually grounded in accordance with the plans and specifications. The finished pole foundations should not be placed in depressed areas and anchor bolts should be embedded to the proper depth. Poles should be mounted to the anchor bolts, plumbed, and the nuts should be properly tightened in accordance with the specifications. When the plans call for the installation of a lighting standard with a safety base, check that the safety base is properly installed by the contractor. Specific safety base installation and torque requirements are explained in detail in the plans and specifications. Installing the safety base in accordance with torque requirements is critical for the safety base to perform as designed.

Concrete for pole foundations is often placed without forms against the excavation. The resulting rough block of concrete is functionally satisfactory, however, confirm that the contractor forms and finishes the exposed part of the footing and that all exposed forms are stripped after the concrete is at full strength. Verify that the foundation excavation is of the proper size and depth as detailed in the plans and specifications, and confirm that the specified concrete is used.

Mast arms on poles for traffic signals and lighting must be bolted to the flanges and installed in accordance with the specifications. Traffic signal mast arms will require tenons, which are steel tubes to which the signal heads are attached. The contractor may be required to field weld the tenons to the mast arms in order to properly align the signal heads with the travel lanes. All field welds need to be certified welds, performed in accordance with the specifications. After welding, metal surfaces must be repainted or galvanized in accordance with the specifications. Signal poles and mast arms are designed to withstand not only the dead loads that result from traffic signal heads and signs, but also from live loads caused by winds and truck gusting. The loads on the arms and poles must not exceed the loads for which they were designed. Do not allow any additional equipment or signs to be placed on the poles or mast arms, and do not allow the installation of a longer signal arm on an existing pole without approval from the Safety/Traffic Division

6-623.3.7 VEHICLE AND PEDESTRIAN SIGNAL HEADS

Vehicle and pedestrian signal heads are installed at traffic signals to control vehicle and pedestrian movements. Signal heads generally consist of indication lenses installed in a main housing; a back plate and visors are also usually required to be attached to the housing. All signal heads should conform to the plans and specifications and should be inspected for damage to the housings and lenses prior to and after construction. Minor paint scrapes or blemishes may be touched up in the field, but any housings or lenses with cracks must be rejected.

Signal heads are designated in the project plans under “pole schedule” by a standard code. For instance, a 1W3C head is a typical one way, three-color head. Vehicle and pedestrian signal heads should be installed at the locations shown on the plans and oriented towards the movement they are designed to control. Vehicle signal heads must be properly aligned with the travel lanes and leveled. The type of mounting for vehicle and pedestrian signal heads can also be found in the signal summary sheet under “Pole Schedule”. There are three basic types of mounts: mast arm mounted heads, bracket or side mounted heads, and post-top mounted heads. Details of the various mounts can be found in the plans. Make sure the contractor places them in accordance with the plans.

Signal heads are wired from the head to the terminal block on the pole with single conductors. All wiring should be performed neatly and labeled in accordance with the plans and specifications.

6-623.3.8 VEHICLE AND PEDESTRIAN DETECTION

The standard types of vehicle and pedestrian detection consists of loop detectors, video detection, preemption, and pedestrian push buttons. Vehicle and pedestrian detection is an area where evolving technology creates advances in equipment. Because of this, the plans and specifications for each project should be thoroughly reviewed to confirm that the detection equipment being provided is of the correct type, and is properly installed.

6-623.3.8.1 LOOP DETECTORS

Loop detectors are installed by sawcutting slots into the pavement, wrapping a cable in the slots, and filling the slots with an approved loop sealant. The loop wires are run from the loop to the pull box, where they are spliced to a loop cable, and the loop cable runs from the loop wires to the controller cabinet. Typically, splicing of the loop cable is not allowed. Proper detector loop installation techniques and details are shown and explained in further detail in the plans and specifications. Proper installation and labeling of individual loop wires is essential, as improperly installed detector loops will cause ongoing problems with vehicle detection and can result in malfunctioning signal systems. Maintenance and replacement of improperly installed detector loops is time consuming and expensive. .

When inspecting loop detector installations, check that the overall loop layout and proposed loop type match the plan details. Loops should not be placed across cracks or joints in the pavement and should be at least 2 feet from the lane lines. Generally, loops should be centered in the travel lane unless the plans show otherwise. Placing loops across cracks can result in early loop failure, and placing them too close to a lane line may cause vehicles in the opposing lane to be detected. If no alternative location can be provided for loop wires and they must cross a joint or crack in the pavement, a flexible slip joint should be provided in accordance with the plans and specifications. If a manhole or water valve is located where a loop detector is to be installed, the loop detector must be modified; the Safety/Traffic Division should be contacted for a design change.

Sawcuts should be inspected to verify that the cut is de-burred, cleaned out, and blown dry prior to installation of the loop wires. The contractor performs testing on detector loops as required by the plans and specifications before and after they are permanently secured in the pavement. Test results should be documented by the inspector and submitted to the Resident Engineer.

The loop wires should have identification bands placed on them and be properly labeled in the pull box, and the loop cables should be properly labeled in the controller cabinet. If loops are installed for future use, the ends of the wires must be taped and waterproofed in the pull box, and the wires should be labeled.

6-623.3.8.2 VIDEO DETECTION

Video detection is a system that uses video cameras instead of loops for detecting vehicles. Cameras are typically mounted on poles or mast arms and pointed towards the approach that they will detect. The method used to mount the cameras should be in accordance with the plans and specifications, or the manufacturer's recommendations. The symbol shown on the plans does not necessarily indicate the proper mounting location. There are many different types of video detection systems available, and the system used needs to be compatible with the controller. Because of this, it is important to check that all components of the video detection system comply with the specifications.

Field wiring for the video cameras is relatively easy, consisting of a coaxial cable and power wiring run from the camera to the controller. Wiring should be done neatly and labeled properly. Wireless video detection systems are also available. If a wireless system is to be used on the project, it will be specified in the plans and specifications. .

6-623.3.8.3 PREEMPTION

Preemption is a type of vehicle detection that recognizes certain types of vehicles as they approach and assigns their movement priority at a traffic signal. Preemption is typically installed at traffic signals for emergency vehicles, but it can also be used for transit and for rail vehicles. Emergency vehicle and transit preemption equipment, if applicable, consists of detectors that are mounted on signal arms or luminaire arms and a phase selector that is mounted in the controller cabinet. The locations of the preemption detectors and mounting details will be shown on the plans. Check that the proposed detector location is within the line of sight of an approaching vehicle from the direction that it controls. If the line of sight to the detector is impeded due to curvature of the roadway, landscaping, or any other fixed object, contact the Safety/Traffic Division to provide an alternate location. Make sure the equipment is the type specified in the plans and specifications and is properly mounted. Special cable is typically used to connect the preemption detectors to the phase selectors in the cabinet, splicing of this cable between the detectors and phase selectors should not be allowed. .

For railroad preemption, the railroad company provides the operator of the traffic signal system with a railroad preemption circuit that is connected to the controller. Wire will be run through conduit from the traffic signal controller to a pull box located at the railroad right-of-way that will be connected to the railroad's circuit. Railroad preemption at a traffic signal must be coordinated with the railroad and the coordination is typically handled through the Right-of-Way Division Utilities Section. If railroad preemption is applicable for a project, the inspector needs to confirm that the conduits, pull boxes, and wiring are installed in accordance with plans and specifications.

6-623.3.8.4 PEDESTRIAN PUSH BUTTONS

Pedestrian push buttons are used to detect pedestrians at traffic signals. A standard pedestrian push button assembly consists of a base, sign panel and push button. The push button assemblies will typically be mounted on a traffic signal pole or on a smaller pole called a pedestrian push button post. The mounting height, location, and accessibility of pedestrian pushbuttons must comply with the most recent editions of the Americans with Disabilities Act (ADA), the *Manual on Uniform Traffic Control Devices,* and the NDOT Standard Plans. If a proposed pedestrian push button location is not accessible, the Safety/Traffic Division should be contacted to provide an alternate location. The push buttons should be securely mounted to the pole at the correct height and in the correct quadrant, as shown in the plans. Make sure the arrow on the sign panel points in the correct direction.

6-623.3.9 LUMINAIRES

Luminaires are used on electrical projects for the lighting of roadways and overhead signs. Luminaires for overhead signs are mounted on the supporting framework in front of the sign, mounting details for these lights can be found in the plans. Luminaires for roadway lighting can be mounted on a pole or on a structure. The plans and specifications will show mounting details and show the locations of all luminaires on the project. The inspector needs to check that all luminaires match the type and wattage called for in the approved equipment submittals and are properly mounted and oriented in the correct direction so that the light distribution lights the roadway as designed. For luminaires mounted on poles, the pole should be plumbed and the anchor bolts should be tightened before the tilt angle on the luminaire is set. Structure and wall mounted luminaires should be oriented and installed per the manufacture's specifications.

6-623.3.10 INTELLIGENT TRAFFIC SYSTEMS (ITS)

While many ITS components are commonly used electrical items, other ITS components may require highly specialized equipment. The plans and specifications should be thoroughly reviewed for all projects with ITS equipment to confirm that the equipment being installed meets the requirements of the project. There may also be test procedures and knowledge of operational parameters that require specialized expertise to be provided by the equipment suppliers, installers, or manufacturers. Any specialized tests and procedures should be observed and documented by the inspector.

6-623.3.11 UTILITY COORDINATION

Utility coordination will typically be required on electrical projects to obtain electrical and/or telephone service points. Prior to construction, contact the Safety/Traffic Division and district utility coordinator to discuss the status of electrical and utility agreements for the project. If an electrical or telephone service connection needs to be obtained, the district utility coordinator should submit an application to the utility company. Once the meter pedestal is installed and ready for inspection, the district utility coordinator should be notified to perform a final inspection. The district utility coordinator will work with the Resident Engineer and the utility company for the final meter installation and activation.

6-623.3.12 TESTING

Before completion and acceptance of electrical work, testing must be completed in accordance with the plans and specifications. All electrical systems should be tested for system voltages, insulation resistance, ground continuity, and current before final inspection. If detector loops are being installed on the project, they should be tested before and after they are permanently secured in the pavement. Testing techniques and acceptable tolerances are explained in detail in the plans and specifications. The tests should be performed by the contractor, in the presence of the inspector, and documented by the inspector. Test results should be submitted to the Resident Engineer. Any items which fail to test satisfactorily should be repaired or replaced.

6-623.3.13 TRAFFIC SIGNAL TURN-ON

Prior to the turn on of a new traffic signal system, the following should be performed:

- Until signals are placed in operation, the signal heads are to be turned away from traffic and/or completely covered with an approved method
- Before a new traffic signal is opened to traffic, do a final check to verify all traffic control devices are in place and working properly
- Check that the contractor has properly installed all signing and striping items
- Give two weeks notice of the proposed turn-on of a signal system to the District traffic engineer, public information, local jurisdiction, local maintaining agency, local fire and police departments, and schools
- If timing information is required and not provided by the local agency, contact the Safety/Traffic Division

6-623.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*. Typically, measurement and payment of the wiring and conduit is paid for by the linear foot, and most other items are paid for by each. Items such as pole and cabinet foundations are included in the price of the item to be installed. On new installations, the payment for traffic signal controller cabinet will include a fully equipped cabinet, except for preemption and video detection equipment, which will be included in the payment for those items. The payment for electrical service cabinet also includes a fully equipped cabinet.

6-624 ACCOMMODATIONS FOR PUBLIC TRAFFIC

6-624.1 GENERAL

This section provides guidance on worker protection and the safe passage of public traffic through and around construction with as little inconvenience and delay as possible. Refer to the current version of the *Manual on Uniform Traffic Control Devices (MUTCD)* and the plans for details on signs, lights, and traffic control devices used on construction projects. An electronic version of the MUTCD is found at the following web site: http://mutcd.fhwa.dot.gov/kno-2003r1.htm .

A traffic control plan addresses management of public traffic in and around a construction project. When NDOT prepares the traffic control plan, the designer, in consultation with the District, Construction Division, and Safety/Traffic Division, develops a plan to accommodate public traffic during construction. If the plans and specifications require the contractor to prepare the traffic control plan, the contractor, in consultation with the Resident Engineer, develops a plan to accommodate public traffic during construction, as required in Section 625 of the specifications. The purpose of the plan is to provide safe passage of traffic as well as to create and maintain safe work areas for construction personnel. When the plan is prepared by NDOT, it is based on a logical sequence of operations. When submitted by the contractor, the plan is based on the contractor's scheduled construction operations.

Traffic control plans have the following basic objectives:

- Protect the traveling public
- Protect construction workers
- Reduce traffic delays in work zones
- Channelize traffic
- Provide directional information to drivers
- Provide an acceptable level of service during construction operations
- Provide for pedestrian and bicycle traffic

Because NDOT places importance on traffic flow and safety in work zones, it has developed Policy 07-02 on Work Zone Safety and Mobility, and the *Work Zone Safety and Mobility Implementation Guide*. The traffic control plan may be included in the plans and specifications, or the specifications may require the contractor to prepare traffic control plans.

Traffic control plans developed by the contractor are reviewed and either accepted or rejected by the Resident Engineer. The Resident Engineer works with the contractor and project stakeholders in reviewing the contractor's traffic control plans. The Resident Engineer confirms that the contractor's traffic control plans comply with Policy 07-02, and the plans and specifications. The Resident Engineer may confer with the District Engineer or the Safety/Traffic Division for assistance.

The Resident Engineer may propose changes to traffic control plans included in the plans or developed by the contractor. Typically, changes to traffic control plans are considered when field conditions are different from those contained in the plans. The traffic control plan must be appropriate for expected conditions during construction. If the traffic control plan is included in the project plans and specifications, the traffic control may require modification to address the contractor's proposed operations. The Resident Engineer documents the proposed traffic control changes and submits them to the District Engineer and the Safety/Traffic Division for review and approval.

6-624.2 BEFORE CONSTRUCTION

The Resident Engineer should perform the following duties:

- Compare the project traffic control plan to jobsite conditions. Note any unusual local traffic movements and the movements of emergency vehicles. Discuss the traffic control plan at the preconstruction conference.
- Review the specifications for operations limitations as related to traffic control.
- Review proposed changes to traffic control plans with the Safety/Traffic Division and the District traffic engineer.

6-624.3 DURING CONSTRUCTION

During construction, the Resident Engineer assigns an inspector to monitor and document traffic control activities. The inspector must be certified by the American Traffic Safety Services Association (ATSSA) as a traffic control supervisor. The inspector should consider the following:

- Observe installation of specified signs and traffic control devices. Signs, barricades, drums, cones, and flagger paddles must meet specified retro-reflectivity requirements described in Section 625 of the specifications.
- To document the markings, devices, and signs that exist during the project, maintain a detailed record of the placement and spacing of signs and other traffic control devices on the inspector's daily inspection report.
- On the back of each sign, print the assigned installation number, contract number, date of installation, and inspector initials. Also enter this number in the appropriate field book.
- Regularly drive through the project and review the traffic control installed to confirm continued conformance with the traffic control plan. Monitor the effectiveness of the traffic control while driving through the project. Discuss ideas for improving the traffic control with the Resident Engineer. Note deficiencies and immediately notify the contractor to take corrective action.
- Regularly monitor the retro-reflectivity of signs, barricades, drums, cones, and flagger paddles. The contractor may be required to clean or replace devices with unacceptable retro-reflectivity.

- The contractor's traffic control supervisor must submit the original and copies of completed NDOT form 040-056B, "Work Zone Traffic Control Checklist," as required by the specifications. If documentation is not provided by the contractor, the Resident Engineer may withhold payment to the contractor for the Traffic Control Supervisor bid item.
- Verify flaggers are at designated locations and that they meet the requirements of the specifications. Flaggers must have certifications in their possession. Flagger qualification is obtained through the following approved instructional courses: NDOT in-house flagger training, University of Nevada, RenoT2 program, American Traffic Signing and Safety Association (ATSSA), and National Safety Council.
- Record work hours for all flaggers on the project using NDOT form 040-036, "Flagging Hours," for proper payment.
- When unpredictable situations occur, a formally approved traffic control plan is not required, but written documentation is required to record actions taken and directions given.
- If the contractor's operations interfere with or cause potential safety problems with vehicular or pedestrian traffic, notify the contractor to correct the deficiency immediately. If the notification to the contractor is verbal, document the notification in writing to the contractor.
- Because the safety of the traveling public is of the utmost concern, NDOT maintenance forces may need to correct traffic control deficiencies when the contractor is physically unable or refuses to act. The Resident Engineer may terminate the contractor's work operations if the contractor fails to perform. Keep the Resident Engineer informed of traffic control deficiencies. If danger persists, take immediate action.

To reduce the impacts to existing traffic, NDOT may require the contractor to conduct construction activities when traffic volumes are low. These low volume periods typically occur at night. Although nighttime construction can reduce traffic impacts in the work zone, it can also create situations that require diligent attention to worker and motorist safety.

The contractor's traffic control supervisor is responsible for initiating, installing, and maintaining all traffic control devices. A uniformed traffic control officer is required when a signalized intersection is interrupted for construction activities. Uniformed traffic control officers are city, county, or state police officers. The specifications will state if a uniformed traffic control officer is required.

The effectiveness of handling traffic through night construction depends upon the plans and upon the details of the contractor's operations. Consider the following during nighttime operations:

- Light the immediate work area and flagger stations with floodlights, taking care to not blind drivers.
- Require workers to wear bright colored clothing with reflective material that conforms to the specifications.
- Ensure that signs, barricades, and traffic control devices are clean and have proper retro-reflectivity.

- Confine the work area to the shortest practical distance.
- Verify the contractor's operation plan provides sufficient room for construction vehicle access with the least impact to traffic.
- Either through illumination or suitable marking, all construction equipment should be visible to traffic.

In the event of an accident within the work zone, the traffic control inspector must document the traffic control devices in use at the time of the accident on NDOT form 040-056, "Daily Construction Report." Photos are useful additions to written records. For information on other required accident documentation, refer to Section 3-404, Safety, of this *Construction Manual*.

Although a traffic control plan reflects the contractor's operations and traffic conditions during construction, setting up the various elements of the plan at the appropriate time is also important. The traffic control measures must address current activities and conditions. For example, a flagger may or may not be present. If the flagger is not present, "Flagger Ahead" signs should not be visible to traffic. Traffic control measures create driver expectation of upcoming conditions. When traffic control measures do not accurately reflect upcoming conditions, drivers tend to disregard signage and other traffic control devices.

Timely publicity can significantly improve traffic behavior on a construction project. A motorist who is forewarned of construction conditions will be more tolerant of delay and inconvenience and probably will be more alert and responsive to construction zone traffic control. The Resident Engineer must verify that information on project road closures, new road openings, traffic rerouting, and changes in traffic conditions is made available before such changes.

6-624.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-625 CONSTRUCTION SIGNS

6-625.1 GENERAL

Construction signs are a part of accommodating public traffic through a construction project. The project plans and specifications address requirements for construction signing, temporary traffic control devices, and traffic control plans. General guidance relating to construction signs is included in Section 6-624, Accommodations for Public Traffic.

When the specifications require the contractor to develop a traffic control plan, the Resident Engineer reviews and either accepts or rejects the contractor's traffic control plan. The contractor must submit a traffic control plan that complies with the specifications at least seven days before the preconstruction conference. The Resident Engineer works with the contractor and project stakeholders in reviewing the contractor's traffic control plans. The Resident Engineer confirms that the contractor's traffic control plans comply with Policy 07-02, and the plans and specifications. The Resident Engineer may confer with the District Engineer or the Safety/Traffic Division for assistance.

The Resident Engineer may propose changes to the contractor's traffic control plan. Typically, changes to traffic control plans are considered when field conditions are different from those contained in the plans. The traffic control plan must be appropriate for conditions that will be encountered during construction.

6-625.2 MEASUREMENT AND PAYMENT

Traffic control devices such as signs, barricades, cones, and drums are paid as rental items. As a traffic control device is installed, the sign installation is noted and it is measured for payment. The rental payment for each specific device is for the duration of the project. No additional compensation is paid if the same device is used at a different location. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-632 PERMANENT PAINTED PAVEMENT MARKINGS

6-632.1 GENERAL

This work consists of applying permanent painted traffic stripes or pavement markings to the roadway surface. Pavement striping or markings materials can be any of the following:

- Epoxy paint
- Waterborne paint
- Thermoplastic
- Polyurea paint

The plans and specifications will describe the striping and markings locations and types.

6-632.2 BEFORE CONSTRUCTION

Before work begins, the Resident Engineer should discuss the pavement markings with the NDOT District maintenance striping superintendent or supervisor. Determine if any striping or marking concerns require attention. In addition, the Resident Engineer should take the following preliminary steps:

- Discuss pavement marking materials and placement operations with the contractor.
- Review striping and marking plans, details, and any special requirements.
- Review existing field conditions. The Resident Engineer consults with the Safety/Traffic Division and the District Traffic Engineer if any changes to the plans appear to be necessary.
- Obtain material certificates of compliance before or when the material is delivered to the project. Examine the material as it arrives on the project. Look for clearly labeled containers. Verify the delivered material is the type specified to be applied.
- Obtain required samples as specified in Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.

- Inspect the contractor's equipment for specification compliance. Examine the contractor's methods for checking spread rates of paint and glass beads, application temperatures of paint material, and maximum temperatures of paint.
- Verify that the survey crew has coordinated with the contractor to establish an appropriate pilot line for proper application of pavement striping and markings.
- If installing pavement markings, verify that the contractor's stencils will produce correctly dimensioned pavement markings.

6-632.3 DURING CONSTRUCTION

During the work, do the following:

- Require that paint and thermoplastic material be placed within the specified temperature range. Thermoplastic material heated to excessive temperatures can flash and splatter when exposed to air. Check the accuracy of temperature gauges mounted on heating equipment. Employees working around thermoplastic material should wear suitable personal safety equipment, long-sleeved shirts, and eye protection.
- Verify that paint and other pavement marking material temperatures are within the limits contained in the specifications.
- Before applying pavement marking material, check and document the pavement temperature, atmospheric temperature, and expected weather conditions. Never apply materials when rain, fog, or condensation could damage the freshly painted surface.
- Before applying pavement markings, check the condition of the pavement. The pavement must be dry and clean as specified.
- Apply pavement markings within the specified time limits after completing the pavement surfacing.
- Check traffic stripes for the correct width, lengths of gaps and stripes, alignment, and direction of application.
- Check that the applied paint material complies with thickness requirements. Check the paint thickness before application of glass beads and record it on NDOT form 040-021 "Striping Paint Thickness Report."
- Check application rates for glass beads and paint. Inspect the stripes to verify that glass beads are spread uniformly and are properly embedded.
- Check thermoplastic markings for workmanship as the markings are applied. Do not permit bumps resulting from overlaps in extruded materials.
- Take samples, when necessary, in accordance with the sampling frequency Table 5.1 in Section 5, Sampling and Testing, of this *Construction Manual*.

- After application, look for any damage to striping or marking. Document any deficiencies, and notify the contractor of any required corrective action.
- Conduct and document an immediate night inspection to verify the retro- reflectivity of the installed material. One to two weeks after installation, monitor the contractor checking the retro-reflectivity of the installed material with a reflectometer listed on QPL. Checking the retro-reflectivity is required for final acceptance and is reported on NDOT form 040-041, "Retroreflectivity Measurements". If the retro-reflectivity fails to meet specifications, notify the Resident Engineer who will confer with the Materials Division and the Construction Division Quality Assurance Section to determine if corrective actions are necessary.

6-632.4 MEASUREMENT AND PAYMENT

Measure the striping and markings as described in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Solid double lines are considered a single line when measured for payment. Gaps in the broken or dotted lines are included in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-633 PAVEMENT MARKERS

6-633.1 GENERAL

This work consists of applying raised or recessed pavement markers to the roadway surface. Recessed pavement markers may be used in areas subjected to snow. Raised pavement markers are typically used in areas that are not subject to snow removal operations. The plans and specifications will describe the locations and type of pavement markers to be installed.

6-633.2 BEFORE CONSTRUCTION

Before work begins, take the following steps:

- Review striping plans, details, and any special requirements.
- Review existing field conditions. Consult the District Traffic Engineer and Safety/Traffic Division with any potential changes.
- Verify that the survey crew has coordinated with the contractor to ensure an appropriate pilot line is established for proper application of pavement markers.
- Review the contractor's proposed method of controlling traffic and verify that all the specified components of any required traffic control are in place.
- Verify the receipt of specified material certifications before installing markers. Confirm that markers and adhesive are on NDOT's approved Qualified Product List.
- Take samples, when necessary, in accordance with the sampling frequency Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.

6-633.3 DURING CONSTRUCTION

During the work, do the following:

- Before placing pavement markers, confirm that new pavement has cured for the specified time.
- Before applying adhesives, check that the pavement is clean and the surface is dry.
- Determine that the patterns and types of pavement markers are placed correctly in accordance with the typical details on the plans.
- After placement, determine that the pavement markers are not on longitudinal or transverse joints and that they are fully supported with adhesive.
- Also after placement, look for any missing or damaged pavement markers and document any deficiencies.
- Conduct and document an immediate night inspection to verify the retro-reflectivity of the installed material. Notify the contractor immediately with any problems.
- When installing temporary markers, the contractor must replace lost or damaged markers daily.

6-633.4 MEASUREMENT AND PAYMENT

Pavement markers are paid by the marker for the types installed. Record counts for payment in the appropriate field book. When placing large quantities of pavement markers, the inspector may count the markers by keeping track of the number of boxes of markers used. Check this number against the estimated number of markers to be placed. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-634 PAVEMENT MARKING FILM

6-634.1 GENERAL

This work consists of applying pavement marking film to the roadway surface. The plans and specifications will describe the locations and type of pavement marking film to be installed. Pavement marking film should be inlaid in the fresh open-graded surface during final rolling of the mat, before the surface temperature on the mat falls below 160°F. Coordination between the paving crew and the pavement marking crew is critical to proper installation of marking film. An additional roller may be necessary to properly install marking film. For final acceptance the inspector must perform an adhesion test in accordance with the specifications. The test results are recorded on NDOT form 040-047, “Pavement Marking Film Adhesion Test”.

Pavement marking film has similar requirements to painted pavement markings. Therefore, refer to Section 6-632, Permanent Painted Pavement Markings, for installation, and measurement and payment guidance.

6-635 TEMPORARY PAVEMENT STRIPING TAPE

6-635.1 GENERAL

This work consists of applying temporary pavement striping tape. The plans and specifications will describe the locations and type of temporary striping tape to be installed. Temporary striping tape must be completed before opening the roadway to traffic. The contractor must maintain temporary striping tape without additional compensation.

6-635.2 BEFORE CONSTRUCTION

Before work begins, take the following preliminary steps:

- Discuss pavement marking materials and placement operations with the contractor.
- Review traffic control sheets for temporary striping details.
- Review existing field conditions. Consult with the District Traffic Engineer and the Safety/Traffic Division if any changes appear to be necessary.
- Obtain material certificates of compliance before or during material delivery. Examine the material as it arrives on the project. Verify the delivered material is the type specified to be applied.
- Verify that the survey crew has coordinated with the contractor to ensure an appropriate pilot line is established for proper application of temporary pavement striping.

6-635.3 DURING CONSTRUCTION

During the work, do the following:

- Determine that temporary striping tape will be correctly located.
- Before applying striping, check the condition of the pavement. Ensure the pavement is dry and clean as specified.
- Observe and document the installation. Notify the contractor immediately to correct any deficiencies.
- After construction, remove all temporary pavement striping tape.

6-635.4 MEASUREMENT AND PAYMENT

Measure the striping and markings according to the units and manner specified in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Include gaps in the broken or dotted lines in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. The contractor is required to maintain and remove temporary pavement striping tape without additional compensation; therefore, only the initial installation is measured for payment. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-636 TEMPORARY PAINTED PAVEMENT MARKING

6-636.1 GENERAL

This work consists of applying temporary painted pavement striping and marking. The plans and specifications will describe the locations and type of temporary pavement striping to be installed.

Temporary striping must be completed before opening the roadway to traffic. For temporary striping paint to adhere to the pavement surface the air temperatures must be at least 45°F and the surface temperature must be above 32°F. The contractor must maintain temporary pavement striping without additional compensation.

Temporary painted pavement marking has similar application requirements to temporary pavement striping tape. Refer to Section 6-635, Temporary Pavement Striping Tape, for installation guidance.

6-636.2 MEASUREMENT AND PAYMENT

Measure the striping and markings according to the units and manner specified in the specifications. Record measurements in the appropriate field book. The specifications require measurements along the line of the traffic stripe. Include gaps in the broken or dotted lines in the linear measurement. Measurements are typically taken with a measuring wheel, or a vehicle mounted electronic measuring device. The contractor is required to maintain temporary painted pavement markings; therefore, only the initial installation is measured for payment. Refer to the specifications and the *Documentation Manual* for additional information related to measurement and payment.

6-637 POLLUTION CONTROL

6-637.1 GENERAL

Pollution control consists of the construction, installation, maintenance, and removal of temporary pollution and erosion control measures. This work prevents or minimizes air pollution, erosion, sedimentation, and pollution of water and wetlands that can occur during a construction project.

During the design phase, a project is evaluated to determine whether a storm water permit is required. If a storm water permit is not required, Section 637 of the project specifications will identify the project as "No Impact." A "No Impact" project has no storm water pollution requirements. For all other projects, the contractor is required to use temporary pollution control measures during construction.

Temporary pollution control measures used to reduce water pollution and erosion are called "Best Management Practices." Temporary pollution control and erosion control work must conform to the requirements of NDOT's *Construction Site Best Management Practices (BMPs) Manual*. The contractor and the Resident Engineer have the following responsibilities relating to temporary pollution control:

- Contractor responsibilities:
  - Contact the Nevada Department of Environmental Protection (NDEP) at least seven days before the Pre-Construction Conference to obtain appropriate permits
  - Prepare a Storm Water Pollution Prevention Plan (SWPPP) containing Best Management Practices that conform with NDOT's *Construction Site Best Management Practices (BMPs) Manual* before submitting the Notice of Intent (NOI) to NDEP
  - File a NOI with NDEP at least two days before starting work
  - Provide copies of the SWPPP and environmental permits to the Resident Engineer before beginning work
  - Photograph existing vegetation in areas that will be disturbed
  - Submit applications for Temporary Working in Waterways/Discharge Permit to NDEP
  - Photograph installed BMPs within two weeks of completion
  - Designate an individual as the Water Pollution Control Manager (WPCM)
- Resident Engineer responsibilities:
  - Photograph existing vegetation in areas that the contractor will disturb
  - Inspect BMP installations weekly and document on NDOT form 040-054, "Weekly NDOT Construction Site Discharge Inspection Checklist"
  - If deficiencies are noted, monitor the situation daily to confirm compliance within seven days

The Best Management Practices in the NDOT *Construction Site Best Management Practices Manual* are minimum requirements that the contractor implements on construction projects. As necessary, the contractor may implement other best management practices in addition to the minimum required by the NDOT *Construction Site Best Management Practices Manual*.

When temporary pollution control measures are required, the Resident Engineer must perform weekly inspections. Under the following situations, weekly inspections are not required:

- Frozen ground conditions are expected to continue for at least one month
- Land disturbance activities have been suspended
- Beginning and ending dates of the waiver period are documented in the contractor's SWPPP

The Resident Engineer documents observations using NDOT form 040-054. The form is first completed on the date that the contractor begins work on the project, and is completed weekly until the conditions of the storm water permit are fulfilled. If inspections are suspended, the Resident Engineer completes NDOT form 040-054, noting that inspections are suspended and reasons for the suspension.

The contractor must construct and maintain erosion and sedimentation control measures in accordance with the Best Management Practices designated in the contractor's Storm Water Pollution Prevention Plan (SWPPP) for the project. The NDOT *Construction Site Best Management Practices Manual* contains additional information. Section 3-405, Environmental, of this *Construction Manual* also contains additional information.

6-637.2 BEFORE CONSTRUCTION

Before the contractor begins pollution control work, the Resident Engineer should consider the following guidelines:

- Review the contractor's schedule to identify construction activities that require placement of temporary and permanent erosion control measures.
- Review the contractor's approved SWPPP to identify the types and locations of the Best Management Practices (BMPs) that the contractor proposes to use.
- At the Pre-Construction Conference, discuss environmentally sensitive areas and other areas to be preserved as described in the plans and specifications. These areas should be clearly marked and communicated to the contractor.

6-637.3 DURING CONSTRUCTION

During pollution control work, the inspector does the following:

- Observe installation of the BMPs and verify that the installation conforms to the contractor's approved SWPPP.
- Inspect the installed BMPs and verify that each is performing in the intended manner.
- Complete NDOT form 040-054, "Weekly NDOT Construction Site Discharge Inspection Checklist." Note that the form must be completed weekly. A contractor's representative must sign the form before it is submitted to the Resident Engineer.
- Inspections may be suspended under the following conditions:
    - Frozen ground conditions are expected to continue for at least one month
    - Land disturbance activities have been suspended
    - Beginning and ending dates of the waiver period are documented in the contractor's SWPPP
- Temporary erosion and sediment control features that have served their useful purpose must be removed by the contractor, unless directed otherwise by the Resident Engineer.
- The Resident Engineer must continue inspections until the National Pollutant Discharge Elimination System permit is closed and the contractor removes the Best Management Practices.

After the contractor completes all items of work, the contractor requests to be relieved of maintenance. When the contractor is granted relief of maintenance, NDOT maintenance forces become responsible for maintaining the BMPs. Before the Resident Engineer grants relief of maintenance, the following actions and items must be completed for BMPs remaining in place:

- Coordinate with the Environmental Services Division and the NDOT Maintenance Manager for the project location to review BMPs that will be left in place
- Obtain a report from the Environmental Services Division that identifies the approximate time when acceptable stabilization will occur
- Provide the Maintenance Manager with copies of the most current inspection reports (form 040-054) for all BMPs remaining in place
- Confirm that BMPs that will remain in place are in an acceptable condition
- Provide a current copy of the contractor's SWPPP to the Maintenance Manager

With projects that have a bid item for plant establishment, the contractor is not relieved of maintaining the BMPs related to plant establishment until all plant establishment requirements are met.

6-637.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-640 RETAINING WALLS (MSE WALLS)

6-640.1 GENERAL

A retaining wall is a structure that holds back soil or rock. In roadway construction, retaining walls are used along cuts or fills where space is inadequate for construction of cut slopes or embankment slopes. Bridge abutments and foundation walls, which support earth fills, are also designed as retaining walls. Retaining walls are typically used in the following situations:

- New or widened roadways in developed areas
- New or widened roadways in mountains or near steep slopes
- Bridge abutments, wing walls, and bridge embankments
- Slope stabilization
- Protection against falling rock
- Depressed roadway sections

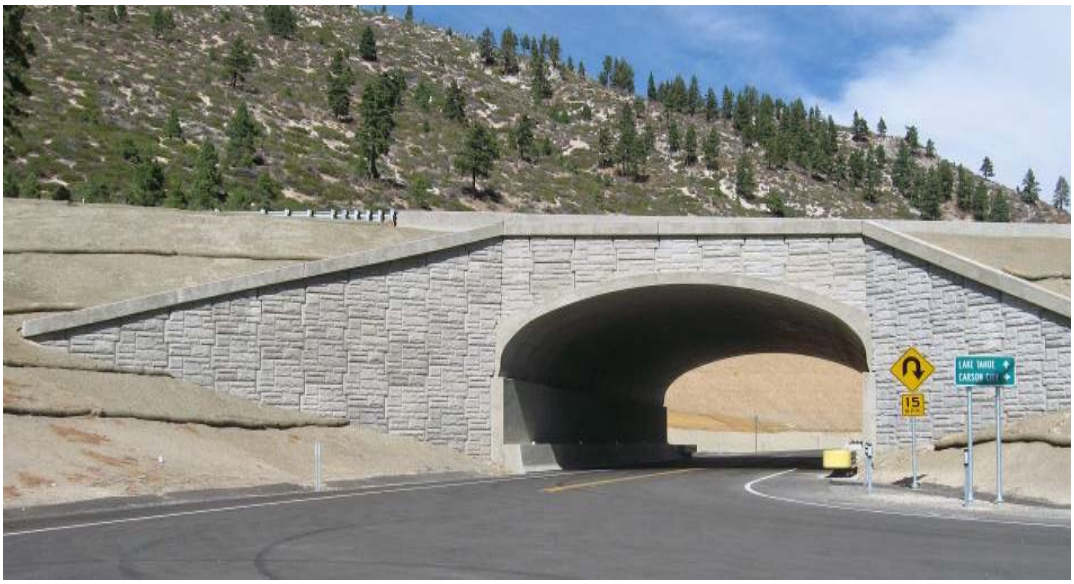

Figure 6-640.1. Typical MSE Wall.

Retaining walls prevent downslope movement or erosion and provide support for vertical or near-vertical grade changes. Retaining walls are generally made of masonry, stone, brick, concrete, steel, or timber.

A common type of retaining wall is the MSE wall (Mechanically Stabilized Earth). MSE walls utilize metallic (strip, bar mat, or wire mesh) or polymer (strip, grid, or sheet) reinforcement embedded in soil during backfilling of the MSE wall. The reinforcement is connected to precast MSE facing panels or modular blocks to create a reinforced soil mass. The backfill soil and reinforcement act together to restrain the soil. Figure 6-640.1 shows a typical MSE wall.

MSE wall systems are available in a variety of patented configurations. MSE wall systems consist of precast facing panels, wall panel spacers, and soil reinforcement. Because MSE wall systems are patented processes, the contractor designs the MSE wall system based on the design constraints contained in the plans and specifications. MSE walls approved for installation are listed on the QPL. The contractor is required to submit MSE wall shop drawings for review and approval.

MSE wall installation typically includes the following:

- Prepare the base material. This includes excavating to the MSE wall foundation grade, removing and replacing any unsuitable soil, and compacting the foundation soil.
- Construct a concrete leveling pad for MSE wall facing panels. Occasionally, a gravel pad is substituted for a concrete leveling pad.
- Place the first row of MSE wall facing panels on leveling pad. The first tier of precast facing panels is braced to maintain alignment and stability.
- Place and compact MSE backfill, and embankment if called for in the plans, up to the first layer of reinforcement.

- Place the second row of MSE wall facing panels.
- Layout and install soil reinforcement.
- Place and compact backfill over soil reinforcement.
- Repeat placement of wall panels, soil reinforcement, and backfill to final wall height.
- Construct traffic barriers, copings, or other appurtenances to the wall.

6-640.2 BEFORE CONSTRUCTION

Because the contractor designs the MSE wall system based on the design constraints contained in the plans and specifications, the contractor must submit plans, calculations, and construction manuals to the Resident Engineer. The specifications describe contractor submittal requirements. The Resident Engineer reviews the contractor's submittal for completeness and, if the submittal is sufficient, forwards the submittal to the Structures Division, which consults with the Materials Division for review and approval.

Before work begins, take the following steps:

- Review plans, specifications, and the project geotechnical reports as they relate to MSE wall construction.
- Review contractor's approved method of construction, plans, and manuals.
- Verify that panels and soil reinforcement material delivered to the projects are in acceptable condition and stored appropriately.
- Check with the survey crew to verify that the layout is in the correct location.
- Verify the contractor has located all utilities within the work area.

6-640.3 DURING CONSTRUCTION

During the work, do the following:

- Verify that the site is excavated to the proper elevation, all unsuitable material is removed and replaced, and the foundation soil is properly compacted. Confirm that the soil types and groundwater conditions encountered at the MSE wall locations match the conditions established in the geotechnical report for MSE wall design. If significant differences are noted, notify the Resident Engineer and the contractor immediately.
- Check the survey crew's stakeout. Determine that adequate survey control is established.
- Monitor MSE wall construction to verify that it conforms to the contractor's approved construction plans and manuals, and the specifications.
- When drainage structures are specified, verify that the structures are correctly located and constructed according to the plans and specifications.

- Observe and document the installation of facing panels, verifying the correct spacing and batter (vertical angle); where connectors are required, verify that connectors are installed correctly and not in contact with non-galvanized reinforcing steel. If any deficiencies are noted, notify the Resident Engineer and the contractor immediately for corrections.
- Confirm that the testers perform tests on the backfill in accordance with Table 5.1, Minimum Required Samples and Tests – Project, in Section 5, Sampling and Testing, of this *Construction Manual*.
- Monitor placement of backfill material and soil reinforcement, and compaction of backfill material, until the top of the wall is reached.
- Verify that the traffic barrier, coping, or other appurtenances to the wall are properly installed on the top of the wall.

Figure 6-640.2 MSE Wall Installation.

Figure 6-640.3 Soil Reinforcement Connected to MSE Wall Facing Panel.

Figure 6-640.4 MSE Wall Facing Panel.

Figures 6-640.2, 6-640.3, and 6-640.4 show elements of MSE wall installation, including placement of facing panels, stepped foundation excavation, soil reinforcement, and temporary wall bracing.

6-640.4 MEASUREMENT AND PAYMENT

Because MSE wall systems, including soil reinforcement, are patented processes, the quantities incorporated into the work may vary from planned quantities. Quantities for payment are limited by the specifications. Measurement and payment are described in the specifications and the *Documentation Manual*.

6-643 GROUND ANCHORS

6-643.1 GENERAL

Ground anchors are steel tendons, such as bars or cables, that are grouted in holes drilled into soil. The ground anchors transmit tensile loads into the ground, using the strength of the soil to restrain or anchor other structural elements, such as retaining walls.

Each ground anchor is installed into a pre-drilled hole and then grouted into place. Grouted ground anchors, also called tiebacks, are usually installed at a slight downward inclination. Refer to Figure 6-643.1 for a cross-sectional view of a ground anchor.

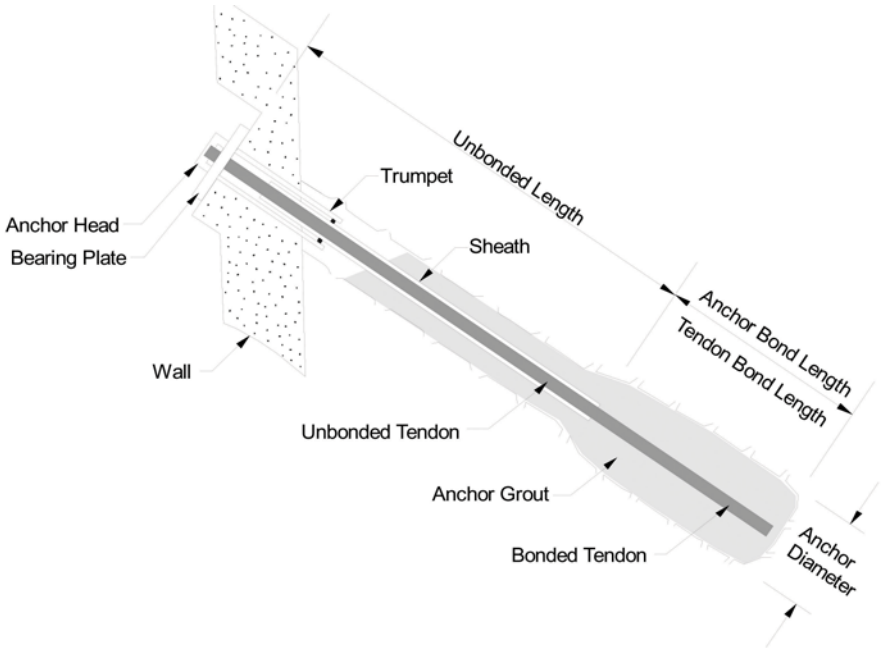

Figure 6-643.1. Ground Anchor Cross-Sectional View.

Many similarities exist with the installation of ground anchors and soil nails. Refer to Section 6-644, Soil Nail Retaining Walls. The significant difference between ground anchors and soil nails is that ground anchors are post-tensioned after construction of the retaining wall. Because of the similarities of installation methods, review Section 6-644, Soil Nail Retaining Walls, for general guidance on installation. Review Section 643, Ground Anchors, of the specifications for post-tensioning and other detailed requirements.

6-643.2 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-644 SOIL NAIL RETAINING WALLS

6-644.1 GENERAL

Soil nailing is a technique for reinforcing soil slopes, excavations, or retaining walls by inserting relatively slender steel reinforcing bars. The bars are usually installed into pre-drilled holes and then grouted into place or drilled and grouted simultaneously. Soil nails are usually installed at a slight downward inclination. Refer to Figure 6-644.1 for a cross-sectional view of a soil nail wall. The soil is stabilized by installing threaded steel bars into the slope as construction proceeds from top down. Installing and grouting these bars creates a stable mass of soil.

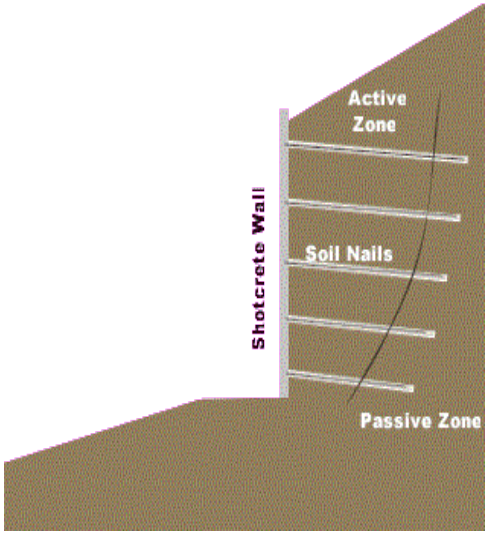

Figure 6-644.1. Soil Nail Wall.

Soil nail wall construction is sensitive to ground conditions, construction methods, equipment, and excavation sequencing. For soil nail walls to be economical, construct them in ground that can stand unsupported on a vertical or steeply cut slope of 3 to 6 feet for at least one to two days, and that can maintain an open drilled hole for at least several hours.

After soil nails are installed, the face of the slope is typically covered with shotcrete, which is reinforced using woven mesh. Following are common soil nail wall applications:

- Temporary and permanent walls for excavations.
- Cut slope retention for roadway widening and depressed roadways.
- Bridge abutments – addition of traffic lanes by removing end slopes from in front of existing bridge abutments.
- Slope stabilization.
- Repair or reconstruction of existing structures.

Following is the construction sequence for soil nail wall construction:

- Excavate a vertical cut to the elevation of the soil nails.
- Drill the hole for the nail.
- Install and grout the soil nail.
- Place drain strips and weep holes (if required), mesh reinforcing, the initial shotcrete layer, and install the bearing plates and nuts.
- Repeat process to final grade.
- Place the final facing (for permanent walls).

6-644.2 BEFORE CONSTRUCTION

The contractor must be pre-qualified to perform soil nail wall construction and must provide a construction plan to perform the work specified. The contractor submits the qualifications and construction plan before beginning the soil nail work. The Resident Engineer reviews the submittal for completeness, and if the submittal is sufficient, forwards it to the Materials Division for review and approval.

Before work begins, take the following preliminary steps:

- Review plans and specifications as they relate to soil nail wall construction.
- Review the contractor's approved soil nail wall construction plan.
- Attend the mandatory pre-construction meeting.
- Verify the contractor has located all utilities within the work area.
- Observe and document the pre-construction condition of the work area. Photo images provide indisputable supporting documentation.
- Coordinate with the Structures Division Nondestructive Testing Section for inspection of soil nail walls.

Before soil nailing begins, complete a verification testing program. The verification program tests the installation methods and verifies that the soil performs as anticipated. Nails used in the verification testing are sacrificial and are not incorporated as production soil nails. Bare nails may be used for the verification testing nails.

6-644.3 DURING CONSTRUCTION

During the work, do the following:

- Check the layout of the soil nails. Determine that adequate survey control is established.
- Monitor the work and confirm that it conforms to the specifications and the contractor's approved construction plan.
- Observe and document the installation. Notify the contractor immediately for correction of any noted deficiencies.
- Monitor the soil nail wall for movement and for signs of failure. If downward excavation uncovers unanticipated material, the contractor may need to change the construction plan or safety provisions. Notify the Resident Engineer of observations.
- If excavation exposes unstable areas, suspend work until the contractor develops approved corrective measures.
- Obtain the specified contractor records that document the soil nail wall construction.
- Assist the Structures Division Nondestructive Testing Section with inspection of soil nails.

6-644.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-646 WATERPROOFING, DAMPPROOFING AND CRACK SEALING

6-646.1 GENERAL

Waterproofing consists of sealing concrete surfaces to prevent the passage of water. Waterproofing materials include membranes with applications of waterproofing asphalt, and polymer concrete. For bridge decks, overlaying the deck with a thin layer of polymer concrete is the most common method of waterproofing a bridge deck. Polymer concrete is described in Section 6-496, Bridge Deck Seal Concrete. When membranes and asphalt are used to waterproof a bridge deck, a bituminous pavement is placed on the waterproof membrane. Waterproofing of other types of concrete surfaces, besides bridge decks, is accomplished with spray-on sealant chemicals.

Dampproofing consists of treating concrete surfaces to retard the passage or absorption of water or water vapor. Concrete surfaces, such as retaining walls, are dampproofed to protect the concrete from nuisance water that may discolor or otherwise detract from the appearance of the concrete. Typically, concrete is dampproofed by applying waterproofing asphalt.

Crack sealing consists of sealing random cracks in structures to prevent water penetration. Random cracks are sealed using chemical sealants. Concrete elements that may be sealed include bridge decks or other component parts of the bridge, such as footings, columns, or pier caps. The spray-on chemical silane is used to seal concrete cracks. Silane is typically used to seal concrete surfaces that are not bridge decks. For bridge decks, methacrylate is commonly used as the chemical sealant. While silane is sprayed onto the concrete, methacrylate, which is more viscous, is flooded onto the bridge deck. Guidance on using methacrylate is described in Section 6-496 Bridge Deck Seal Concrete. The specifications will describe the type of waterproofing, dampproofing, or crack sealing material to be used on the project.

6-646.2 SAFETY

Chemical sealants require special handling and safety procedures. All personnel working, handling, or transporting the materials, as well as inspectors and material testers, must be familiar with safety procedures for handling and applying the chemicals. Because of the volatile nature of the chemicals used, strict adherence to handling and safety procedures is required to avoid violent chemical reactions.

The inspector should carefully review and understand the Material Safety Data Sheets (MSDS) that the contractor provides. If chemicals are not shipped, handled, and combined precisely as required by the MSDS and the specifications, the combined chemicals, including chemical vapors, can cause an explosion.

6-646.3 BEFORE CONSTRUCTION

Before the waterproofing, dampproofing, or sealing treatment is applied, consider the following guidelines:

- Review the plans and specifications, paying particular attention to the limits of treatment, type of treatment designated, required deck preparation, traffic control requirements, sampling and testing requirements, and the method and sequence of operation.
- Check the materials delivered to the site to verify they conform to the type designated for the project. Obtain applicable certificates of compliance. Verify compliance with project requirements.
- Be familiar with application requirements such as weather limitations, surface moisture, and surface and ambient temperatures. Pay particular attention to required drying periods of the sealant.
- Before application of the sealant, check that the age of the concrete complies with specification requirements.
- Confirm that the concrete surface has been prepared as required by the specifications. Pay particular attention to the limits of cleaning for the bridge deck, approach slabs, height of curb above asphalt overlay, height of bridge rail above deck, and sidewalks. Also, pay attention to the cleaning sequence, timing, and methods. Where waterproofing membrane is specified, verify that rough surface areas that could puncture or create air pockets in the membrane have been corrected.

6-646.4 DURING CONSTRUCTION

During the application of waterproofing, dampproofing, or sealing treatment, consider the following guidelines:

- When a primer is specified, observe the application, making sure that the limits and application rate conform to the plans and specifications.
- Monitor the membrane placement. Verify that the membrane is placed at the appropriate time after the primer is applied. Check the limits of placement. The contractor must place the membrane with an overlap at the seams so that a shingling effect is achieved that directs runoff toward curbs and drains. The placed membrane must not have wrinkles and air bubbles. If placement is unacceptable, the contractor must repair the defects. Near joints and drain pipes, pay particular attention to placement and priming requirements.
- Where protective covering is designated over the membrane, do not permit more membrane to be placed than can be properly covered in the same work day. Pay particular attention to the limits of covering and the required treatment of overlaps and joints.
- If traffic will use the chemically sealed surface, sand is applied to increase the skid resistance of the riding surface. The specifications describe the type of sand and application requirements.
- The contractor must follow the manufacturer's safety recommendations when applying chemical sealers. The technical representative from the manufacturer is required to be on the project.
- The contractor must correct defective work as soon as practical..

6-646.5 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.

6-660 PNEUMATICALLY PLACED CONCRETE MORTAR

6-660.1 GENERAL

Pneumatically placed concrete is mortar or concrete that is applied under pressure through a hose. Pneumatically placed concrete mortar is also called shotcrete. Shotcrete is pneumatically projected at high velocity onto a surface. Placement and compaction occurs at the same time due to the force with which it is projected from the nozzle. Shotcrete can be applied or impacted onto a variety of types or shapes of surfaces, including vertical or overhead areas.

Shotcrete is used for lining ditches and channels, slope paving, temporary wall facings, and other similar features. When used as a ditch lining or slope paving, shotcrete stops soil from eroding. As a temporary wall facing, shotcrete also restrains the soil during the process of constructing retaining walls that require soil to be excavated from the top to the bottom.

When shotcrete is used as a temporary wall facing, it is used in conjunction with ground anchors or soil nails, providing a system that stabilizes a slope prior to constructing a permanent retaining wall. For details relating to ground anchors and soil nails, refer to Section 6-643, Ground Anchors, and Section 6-644, Soil Nail Retaining Walls. The sequence of construction operations when using shotcrete as a temporary wall facing begins at the top of the slope being excavated and proceeds downward. For example, if a slope is to be excavated in thirds, the top third is excavated first, then soil nails or ground anchors are installed, and then shotcrete is applied to the slope face. The process progresses downward to the middle third, then to the bottom third. After the bottom third is completed, construction of the permanent retaining wall begins. The excavation dimensions are detailed in the plans and specifications, and must be constructed in conformance with the approved construction plan for soil nails or ground anchors submitted by the contractor.

Shotcrete used with soil nail walls has specific requirements relating to contractor qualifications and material submittals. Because of the stricter requirements of shotcrete used with soil nail walls, this section focuses on shotcrete used in soil nail walls. For other applications in which shotcrete has no structural function, the plans and specifications should provide sufficient direction.

6-660.2 BEFORE CONSTRUCTION

Before shotcrete is applied, the contractor must provide required submittals including qualifications of the person applying the shotcrete, as described in the specifications. The Resident Engineer reviews the submittal for completeness. Shop drawings and contractor qualifications are submitted to the Structures Division for review and approval. The Resident Engineer submits the shotcrete mix design to the Materials Division for review and approval. After the contractor has provided the required submittals, a mandatory pre-construction meeting is held prior to the start of the shotcrete operation. Attendees of the pre-construction meeting typically include representatives from the contractor, soil nail subcontractor, shotcrete subcontractor, and NDOT representatives.

Before the shotcrete work begins, the inspector takes the following preliminary steps:

- Review plans and specifications as they relate to temporary wall construction.
- Confirm that the required submittals have been reviewed and approved.
- Attend the mandatory pre-construction meeting conducted by the Resident Engineer.
- Confirm that the proposed mix design is approved and method of placement is acceptable, including the qualifications of the person applying the shotcrete.
- Confirm soil nails and ground anchors have been successfully proof tested. If proof testing has not been completed, coordinate with the Structures Division Nondestructive Testing Section to complete the required proof testing.
- Confirm that the pre-construction test panels have been tested and accepted before beginning the shotcrete operation.

6-660.3 DURING CONSTRUCTION

Before the shotcrete operation begins, inspect the excavation face, observing that the face is free of loose debris. The face of the excavation should be free of irregularities that could cause quantity overruns. Monitor placement of drainage elements, such as geocomposite drainage strips. Geocomposite drainage strips must be connected to drainage holes, commonly called weep holes, and be secured to prevent movement during shotcrete placement. Confirm that weep holes are located above the finish grade, thereby providing unobstructed drainage. Shotcrete wall facings are reinforced with welded wire fabric or mesh, or reinforcing steel. Before shotcrete placement, inspect reinforcement to verify conformance to the plans and specifications.

During the shotcrete placement, do the following:

- Monitor the work; verify it conforms to the specifications, the contractor's approved construction plan, and approved shop drawings.
- Observe and document the installation. If any deficiencies are noted, notify the Resident Engineer and the contractor immediately for corrections.
- If groundwater is encountered causing displacement of the applied shotcrete, suspend work until the contractor develops approved corrective measures.
- Shotcrete placement should be suspended during inclement weather, such as rain and wind, unless the contractor provides approved protection methods.
- Before the initial set of shotcrete, confirm that the contractor installs the bearing plate and nut to each nail head in accordance with the specifications.
- Verify proper controls are in place to monitor the thickness of the applied shotcrete. Incorrect shotcrete thickness can negatively affect permanent retaining wall construction.

The inspector observes the contractor obtaining core samples of the placed shotcrete, collects the contractor's samples, and transmits the samples to the Materials Division for compressive strength testing. Samples are taken in accordance with ASTM C171. Core holes are filled according to the specifications. Cores are sent to the Materials Division for testing as described in the specifications.

6-660.4 MEASUREMENT AND PAYMENT

Measurement and payment are described in the specifications and the *Documentation Manual*.