



# Electrical System Components

## Part 1

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- Conduit
- Pull Box,  
Communication Vault
- Base (Foundation)
- Transformer(Break  
away Base)





# Conduit

(UL or NRTL listed)

**Rigid Metallic Conduit (Galvanized)**

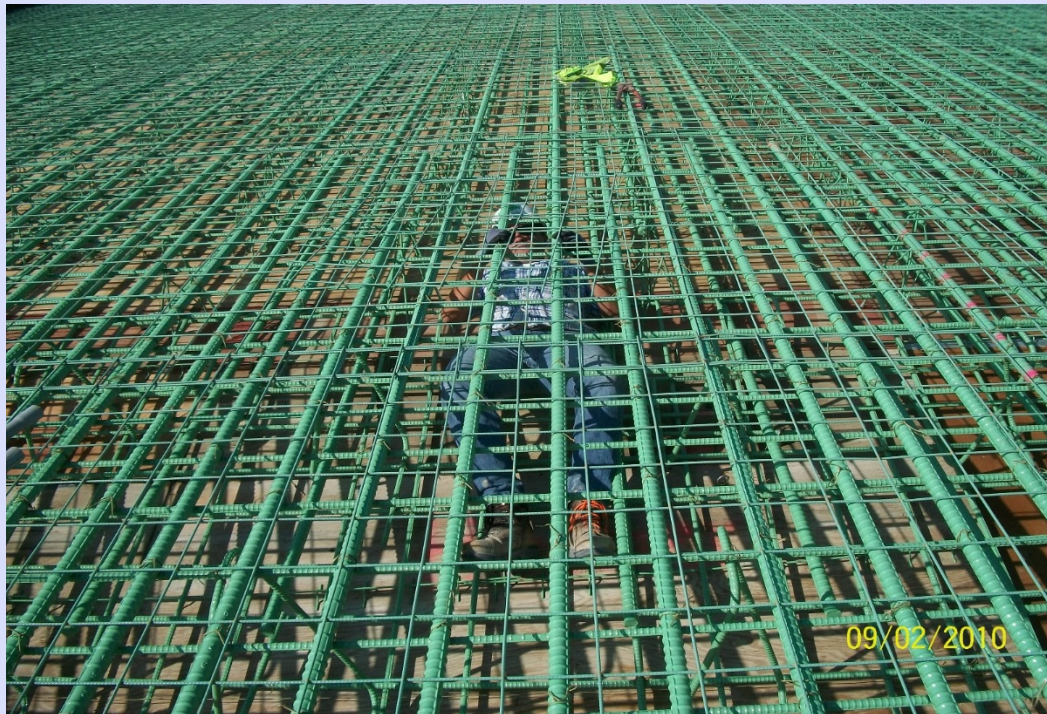
**Rigid Non Metallic PVC Conduit (Schedule 40–80)**

**Fiberglass Conduit -RTRC (Reinforced  
Thermosetting Resin Conduit)**

**HDPE Conduit (High-density Polyethylene)**



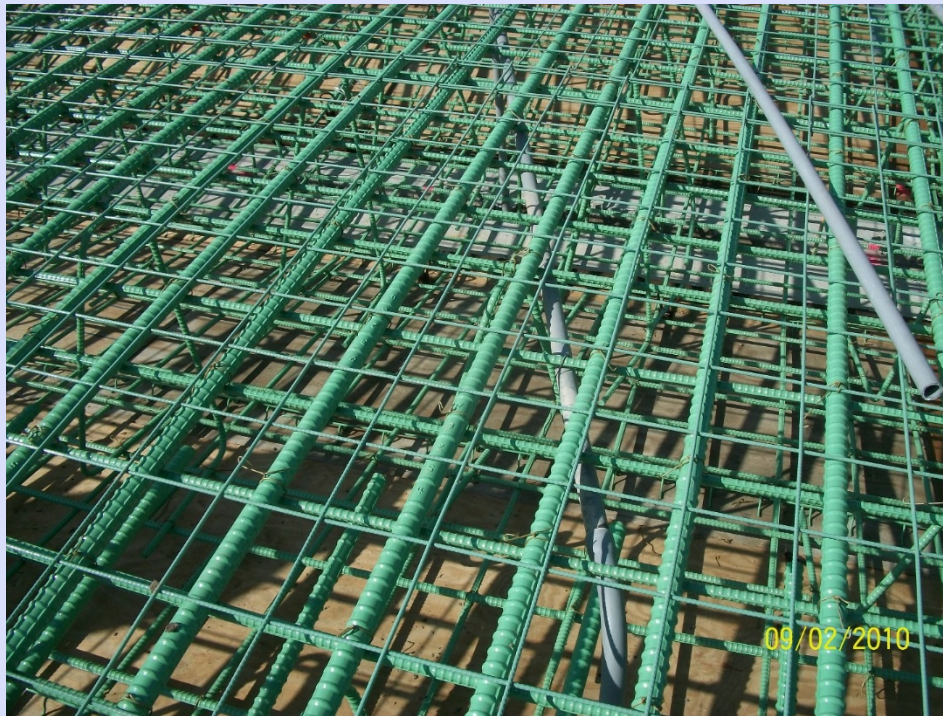
## Unintended results







# Missing Conduit





## Galvanized Rigid Conduit



Differences between IMC and Rigid **intermediate metal conduit** is not permitted to Install on DOT projects.

- 10 foot lengths and is assembled using threaded joints.
- Bends are prefabricated or made with mechanical benders.
- Conduit is hot dipped galvanized to prevent corrosion and rust.
- If corrosion protection is compromised it needs to be repaired with equivalent corrosion protection.



## Rigid Nonmetallic Conduit (PVC)



- 10-20 foot lengths and is assembled using glued joints.
- Bends are prefabricated or made by heating the conduit.
- Two different thickness Schedule **40** or Schedule **80**



# Reinforced Thermosetting Resin (Fiberglass) Conduit



- RTRC is used for installation on bridges.
- The lighter weight conduit provides protective qualities equivalent to rigid but at a much lighter weight.
- RTRC has less expansion and contraction than standard PVC products and also allows for greater spacing between hangers.









# HDPE Conduit

- HDPE conduit comes in continuous lengths usually coiled on large reels.
- It is used underground typically installed by directional boring or by plowing. The joining of the conduit is accomplished by drive on couplings, threaded compression couplings, or a splice using electrofusion process. Mostly use ITS applications
- Additional options available for HDPE conduit is to purchase conduits with cables pre-installed (cable in duct).
- Do not install HDPE conduit above ground or on structures.





# Conduit Installation Methods

- Directional Boring
- Hydro Excavation
- Plowing
- Hand Digging
- Backhoe







# Directional Boring

- Allows installation with minimal surface disruption.
- Popular method for crossing paved road and difficult side conditions.
- Problems shrink conduit from pull boxes connection.







# Hydro Excavation

- Uses water jets with a vacuum system to remove dirt.
- Less risk of underground utilities disturbance.
- Water use around electrical utilities could be hazardous.
- Ground can become saturated and collapse.



# Plowing

- Similar to traditional excavation.
- Machine with a blade is used to cut conduit path.
- Can create dips or wiggles
- in the conduit system.





# Hand Digging

- Any earth moving equipment must maintain a clearance of 18 inches.
- Hand digging is required within 18 inches by State Statute 182.0175.





# Backfill

- Materials (Check with Department)
- Compaction
  - Backfill must be compacted in layers not exceeding 12 inches.
  - Proper compaction will minimize frost heaves.
- Avoiding Washouts
- Protecting Excavations and Adjacent Construction
- Soil conditions
- Restoration and cleanup

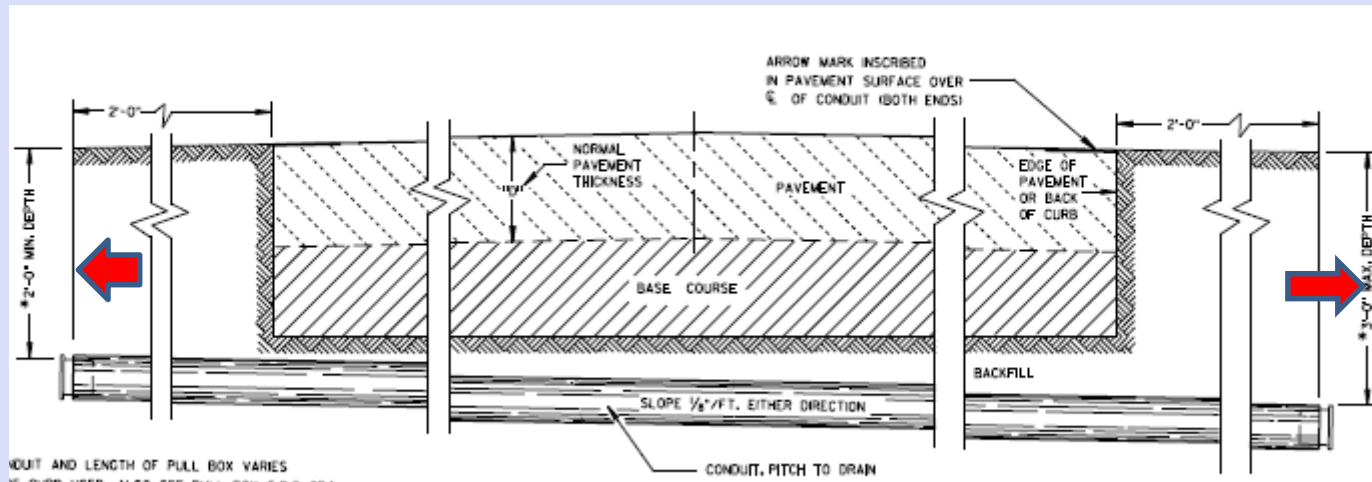






# General Installation Practices

- Ream and thread the ends of rigid metallic conduit
- Cap/plug conduit immediately after installation,
- Depth of conduit



<http://wisconsindot.gov/rdwy/sdd/sd-09b02.pdf#sd9b2>





# Protecting Conduit From Foreign Material Entry



Conduits need to be protected against entry of foreign material during installation. Water can carry dirt and stones into the conduit. When back filling dirt and stones can also enter the conduit. This can cause damage to the wires when they are installed and may cause damage months or years later. During construction be sure to keep the end of conduits covered or plugged to avoid soil or rocks from entering.





- Sizing Conduit size/schedule always shown on plan
- Ensure that the number of cables in conduits meet conduit fill requirements based on NEC (Important when pulling new cables in existing conduits)
- **Install tracer wire/cable** in each conduit Unless the plan specifies install a 12 AWG. XLP insulated, stranded, copper, 600-volt AC,





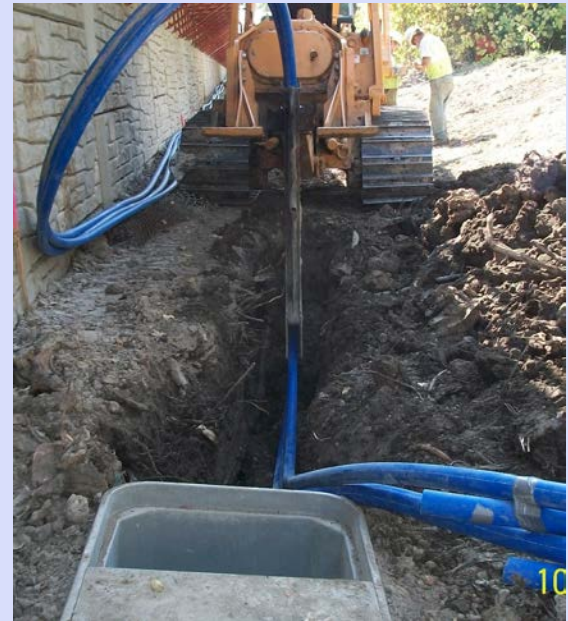


## Conduit Runs and Transitions

- Conduits are to be installed as a complete run prior to installation of cables or conductors.
- Transitions between sizes require boxes or fittings.
- **Maximum Number of bends shall exceed (360°)** between junction points is limited in the State of Wisconsin design guides.

# Conduit Paths

- Verify location and cable route from the contract drawings.
- Coordinate installation to allow for proper drainage and burial depth.





- Straight runs are required
- Reduced pulling tension
- Greater ease in digger locates





# Conduit Coupling

- Threaded coupling shall be made up wrench tight using suitable tools.
- Threads cut in the field shall be made using appropriate NPT dies.





# Rigid PVC Conduit Coupling

- PVC conduit shall be primed and glued with primer and cement as approved by the conduit manufacturer.
- Cuts ends should be squared and fully seated into the fittings.
- Conduits installed by boring must utilize couplings suitable for the pulling force.





## High Density Polyethylene (HDPE) Coupling

- Furnish bends, adapters, couplings, fittings, and other materials used to install conduits. Meet manufacturer's installation recommendations. Furnish anodized aluminum reverse threaded couplers sized as appropriate.





## Reinforced Thermosetting Resin Conduit (RTRC) Coupling

- RTRC is joined or coupled by mechanical (threaded joints) or adhesive (epoxy) means.
- Epoxy termination must be made up using sufficient quantities of manufacturer approved two-part epoxy.





# Inspection Requirements

- See checklist(CMM 6-55)
- Notify of DOT for Inspection before covering underground conduit and prior to wire/cable installation
- Conductors are not to be installed until inspection is complete and all non-compliance items corrected



# Bending Techniques

- Avoid using bends on conduit runs into pull boxes or base
- Methods of Heating
  - Hot Boxes
  - Heat Blankets
  - Do not use torches to heat rigid PVC (SDD 9B2 Notes)
    - Scorched conduit will be required to be replaced at contractors expense
- Minimum Bending radius must be maintained







# Methods of Heating





# Abrasion and Corrosion Protection

- Internal finish of the conduit shall be free of sharp edges or burrs.
- All conduits shall be cut using suitable tools.
- Ends of all conduits need to be terminated on a fitting or with an improved bushing.
- Corrosion protection that has been compromised must be reapplied.







What is wrong?..

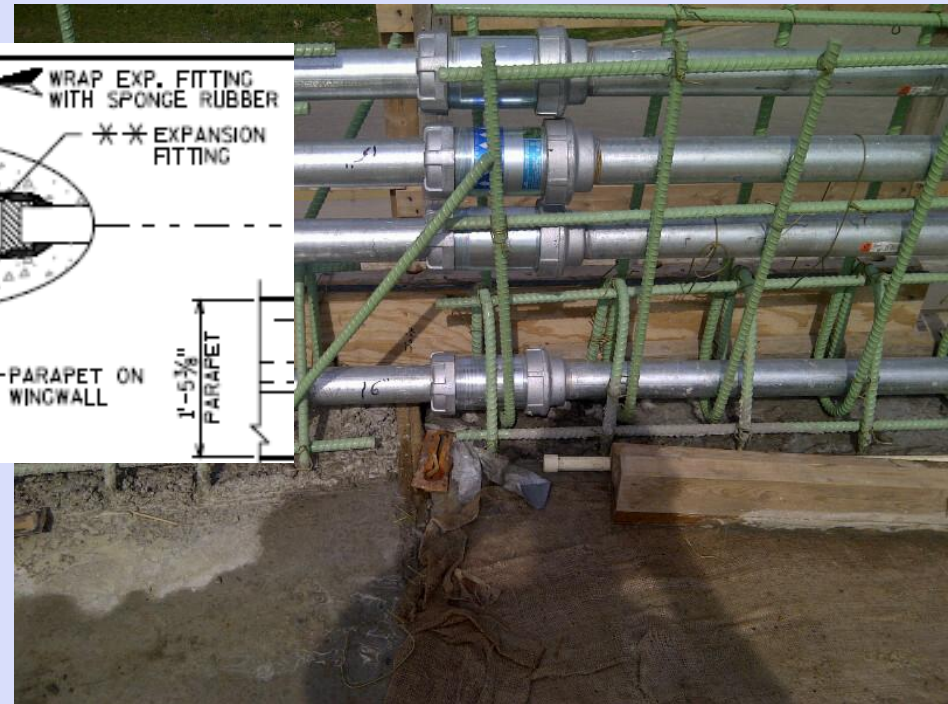
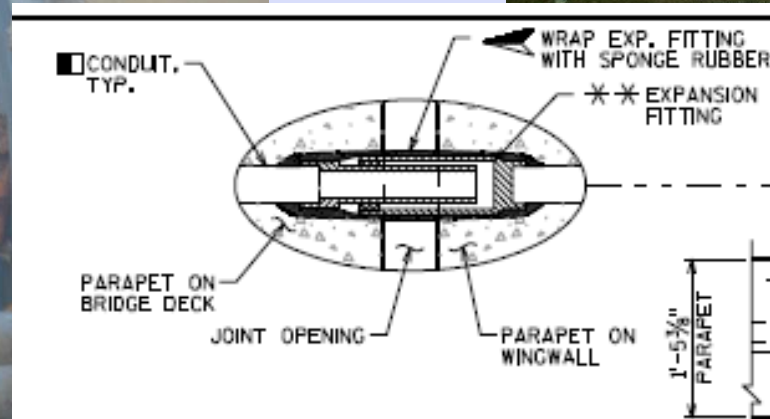
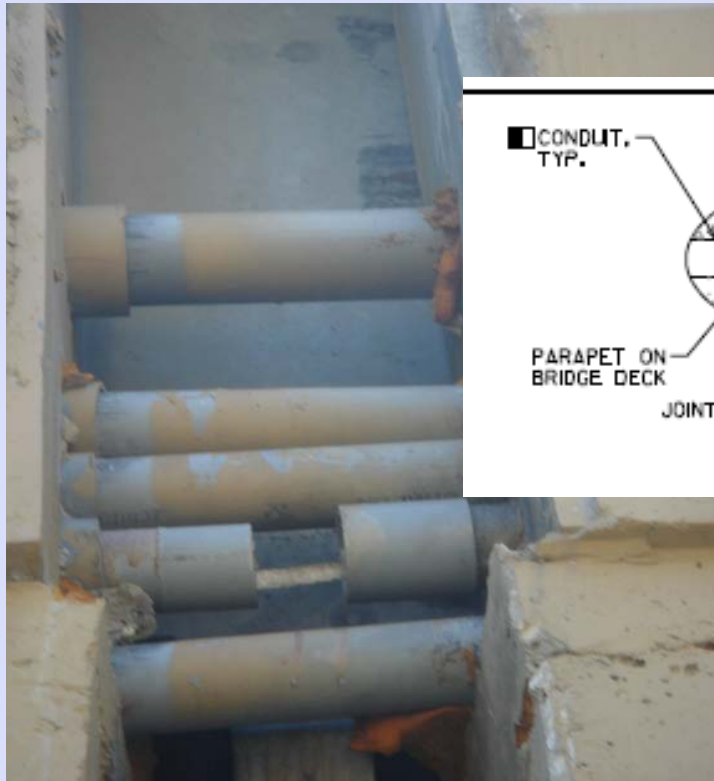




# End Bells and Bushings



# Expansion Fittings



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Sponge rubber wrap to be AASHTO m153



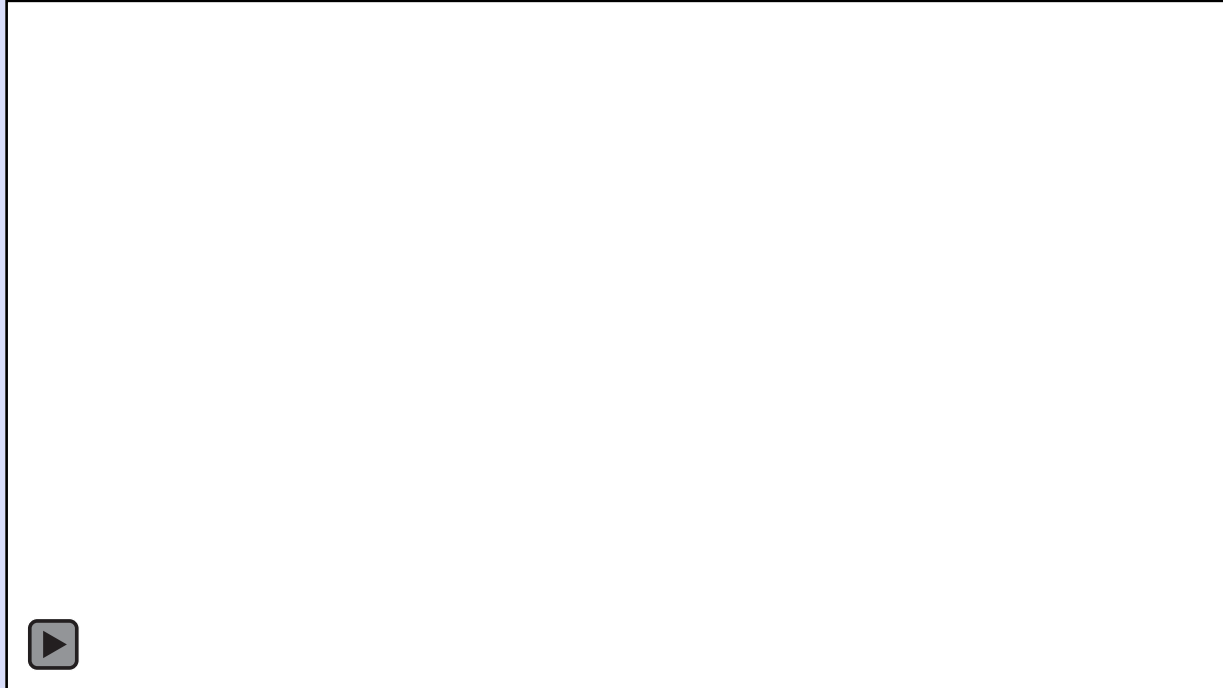








# Electrical System Components Part 2





# Pull & Junction Boxes and Vaults

- Types of Pull Boxes
  - Galvanized Corrugated Steel Pull Box
  - Non Conductive Pull Box
- Junction Boxes
- Communication Vaults









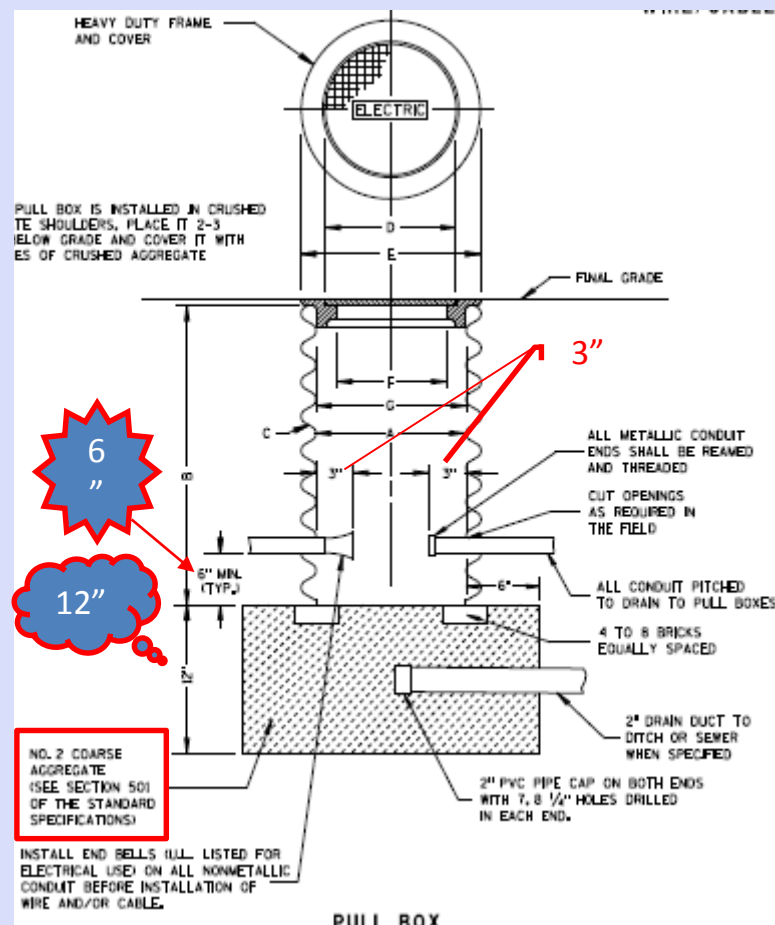




# Pull and Junction Box Locations

- Verify location does not allow accumulation of water.
- Review possible conflict with expected vehicle pathways (Consider larger vehicle movements).
- Verify conflict with utilities.

- Conduits terminating in junction boxes shall terminate not more than 3 inches inside.
- The conduit should run straight into the junction box without any bends.
- The opening around the conduit shall be sealed to prevent water, soil, or rock intrusion.



<http://wisconsindot.gov/rdwy/sdd/sd-09b04.pdf#sd9b4>









# Vault



Typically used for ITS and communication systems.

Typically 30x48x48”.

The lid is stamped with WisDOT Communication.

Inside should contain fiber optic cable support assembly.









## Galvanized Steel Pull Box



Galvanized steel covered pipe with manhole frame and solid cover.

Cover typically marked “Electric”. Pull boxes installed on roadways should have lacking covers.

No. 2 aggregated base is required below for proper drainage.

Pipe depth 24” – 36”

Twelve inches of stone below box  
Drainage if needed





# Non-Conductive Pull Box













## Arranged to Drain

- Where possible conduit systems shall be installed so that they are arranged to drain.
- Consult pull box SDD for provisions to provide drainage.







# Locations/Elevation

- Verify pull box location from the contract drawings.
- Identify surrounding elevations to determine pull and junction box elevations. Verify it's not in a ditch.







# What is wrong?









# Bases

- Concrete Bases Type
- Concrete Control Cabinet Base
- Monotube Pole Base
- Camera Pole Base







# Staking Lighting Pole Location

- Verify base location from the contract drawings.
- Verify set back dimensions from roadway.
- Locate all utility conflicts (Don't forget to look up).







# Concrete Foundations

- Locating (Final placement and Grade Elevations)
- Excavating
- Rebar
- Anchor Bolts
  - High Strength
  - Provided by WisDOT
- Base Types
- Standard Methods of Installation
- Backfill



# Locating

- Final Placement
- Grade Elevations



## Locating (Grade Elevation)







# Anchor Bolts

- High Strength
- Monotube anchor bolt provided by WisDOT



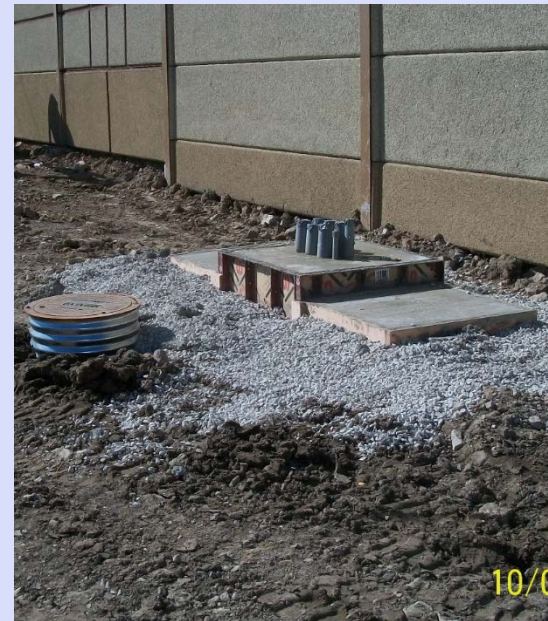
## Pouring Concrete





# Control Cabinet Bases

- Secure controller cabinets on concrete bases as the plan shows.
- Secure cabinet with stainless steel bolted connections using lock washers or locking nuts per detail drawings.







# Staking Signal Cabinet Location

- Verify base location from the contract drawings.
- Verify all traffic operation elements can be seen from cabinet.
- Verify base type, size, and conduit arrangements.
- Verify elevations to avoid flooding or snow accumulation.
- Locate all utility conflicts (Don't forget to look up).





## Cabinet Bases – Smooth and level finish



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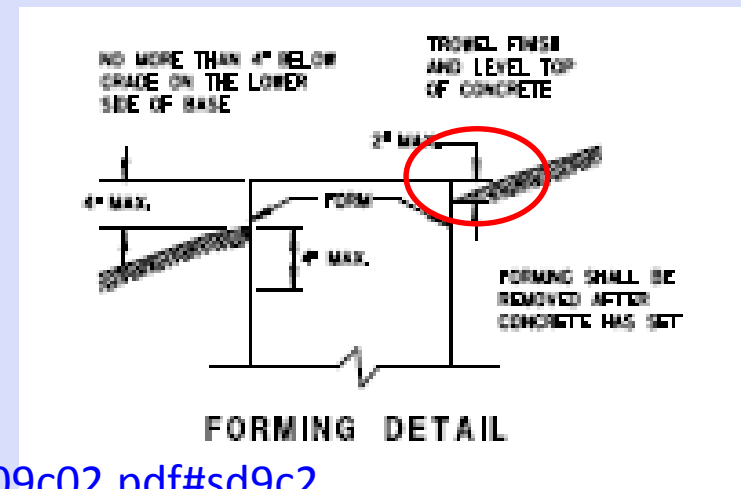
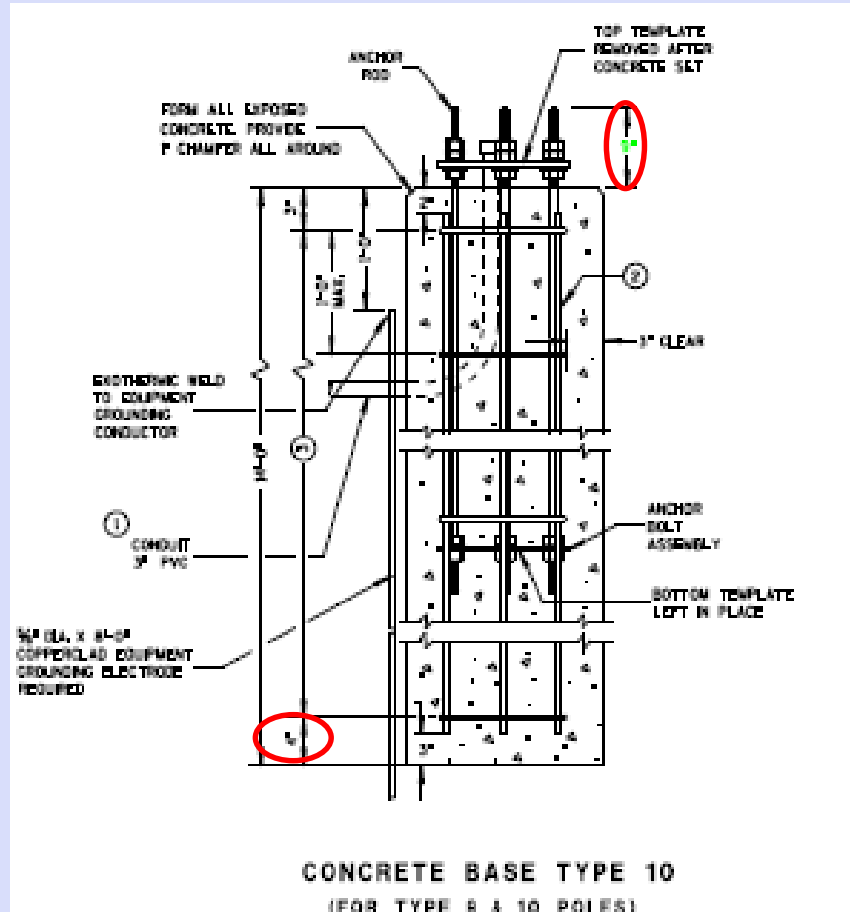




## Location Elevation



# Pole Base Detail




<http://wisconsindot.gov/rdwy/sdd/sd-09c02.pdf#sd9c2>




## Anchor Rod Grade

Anchor bolts conforming to ASTM F1554 grade 105 for type 1 and 2 traffic signal bases; for type 5, 6, 7, and 8 street light bases; for type 10 control cabinet bases; and for type 11 walkway lighting unit bases.

 One End Red	F1554 Grade 105
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Use department-furnished anchor bolts, nuts, and washers for type 10 and 13 monotube pole bases for grade 55

 One End Yellow	F1554 Grade 55
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## What is wrong







# Base Installation







# Poles, Arms, Breakaway Bases

Make sure rodent screen installed

What's up?



## Concrete Base



- Smooth level surface
- Uniform bolt circle
- Consistently level bolt heights



- Backfilled
- Conduits centered
- Round base







Base height and location affect pedestrian button placement





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## Things to Remember when Constructing

- Concrete base location (staking) is crucial
  - Adjusting a base even 1 or 2 feet further from the back of curb can mean the difference in a 5' arm length & base type
  - If push buttons are located on the pole, it must be accessible from the sidewalk
  - Elevation of the top of the base must be determined to guarantee clearance over crest of roadway





- Anchor bolt alignment is critical!!
  - Monotube arm position is fixed in relation to the pole, so there is **one** chance to get the arm alignment (in relation to the roadway) correct
- Type 9, 10, 12 & 13 poles as well as monotube arms will be state supplied
- Monotube arms longer than 40' will come in two pieces







- Anchor bolts must be plumb for a base to be accepted
- Standard Specification for Highway and Structure Construction contains guidance (and form) for bolt tightening sequence
- Each structure will be inspected by a private structural contractor before it is accepted



# Construction – Lessons Learned

Pre-planning and preparation pays off



A rectangle may be a square, but an oval is not a circle!





Even Little Jack Horner wouldn't call this “plumb”b!





Anchor rod will be state supplied

Two templates will be used to ensure proper anchor bolt placement and alignment







Monotubes – What not to do!





## Monotube Base

- Poor concrete finishing – surface cracks
- Off center bolt installation



# Breakaway Transformer Base









## Breakaway or....





<http://wisconsindot.gov/rdwy/sdd/sd-09c03.pdf#sd9c3>

<http://wisconsindot.gov/rdwy/sdd/sd-09c10.pdf#sd9c10>



# Pedestal Bases

- Cast aluminum pedestal and transformer bases must meet the criteria specified in the specifications.
- Ensure castings are true and free from defects that could affect strength or service life.
- Mount and install bases conforming to the manufacturer instructions.
- Thread the standard into the pedestal base and engage until wrench tight.







One NRTL listed ground lug wire connector must be mounted with a single bolt on the Sidewall. The connector must accommodate a **No. 6** copper ground wire and must have a slot head screw to connect the ground wire.





The access door of the base must be oriented away from traffic to allow maintenance personnel to see the intersection while servicing the base.





