Section 3: PRESTRESSING DUCTS

The *Standard Specifications*[9] requires that the duct enclosures for prestressing steel must:

1. Be galvanized rigid ferrous metal.
2. Be fabricated with either welded or interlocked seams, except galvanizing of the welded seams is not required.
3. Be mortar tight.
4. Have sufficient strength to maintain their correct alignment during placing of concrete.
5. Have positive metallic connections at joints between sections that do not result in angle changes at the joints.
6. Have waterproof tape at the connections.
7. Have bends that are not crimped or flattened.
8. Have ferrous metal or polyolefin transition couplings connecting the ducts to anchorage system components. Ferrous metal transition couplings need not be galvanized.
9. Have an inside cross-sectional area of at least 2.5 times the net area of the prestressing steel for multi-strand tendons.
10. Have an inside diameter of at least 1/2 inch larger than the diameter of the bar.
11. Have an outside diameter not exceeding 50 percent of the girder web width.

Rigid duct is used to take advantage of the low tendon-to-duct friction inherent with rigid ducts. The rigid-type duct is stiff enough to eliminate horizontal wobble, but flexible enough to bend and meet the required tendon profiles. The reduced friction coefficients associated with rigid duct as compared to that of flexible duct can result in a 10% to 50% reduction of prestressing steel required, depending on the length of the structure.

Rigid duct is available in various types and diameters. One type of duct is the smooth wall type, made from strip steel held together longitudinally with a continuous resistance weld or a continuous interlocking seam. The duct is normally furnished in 20-foot lengths with one end of each length enlarged to form a slip-type connection. Another type of rigid duct is made from ribbed sheet steel with helically wound interlocking seams. This duct is generally furnished in 40-foot (12.2 m) lengths and is connected by larger rigid duct couplers. A third type of rigid duct that is authorized for use on State Highway structures is the VSL shallow elliptical or rectangular type. This type is used occasionally for transverse deck stressing.

The rigid ducts are to be field released by the Structure Representative. The ducts will not have release tags attached when they arrive on the jobsite. The ducts are to be checked for specification compliance and any damage that may have occurred during shipping. Damaged duct can be repaired if the damage is minor, but must be rejected if the damage is extensive. The placement of the ducts can be checked by using the "duct checker"[10] or with an engineer's rule

[9] 2010 SS, Section 50-1.02D, Ducts and 07-19-2013 RSS, Section 50-1.02D, *D*ucts..
[10] *Bridge Construction Records and Procedures Memo* (BCM) 145-7.0.

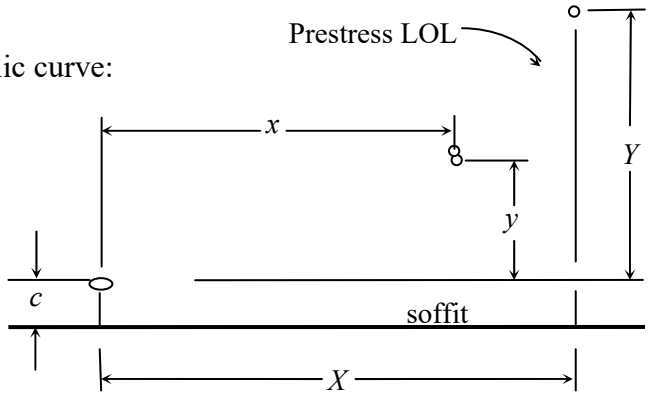
and level. Most tendon paths are parabolic and the distance from the soffit forms to the center of gravity (CG) of the path can be calculated as shown below:

Calculation of points along a parabolic curve:

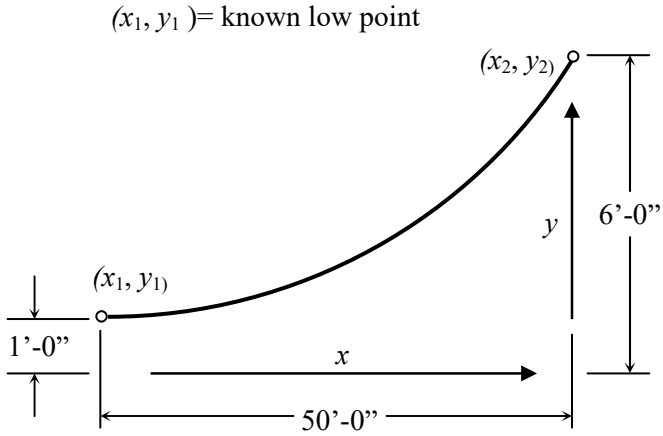
Where:

$$a = Y / X^2$$

$$y = ax^2 + c$$



Example: Given the tendon profile shown below, find the equation to calculate y.



GIVEN:

$x_1 = 0$

$y_1 = 1'\text{-}0"$

$x_2 = 50'\text{-}0"$

$y_2 = 6'\text{-}0"$

X=x2-x1 & Y=y2-y1

Solving for y: $6 = a(50)^2 + 1$

Solving for a: a = 5/2500

The final check for the duct alignment should be verified by visually observing a smooth tendon path. It is recommended that the taped duct joints be staggered for multiple tendon girders so that a misalignment of the ducts does not occur. Waterproof tape must be used at all duct connections.[11]

Once the ducts have been properly aligned, check to verify that the ducts have been properly secured to the bar reinforcing steel to prevent displacement during concrete placement. Ducts are supported vertically and horizontally during concrete placement at a spacing of at most four feet

[11] 2010 SS, Section 50-1.02D, *Ducts*.

intervals along the duct path, and is typically secured to the bar reinforcing steel using tie wire. Tie wire spacing intervals should be reduced if conditions warrant.

The Standard Specifications[12] requires vents for all ducts having a vertical duct profile change of six inches or more. Vents must:

1. Be at least 1/2-inch diameter standard pipe or suitable plastic pipe.
2. Be connected to ducts using metallic or plastic structural fasteners. Plastic components must not react with the concrete or enhance corrosion of the prestressing steel and must be free from water soluble chlorides.
3. Be mortar tight and taped as necessary.
4. Provide a means for injection of grout through the vents and for sealing the vents.
5. Be at the following locations:
    - Anchorage areas at both ends of the tendon.
    - Each high point.
    - Four feet upstream and downstream of each crest of a high point.
    - Each change in the cross section of duct.

The Contractor is required to protect the ducts from any water or debris entering them prior to the placement of the stressing steel. After installation, cover the duct ends to prevent water or debris from entering[13].

Before placing forms for deck slabs of box girder cells, the contractor is required to demonstrate:

- That any prestressing steel placed in the ducts is free and unbounded.
- That the ducts are unobstructed if no prestressing steel is in the ducts.[14]

If prestressing steel is installed after the concrete is placed, the contractor is required to demonstrate that the ducts are free of water and debris immediately before installation of prestressing steel.[15]

All holes or openings in a duct (large enough to let grout out or concrete in) must be repaired prior to concrete placement. Holes less than ¼ inch in diameter can be repaired with several wraps of waterproof tape. Holes or openings larger than ¼ inch should be repaired with an overlapping split metal sleeve.

Revisions to the *Standard Specifications*[16] will require the Contractor to pressure test each duct with compressed air after stressing and prior to grouting.[17]

[12] 2010 SS, Section 50-1.02E, *Vents* and 07-19-13 RSS, Section 50-1.03B(2)(d)(xi), *Vents.*
[13] 2010 SS, Section 50-1.03A(3), *Ducts*.
[14] 07-19-13 RSS, Section 50-1.01D(5), *Duct Demonstration of Post-Tensioned Members.*
[15] 07-19-13 RSS, Section 50-1.01D(5), *Duct Demonstration of Post-Tensioned Members.*
[16] 07-19-13 RSS, Section 50-1.01D(4), *Pressure Testing Ducts.*
[17] See Section 9, *Grouting Operation* and Appendix C, *Inspection Checklist*.

Photo 3-1 – Check of Tendon Profile.

Photo 3-2 – Smooth Duct Profile.

Photo 3-3 – 12 Ducts in One Girder at Midspan

Photo 3-4 – Part and Full Length Duct Profiles

Photo 3-5 – Transverse Ducts in Place.

Photo 3-6 – Transverse and Longitudinal Ducts