Texas Transportation Institute

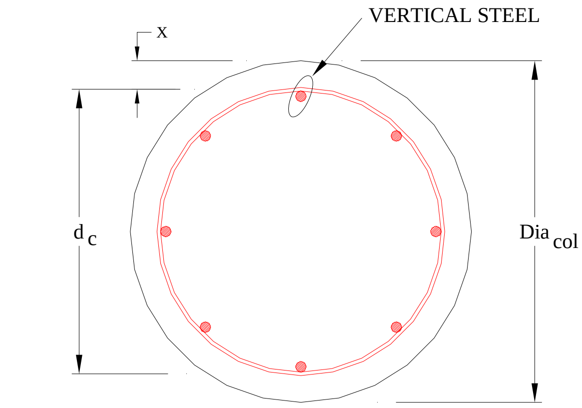
Project #: **424977**

Subject: **Circular Concrete Shaft Shear Capacity** Sponsor: **TxDOT**

1.) Given the following Design Data:

$f'_c := 3600\text{psi}$ Compressive Strength of Concrete (psi)

$f_y := 60000\text{psi}$ Yield Strength of Rebar (psi)



COLUMN SECTION

Information From TxDOT Standards for Different Columns Used:

Diameter of Column from TxDOT Standards for Different Bents & Roadway Widths

$$Dia_{col} := \begin{pmatrix} 24 \\ 30 \\ 36 \\ 42 \end{pmatrix} \text{in}$$

Diameter of Spiral Stirrup (in.) for Columns Size above, (TYP.)

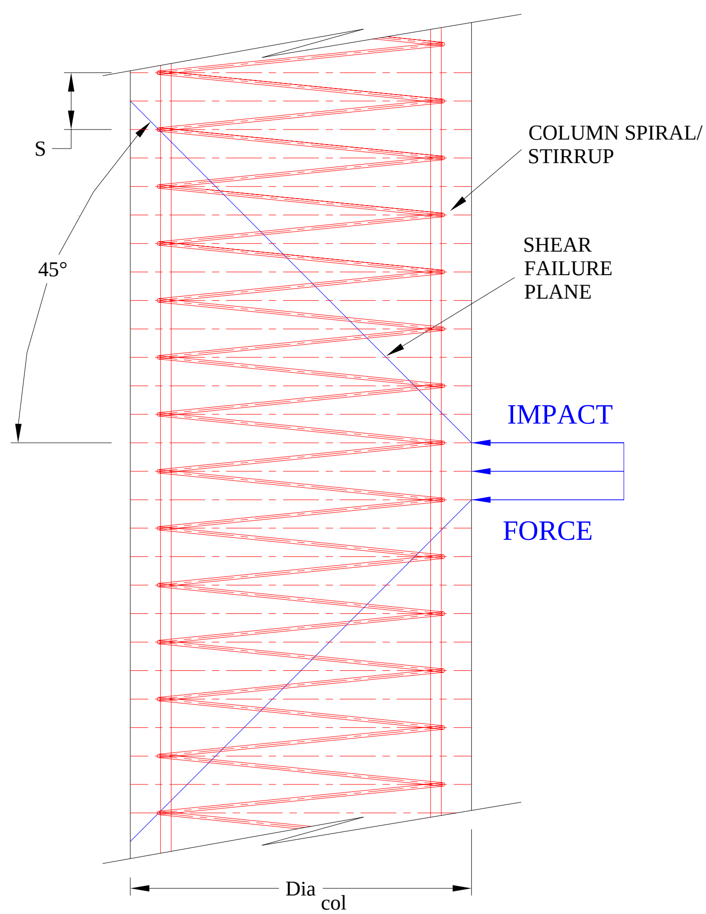
$$Stirrup_{size} := \begin{pmatrix} 0.375 \\ 0.375 \\ 0.375 \\ 0.625 \end{pmatrix} \text{in}$$

Size of Vertical Steel (All Cases)

$$Vertical_{size} := \frac{9}{8}\text{in}$$

$X := 3\text{in}$ Distance to Stirrup Center (in.)

$d_c := Dia_{col} - 2 \cdot X$ Diameter of Spiral Steel



COLUMN SIDE VIEW

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$$d_c = \begin{pmatrix} 18 \\ 24 \\ 30 \\ 36 \end{pmatrix} \cdot in$$ Diameter of Spiral Steel (in.)

$s_{spa} := 6in$ Pitch in Spiral Stirrup

$\gamma_{con} := 150pcf$ Unit weight of concrete (lbf/ft^3)

2.) <u>Calculate V_c ~ Strength Attributable to Concrete:</u>

Members with circular cross-sections, such as columns, are designed to resist crash loading (shear force). When circular ties or spirals are used as web reinforcement, the calculation of V_c is based on ACI Equation 11-4, ACI-318R-05

with:

$$Dia_{col} = \begin{pmatrix} 24 \\ 30 \\ 36 \\ 42 \end{pmatrix} \cdot in$$ Diameter of Column (in.)

$$A_g := \frac{\pi \left(Dia_{col}\right)^2}{4} \qquad A_g = \begin{pmatrix} 452.389 \\ 706.858 \\ 1017.876 \\ 1385.442 \end{pmatrix} in^2$$ Gross Area of column (in^2)

$$N_u := 50ft \cdot 15ft \cdot 12in \cdot \gamma_{con} \qquad N_u = 112.5\,kips$$

Approximate axial force normal to the cross-section occurring simultaneous with the crash impact force on the column. Assume a certain area dead loading from the slab at a certain size and thickness.

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$f'_c = 3600 \cdot psi$ Compressive strength of column concrete (psi)

$d := 0.8 \cdot Dia_{col}$ Approximate distance from extreme compression fiber to the centroid of the longitudinal tension reinforcement, but need not be taken greater than $0.8Dia_{col}$ ..... see ACI 318-05, Section 11.3.3

$$V_c := \overrightarrow{\left[2\left(1 + \frac{N_u}{2000 \cdot psi \cdot A_g}\right) \cdot \sqrt{\frac{f'_c}{psi}} \cdot psi \cdot Dia_{col} \cdot d \cdot 2\right]}$$

See ACI 318-05, Section 11.3.1.2, Equation 11-4 ..... times 2 ... for 2 shear planes

$$Dia_{col} = \begin{pmatrix} 24 \\ 30 \\ 36 \\ 42 \end{pmatrix} in \qquad V_c = \begin{pmatrix} 124.343 \\ 186.551 \\ 262.583 \\ 352.439 \end{pmatrix} \cdot kips$$

Nominal shear strength of concrete alone for corresponding column Dia.

3.) Calculate V_s ~ Strength Attributable to Shear Reinforcement:

As per ACI-318R-05, Section 11.5.7.3 - Where circular ties , hoops, or spirals are used as shear reinforcement, Vs shall be computed using Eq. 11-15 where "d" is defined in 11.3.3 for circular members, Av shall be taken as two times the area of the bar in the circular tie, hoop, or spiral at a spacing "s", "s" is measured in a direction pa to the longitudinal reinforcement, and "f_{yt}" is the specified yield strength of the circular tie, hoop, or dpiral reinforcement.

Calculate the Area of the Spiral Steel (in^2)

$$A_v := \frac{\pi \cdot Stirrup_{size}^2}{4} \cdot 2 \qquad A_v = \begin{pmatrix} 0.221 \\ 0.221 \\ 0.221 \\ 0.614 \end{pmatrix} \cdot in^2$$

Area of Stirrup Steel (in^2) .... times 2 as per ACI 318R-05, Section 11.5.7.3

$f_{yt} := 60ksi$ yield strength of spiral reinforcement (ksi)

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$s_{spa} = 6\,in$ Spiral spacing / pitch (inches)

$$V_s := \overrightarrow{\left(\frac{A_v \cdot f_{yt} \cdot Dia_{col}}{s_{spa}} \cdot 2\right)}$$

See ACI-318R-05, Section 11.5.7.2
..... use times 2 ...for 2 failure planes

$$Dia_{col} = \begin{pmatrix} 24 \\ 30 \\ 36 \\ 42 \end{pmatrix} \cdot in \qquad V_s = \begin{pmatrix} 106.029 \\ 132.536 \\ 159.043 \\ 515.418 \end{pmatrix} \cdot kips$$

Nominal shear strength of spiral steel alone for corresponding column Dia.

4.) Calculate the Nominal Shear Capacity of Column for two Failure Plane Mechanism considering the strength of the concrete and the spiral reinforcing steel:

$$V_n := V_c + V_s$$

Concrete Shear Strength Spiral Reinforcment Strength

$$V_c = \begin{pmatrix} 124.343 \\ 186.551 \\ 262.583 \\ 352.439 \end{pmatrix} \cdot kips \qquad V_s = \begin{pmatrix} 106.029 \\ 132.536 \\ 159.043 \\ 515.418 \end{pmatrix} \cdot kips$$

Column Dia.

$$Dia_{col} = \begin{pmatrix} 24 \\ 30 \\ 36 \\ 42 \end{pmatrix} \cdot in \qquad V_n = \begin{pmatrix} 230.372 \\ 319.087 \\ 421.626 \\ 867.857 \end{pmatrix} \cdot kips$$

Nominal Shear Capacity of Column (kips)

Alpha Calculations

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