STRUCTURAL ANALYSIS REPORT
WATER TANK

Prepared For:

Velocitel, Inc.
200 North Warner Road
King of Prussia, PA 19406

Structure Rating:	
Antenna Mounts:	**Pass**
Handrail:	**Pass**
Water Tank:	**Pass**

Sincerely,
Destek Engineering, LLC

3-12-2018

AHMET COLAKOGLU LICENSE No. 14504 DELAWARE PROFESSIONAL ENGINEER

Ahmet Colakoglu, PE
Delaware Professional Engineer
License No: 14504

Site ID: 1NC9561A
Site Name: University of Delaware Water Tank
540 South College Avenue
Newark, DE 19713

Destek Job No: 1807052 March 12, 2018

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APPENDIX

DESTEK ENGINEERING, LLC
1281 Kennestone Circle, Ste 100, Marietta, GA 30066-Tel: (770) 693-0835

1.0 SUBJECT AND REFERENCES

The purpose of this analysis is to evaluate the structural capacity of the existing antenna mounts and water tank located at 540 South College Avenue, Newark, DE 19713, for the additions and alterations proposed by T-Mobile.

The structural analysis is based on the following documentation provided to Destek Engineering, LLC (Destek):

- Construction Drawings prepared by T-Mobile, dated 01/19/2018.
- Tower Mapping Report prepared by High Tower Solutions, dated 02/05/2018.
- Site Photographs, dated 10/21/2016.

1.1 STRUCTURE

The subject structure is water tank which is approximately 134 feet tall with a capacity of approximately 372,100 gallons. The water tank is supported on (8) braced legs. There are no existing antennas mounted pipes attached to the handrail. The proposed antenna configuration for T-Mobile consists of (4) sectors, (12) antennas and associated equipment, with (3) antennas per sector. Please refer to the calculations in Appendix A for details about geometry and member sizes, etc.

2.0 EXISTING AND PROPOSED APPURTENANCES

T-Mobile is proposing the following appurtenance changes:

Proposed Configuration of T-Mobile Appurtenances:

SECTOR	RAD. CENTER	ANTENNA & TMA	COAX	MOUNT
Alpha, Beta, Gamma and Delta	108' & 106'	(4) AIR32 KRD901156-1 (4) APXVAA24 43-U-A20 (4) RRUS11 B12 (4) Future Antennas (8) Future RRU's (1) Dish (1) ODU	(4) Hybrid Fiber + (1) Dish Coax	(12) Pipe Mounts

*** To be installed behind the antenna**

Existing Configuration by Others:

CARRIER	RAD. CENTER	ANTENNA & TMA	MOUNT
Verizon	108'	(12) Verizon Antennas (12) Verizon RRU's	(12) Pipe Mounts

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3.0 CODES AND LOADING

The analysis is in accordance with:

- 2012 International Building Code
- ASCE 7-10, Minimum Design Loads for Buildings and Other Structures
- AISC, Manual of Steel Construction Manual, ANSI/AISC 360-10

The following loading parameters were used:

- Basic wind speed, V=89 mph (Basic Wind Speed per ASCE 7-10)
- Exposure Category : C
- Risk Category: IV
- Seismic Response Coefficient: 0.03

4.0 STANDARD CONDITIONS FOR ENGINEERING SERVICES ON EXISTING STRUCTURES

The analysis is based on the information provided to Destek and is assumed to be current and correct. Unless otherwise noted, the structure and the foundation system are assumed to be in good condition, free of defects, and can achieve theoretical strength.

It is assumed that the structure has been maintained and shall be maintained during its service lifespan. The superstructure and the foundation system are assumed to be designed with proper engineering practice and fabricated, constructed, and erected in accordance with the design documents. Destek will accept no liability which may arise due to any existing deficiency in design, material, fabrication, erection, construction, etc., or lack of maintenance.

The analysis results presented in this report are only applicable for the previously-mentioned existing and proposed additions and alterations. Any deviation of the proposed equipment and placement, etc., will require Destek to generate an additional structural analysis.

5.0 ANALYSIS AND ASSUMPTIONS

This structural analysis and qualification of the subject structure is based on either a load comparison or a strength check as following:

Pursuant to 2012 International Building Code Sections 3403.3 and 3404.3, any existing gravity load-carrying structural element for which additions and/or alterations cause an increase in design gravity load of no more than 5 percent, shall be permitted to remain unaltered, and thus considered to be Code-compliant and adequate. Any existing gravity load-carrying structural element for which additions and/or alterations cause an increase in design gravity loads exceeding 5 percent is checked against the applicable Code criteria for new structures.

Pursuant to 2012 International Building Code Sections 3403.4 and 3404.4, any existing lateral load-carrying structural element whose demand-capacity ratio with the addition and/or alteration considered is no more than 10 percent greater than its demand-capacity ratio with the addition and/or alteration ignored shall be permitted to remain unaltered, and thus considered to be Code-compliant and adequate. If the demand-capacity ratio increase is more than 10 percent, the subject structural element is checked against the applicable Code criteria for new structures.

The analysis was performed by utilizing Risa 3-D, a commercially available structural engineering software package developed by Risa Technologies, as applicable.

6.0 RESULTS AND CONCLUSION

Antenna Mounts: The existing pipe mounts are found to have **adequate** capacity for the proposed loading by T-Mobile. Under the code specified load combinations and as a maximum, the mount members are stressed to **77.4%** of their structural capacity.

Handrail: The existing handrail is found to have **adequate** capacity for the proposed loading by T-Mobile. Under the code specified load combinations and as a maximum, the handrail members are stressed to **87.6%** of their structural capacity.

Water Tank: The existing water tank is found to have **adequate** structural capacity to support the proposed loading by T-Mobile. By calculation, the proposed loads resulting from T-Mobile's final configuration is deemed negligible in comparison to the original design loads of the water tank.

Therefore, the alterations proposed by T-Mobile **can** be implemented as intended with the conditions and recommendations outlined in this report.

Should you need any clarifications or have any questions about this report, please contact Ahmet Colakoglu at (770) 693-0835 or acolakoglu@destekengineering.com.

APPENDIX A
PICTURES & CALCULATIONS

Existing Water Tank Handrail Front View (Typical)

Existing Water Tank Handrail Inside View (Typical)

CALCULATION SHEET

PURPOSE

The purpose of this analysis is to evaluate the structural capacity of the existing telecommunication installation on the water tank located at 540 South College Avenue, Newark, DE 19713 for the additions and alterations proposed by AT&T.

Tank Structure

By inspection, the existing and proposed telecommuncation intallations do not increase the lateral loads resulting from wind by more than 5%. Thus, check the increase in lateral loads to the water tank resulting from seismic loads to insure those additions are within prescribed building code limits.

Height of water tank $h := 38\text{ft}$

Diameter of water tank $D := 50\text{ft}$

Internal voiume of water tank $\text{Volume} := \frac{4}{3}\cdot\pi\cdot\left(\frac{D}{2}\right)^2\cdot\frac{h}{2} = 372095\,\text{gal}$

$\text{Capacity} := \text{Volume}$

$\gamma_{water} := 64.43\,\frac{\text{lbf}}{\text{ft}^3}$

$W_{water} := \text{Capacity}\cdot\gamma_{water} = 3205\cdot\text{kip}$ — this is also conservatively used as the effective seismic weight (neglects weight of tank's steel shell)

$C_{s\_min} := 0.03$ — seismic response coefficient - value used based upon experience

$W_{att} := 10\text{kip}$ — Weight of all carrier equipment installed, conservatively estimated

Input

ASCE 7-10 Reference

Seismic Base Shear: $V_s := C_{s\_min}\cdot W_{water} = 9.61\times10^4\,\text{lbf}$ — Equation 12.8-1, pg. 89

Compare added loads to design seismic loads

$\text{Addition} := \frac{(W_{att} + W_{water})\cdot C_{s\_min}}{V_s} - 100\% = 0.31203\cdot\%$ < 5%, thus, no additional checks required per IBC requirements

CALCULATION SHEET

CHECK ANTENNA MOUNTS

Wind Load

(reference ASCE 7-10)

Input:

Location:	Newark, New Castle County, DE		Reference, ASCE-7-10
Classification:	IV		Table 1.5-1 pg 2
Equipment height:	$z := 108$	ft	
Exposure category:	$Exp := \text{"C"}$		section 26.7.3 pg. 251

$$z_g := \begin{cases} 1200 & \text{if } Exp = \text{"B"} \\ 900 & \text{if } Exp = \text{"C"} \\ 700 & \text{if } Exp = \text{"D"} \end{cases} = 900$$

$$\alpha := \begin{cases} 7.0 & \text{if } Exp = \text{"B"} \\ 9.5 & \text{if } Exp = \text{"C"} \\ 11.5 & \text{if } Exp = \text{"D"} \end{cases} = 9.5$$

Table 26.9-1, Pg 256

Velocity pressure exposure coefficient:

$$K_z := 2.01 \cdot \left(\frac{z}{z_g}\right)^{\frac{2}{\alpha}} = 1.29$$

Table 29.3-1 pg 310

Topographic factor:	$K_{zt} := 1.0$		Sect 26.8.2 pg. 254
Wind directional factor:	$K_d := 0.95$		Table 26.6-1 pg.250
Basic wind speed:	$V := 115 \cdot \sqrt{0.6} = 89.08$	mph	Figure26.5-1A pg.247b
Gust factor:	$G := 0.85$		Section 26.9 pg 254

Velocity Pressure: $q_z := 0.00256 \cdot K_z \cdot K_{zt} \cdot K_d \cdot V^2 \cdot psf = 24.82 \cdot psf$ — Eq 29.3-1, Pg 307

Force Coeifficients:

For Flat surface — for D*sqrt(qz) >2.5 — for D*sqrt(qz) < 2.5 — Figure 29.5-1 Pg 312

$$C_{F\_flat} := \begin{pmatrix} 1 & 1.3 \\ 7 & 1.4 \\ 25 & 2 \end{pmatrix} \quad C_{F\_round\_1} := \begin{pmatrix} 1 & 0.5 \\ 7 & 0.6 \\ 25 & 0.7 \end{pmatrix} \quad C_{F\_round\_2} := \begin{pmatrix} 1 & 0.7 \\ 7 & 0.8 \\ 25 & 1.2 \end{pmatrix}$$

Loads on AIR32 KRD0901146-1:

Dimensions : $H := 56.6in$ $W := 12.9in$ $D := 8.7in$ $W_{ant} := 105.8lbf$

Front:

$Area := H \cdot W = 5.07\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.4$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 145.12\ lbf$

Side:

$Area := H \cdot D = 3.42\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.39$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 100.42\ lbf$

Loads on APXVAA24 43-U-A20:

Dimensions : $H := 95.9in$ $W := 24in$ $D := 8.7in$ $W_{ant} := 138.6lbf$

Front:

$Area := H \cdot W = 15.98\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 455.25\ lbf$

Side:

$Area := H \cdot D = 5.79\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.53$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 187.54\ lbf$

Loads on APXVAA24 43-U-A20 (Future Ant):

Dimensions : $H := 95.9in$ $W := 24in$ $D := 8.7in$

Front:

$Area := H \cdot W = 15.98\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 455.25\ lbf$

Side:

$Area := H \cdot D = 5.79\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.53$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 187.54\ lbf$

Loads on (RRUS11):

Dimensions : $H := 18in$ $W := 17in$ $D := 7.1in$ $W_{ant} := 50.7lbf$

Front:

$Area := H \cdot W = 2.12\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 58.33\ lbf$

Side:

$Area := H \cdot D = 0.89\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.33$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 24.82\ lbf$

Loads on RRRUS 4478 (Future RRU):

Dimensions : $H := 16.5in$ $W := 13.4in$ $D := 7.7in$ $W_{ant} := 60lbf$

Front:

$Area := H \cdot W = 1.54\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 42.24\ lbf$

Side:

$Area := H \cdot D = 0.88\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.32$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 24.56\ lbf$

Loads on JAHH-65C-R3B (Verizon):

Dimensions : $H := 98.7in$ $W := 13.8in$ $D := 8.2in$ $W_{ant} := 80.2lbf$

Front:

$Area := H \cdot W = 9.46\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.4$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 280.42\ lbf$

Side:

$Area := H \cdot D = 5.62\ ft^2$

$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.57$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 185.93\ lbf$

Loads on B66A RRH4x45 (Verizon):

Dimensions : $H := 25.8in$ $W := 12in$ $D := 7.3in$ $W_{ant} := 67lbf$

Front:

$Area := H \cdot W = 2.15\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$

$F_{ant\_front} := q_z \cdot G \cdot C_f \cdot Area = 59.84\ lbf$

Side:

$Area := H \cdot D = 1.31\ ft^2$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{D}\right) = 1.34$

$F_{ant\_side} := q_z \cdot G \cdot C_f \cdot Area = 37.04\ lbf$

Loads on proposed pipes (2.0 STD):

Dimensions : $H := 96in$ $W := 2.9in$

$Area := H \cdot W = 1.93\ ft^2$

$C_f := linterp\left(C_{F\_round\_2}^{\langle 0 \rangle}, C_{F\_round\_2}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.38$ Figure 29.5-1 Pg 312

$C_f := \begin{cases} C_f & \text{if } C_f \le 1.2 \\ 1.2 & \text{otherwise} \end{cases} = 1.2$

$F_{pipe} := q_z \cdot G \cdot C_f \cdot W = 6.1 \cdot plf$

Loads on PL1.5 x.25 :

Dimensions: $W := 1.5in$ $H := 0.25in$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.29$ Figure (6-19), Pg 69

$C_f := \begin{cases} C_f & \text{if } C_f \le 2.0 \\ 2.0 & \text{otherwise} \end{cases} = 1.29$

$F_{L3} := q_z \cdot G \cdot C_f \cdot W = 3.39 \cdot plf$ Equation (6-15) Pg 31

Loads on PL9"x0.4" kickers:

Dimensions: $W := 9in$ $H := 0.4in$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.28$ Figure (6-19), Pg 69

$C_f := \begin{cases} C_f & \text{if } C_f \le 2.0 \\ 2.0 & \text{otherwise} \end{cases} = 1.28$

$F_{L3} := q_z \cdot G \cdot C_f \cdot W = 20.32 \cdot plf$ Equation (6-15) Pg 31

Loads on L2"x1.5":

Dimensions: $W := 2in$ $H := 1.5in$

$C_f := linterp\left(C_{F\_flat}^{\langle 0 \rangle}, C_{F\_flat}^{\langle 1 \rangle}, \frac{H}{W}\right) = 1.3$ Figure (6-19), Pg 69

$C_f := \begin{cases} C_f & \text{if } C_f \le 2.0 \\ 2.0 & \text{otherwise} \end{cases} = 1.3$

$F_{L3} := q_z \cdot G \cdot C_f \cdot W = 4.56 \cdot plf$ Equation (6-15) Pg 31

Loads on L2.5"x2.5" :

Dimensions: $W := 2.5in$ $H := 2.5in$

$$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0\rangle}, C_{F\_flat}^{\langle 1\rangle}, \frac{H}{W}\right) = 1.3$$ Figure (6-19), Pg 69

$$C_f := \begin{cases} C_f & \text{if } C_f \le 2.0 \\ 2.0 & \text{otherwise} \end{cases} = 1.3$$

$$F_{L3} := q_z \cdot G \cdot C_f \cdot W = 5.71 \cdot plf$$ Equation (6-15) Pg 31

Loads on PL 2"x.25" kickers:

Dimensions: $W := 2in$ $H := 0.25in$

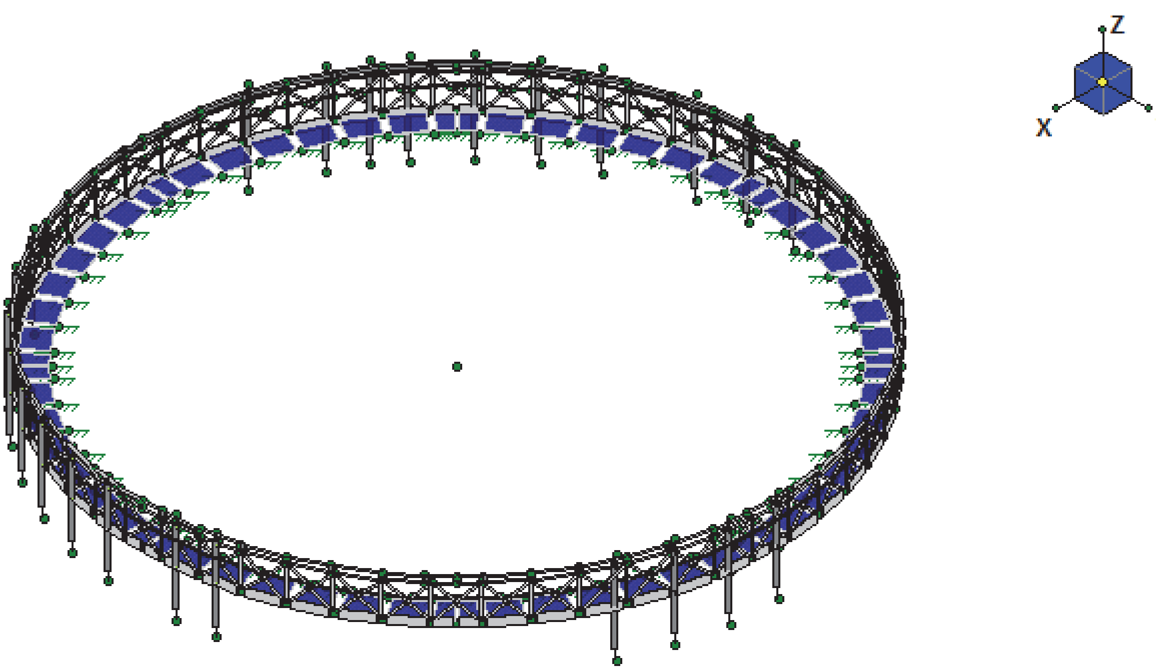
$$C_f := \text{linterp}\left(C_{F\_flat}^{\langle 0\rangle}, C_{F\_flat}^{\langle 1\rangle}, \frac{H}{W}\right) = 1.29$$ Figure (6-19), Pg 69

$$C_f := \begin{cases} C_f & \text{if } C_f \le 2.0 \\ 2.0 & \text{otherwise} \end{cases} = 1.29$$

$$F_{L3} := q_z \cdot G \cdot C_f \cdot W = 4.52 \cdot plf$$ Equation (6-15) Pg 31

Risa-3D Model:

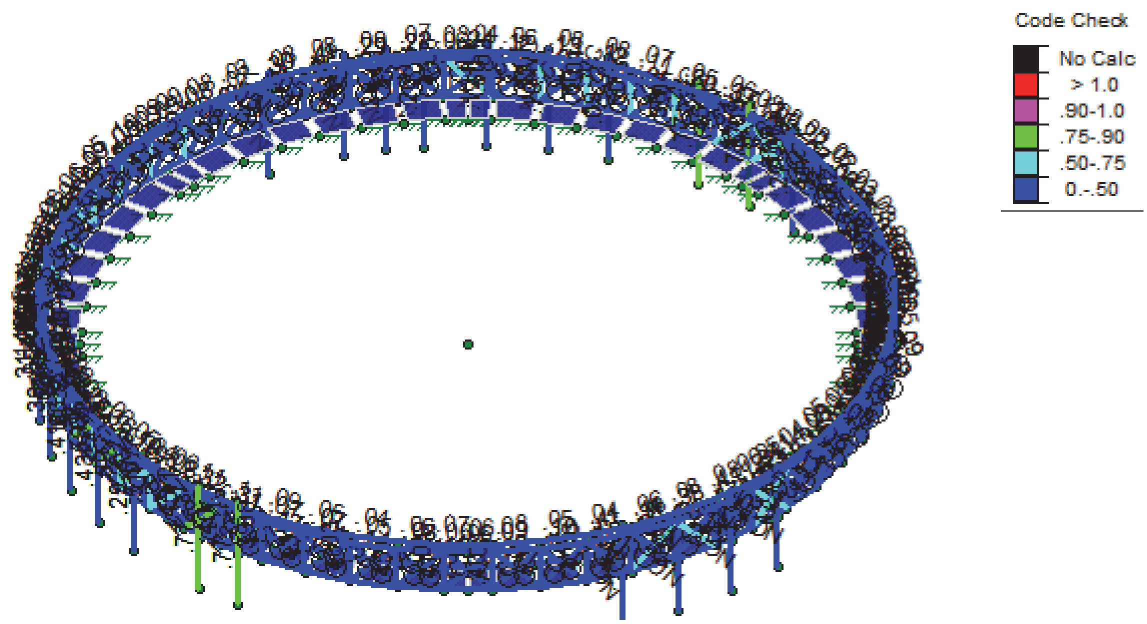
Code Check:



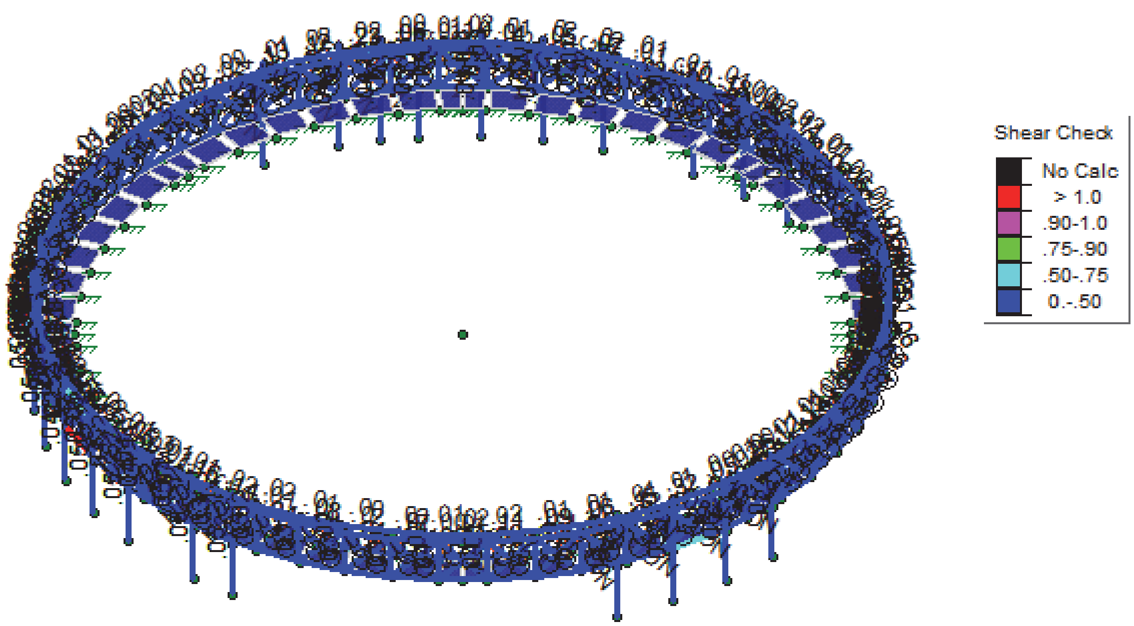
Rendering

CALCULATION SHEET

DESTEK ENGINEERING



Code Check
(Axial+Bending)



Shear Check

As a maximum, the mount is stressed to 87.6% of capacity.