### Project name: Trex Transcend Glass Guardrail System for International Building Code

<table>
<thead>
<tr>
<th>Creation date:</th>
<th>12/31/19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last revision:</td>
<td></td>
</tr>
<tr>
<td>Revision:</td>
<td>0</td>
</tr>
</tbody>
</table>

I hereby certify that the following pages of this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the states shown on the following pages.

Anthony J Barnes, PE

1/22/20
## State certifications

<table>
<thead>
<tr>
<th>State</th>
<th>Professional Engineer license number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>34664</td>
</tr>
<tr>
<td>Arizona</td>
<td>63922</td>
</tr>
<tr>
<td>California</td>
<td>84471</td>
</tr>
<tr>
<td>Colorado</td>
<td>PE.0049211</td>
</tr>
<tr>
<td>Florida</td>
<td>77515</td>
</tr>
<tr>
<td>Georgia</td>
<td>PE039214</td>
</tr>
<tr>
<td>Idaho</td>
<td>P-17222</td>
</tr>
<tr>
<td>Indiana</td>
<td>PE11400345</td>
</tr>
<tr>
<td>Iowa</td>
<td>22527</td>
</tr>
<tr>
<td>Louisiana</td>
<td>39025</td>
</tr>
<tr>
<td>Maryland</td>
<td>45817</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>51462</td>
</tr>
<tr>
<td>Michigan</td>
<td>6201063081</td>
</tr>
<tr>
<td>Minnesota</td>
<td>51612</td>
</tr>
<tr>
<td>Mississippi</td>
<td>26806</td>
</tr>
<tr>
<td>Missouri</td>
<td>PE2014023010</td>
</tr>
<tr>
<td>Nebraska</td>
<td>E-15134</td>
</tr>
<tr>
<td>Nevada</td>
<td>023009</td>
</tr>
<tr>
<td>New Jersey</td>
<td>24GE05291300</td>
</tr>
<tr>
<td>New Mexico</td>
<td>24093</td>
</tr>
<tr>
<td>New York</td>
<td>094109</td>
</tr>
<tr>
<td>North Carolina</td>
<td>041703</td>
</tr>
<tr>
<td>North Dakota</td>
<td>PE-9715</td>
</tr>
<tr>
<td>Ohio</td>
<td>79131</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>27838</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>PE082756</td>
</tr>
<tr>
<td>South Carolina</td>
<td>33939</td>
</tr>
<tr>
<td>Tennessee</td>
<td>00117639</td>
</tr>
<tr>
<td>Texas</td>
<td>PE 117821</td>
</tr>
<tr>
<td>Utah</td>
<td>9163877-2202</td>
</tr>
<tr>
<td>Virginia</td>
<td>402054114</td>
</tr>
<tr>
<td>Washington</td>
<td>51729</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>PE907658</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>43059-6</td>
</tr>
<tr>
<td>Wyoming</td>
<td>16000</td>
</tr>
</tbody>
</table>
Contents
1 State certifications .................................................................2
2 Description .............................................................................9
3 Summary tables .....................................................................10
4 System details .........................................................................12
   4.1 Composite material data ....................................................12
   4.2 Top and bottom rail ............................................................13
   4.3 Posts .................................................................................14
   4.4 Bracket ..............................................................................14
5 Design criteria .........................................................................14
   5.1 Building codes/standards/project specifications .......................14
   5.2 Design loads .......................................................................14
6 Glass analysis ...........................................................................15
   6.1 4.25’ wide by 42” tall panel .................................................15
       6.1.1 ¼” thick monolithic glass ...........................................15
   6.2 4.25’ wide by 36” tall panel ...............................................15
       6.2.1 ¼” thick monolithic glass ...........................................15
   6.3 4’ wide by 42” tall panel .....................................................16
       6.3.1 ¼” thick monolithic glass ...........................................16
   6.4 4’ wide by 36” tall panel .....................................................16
       6.4.1 ¼” thick monolithic glass ...........................................16
   6.5 3’ wide by 42” tall .............................................................17
       6.5.1 ¼” thick monolithic glass ...........................................17
   6.6 3’ wide by 36” tall .............................................................17
       6.6.1 ¼” thick monolithic glass ...........................................17
7 Calculations .............................................................................18
   7.1 Applied loads for analysis ..................................................18
7.2 Posts ................................................................................................................................. 19
  7.2.1 Allowable post wind loads ......................................................................................... 20
  7.2.2 Vertical load .............................................................................................................. 21
8 Test results .......................................................................................................................... 22
  8.1 Universal rail (bottom rail) ........................................................................................... 22
  8.1.1 Allowable wind load ............................................................................................... 23
  8.2 Transcend crown rail (top rail) ..................................................................................... 25
  8.2.1 Allowable wind load ............................................................................................... 26
  8.2.2 Vertical load ............................................................................................................ 28
  8.3 Brackets ....................................................................................................................... 28
  8.3.1 Allowable wind load ............................................................................................... 29
  8.3.2 Vertical load ............................................................................................................ 31
9 Conclusions ....................................................................................................................... 31
10 Appendix A – ESR report ................................................................................................. 32
11 Appendix B - ATI report no. I0418.01-119-19 R0 dated 05/09/18-05/29/18 37
2 Description

This calculation package illustrates the adequacy of the Trex Transcend glass railing system used in commercial applications at post spacings referred to in this report. For all loading conditions not checked in this report, see test report ATI no. I0418.01-119-19 R0 dated 05/09/18-05/29/18.
3 Summary tables

### Table 3.1

<table>
<thead>
<tr>
<th>Post spacing (ft)</th>
<th>Rail height (in)</th>
<th>Glass type</th>
<th>Max wind load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.25</td>
<td>42</td>
<td>1/4&quot; mono</td>
<td>65</td>
</tr>
<tr>
<td>4.25</td>
<td>36</td>
<td>1/4&quot; mono</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>1/4&quot; mono</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>1/4&quot; mono</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>1/4&quot; mono</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>1/4&quot; mono</td>
<td>90</td>
</tr>
</tbody>
</table>

* Deflection not considered

*Allowable stress = 13.5 ksi (93 N/mm²)

*Based on analysis

### Table 3.2

<table>
<thead>
<tr>
<th>Post spacing (ft)</th>
<th>Rail height (in)</th>
<th>Max wind load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.25</td>
<td>42</td>
<td>73</td>
</tr>
<tr>
<td>4.25</td>
<td>36</td>
<td>86</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>82</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>146</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>173</td>
</tr>
</tbody>
</table>

*Based on testing
### Table 3.3
Allowable bracket wind loads (psf)

<table>
<thead>
<tr>
<th>Post spacing (ft)</th>
<th>Rail height (in)</th>
<th>Max wind load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.25</td>
<td>42</td>
<td>53</td>
</tr>
<tr>
<td>4.25</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>56</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>67</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>89</td>
</tr>
</tbody>
</table>

*Based on testing

### Table 3.4
Allowable post wind loads (psf)

<table>
<thead>
<tr>
<th>Post spacing (ft)</th>
<th>Rail height (in)</th>
<th>Max wind load (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.25</td>
<td>42</td>
<td>27</td>
</tr>
<tr>
<td>4.25</td>
<td>36</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>29</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>39</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>52</td>
</tr>
</tbody>
</table>

*Based on analysis

Post strength controls for all conditions.
4 System details

4.1 Composite material data

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STRENGTH &amp; STABILITY PLATFORM</strong></td>
</tr>
<tr>
<td>PVC BASED FORMULATION</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEASUREMENT ASTM UNITS MATERIAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Modulus, 77°F (25°C) D3039 psi (MPa)</td>
</tr>
<tr>
<td>Extrusion direction</td>
</tr>
<tr>
<td>Cross-extrusion direction</td>
</tr>
<tr>
<td>Tensile Yield Strength, 77°F (25°C) D3039 psi (MPa)</td>
</tr>
<tr>
<td>Extrusion direction 5,500 (38)</td>
</tr>
<tr>
<td>Cross-extrusion direction 3,800 (26)</td>
</tr>
<tr>
<td>Tensile Strain at Failure, 77°F (25°C) D3039 %</td>
</tr>
<tr>
<td>Extrusion direction</td>
</tr>
<tr>
<td>Cross-extrusion direction</td>
</tr>
<tr>
<td>Flexural Modulus, 77°F (25°C) D790 psi (MPa)</td>
</tr>
<tr>
<td>Compressive Modulus, 77°F (25°C) D695 psi (MPa)</td>
</tr>
<tr>
<td>Modulus of Rupture, 77°F (25°C) D790 psi (MPa)</td>
</tr>
<tr>
<td>Maximum Flexural Strain [E max] D790 %</td>
</tr>
<tr>
<td>Impact Strength, Gardner, 77°F (25°C) D3029 inch • lbs/inch (J/m)</td>
</tr>
<tr>
<td>0.1” sample thickness</td>
</tr>
<tr>
<td>Izod Notched Impact, 77°F (25°C) D256 inch • lbs/inch (J/m)</td>
</tr>
<tr>
<td>Maximum Allowable Dynamic Stress * psi (MPa)</td>
</tr>
<tr>
<td>Extrusion Shrinkage D3679 %</td>
</tr>
<tr>
<td>Specific Gravity D792 –</td>
</tr>
<tr>
<td>Hardness, Rockwell 'L', 77°F (25°C) D795 –</td>
</tr>
<tr>
<td>Hardness, Rockwell 'H', 77°F (25°C) D795 –</td>
</tr>
<tr>
<td>Static Coefficient of Friction vs. Neolite std. 0.50 wet</td>
</tr>
<tr>
<td>Extrusion direction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIBREX® ENVIRONMENTAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement ASTM Units Material Value</td>
</tr>
<tr>
<td>Moisture Absorption D570-84 %</td>
</tr>
<tr>
<td>Termite Resistance C. formosanus Weight Loss 0</td>
</tr>
<tr>
<td>R. flavipes 0</td>
</tr>
<tr>
<td>Fungal Decay D1413 None</td>
</tr>
<tr>
<td>Moisture Expansion D1037 inch/inch/%ΔMC*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIBREX® THERMAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement ASTM Units Material Value</td>
</tr>
<tr>
<td>Heat Deflection Temperature, 264psi (1.82 MPa) D468 °F (°C)</td>
</tr>
<tr>
<td>At 0.46 MPa</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion D696 in/inch°F (cm/cm°C)</td>
</tr>
<tr>
<td>Thermal Conductivity F433 Btu/hr°F (W/m°C)</td>
</tr>
<tr>
<td>Specific Heat – Btu/lb°F (J/kg°C)</td>
</tr>
<tr>
<td>Flash Ignition Temperature D1929 °F (°C)</td>
</tr>
<tr>
<td>Self Ignition Temperature D1929 °F (°C)</td>
</tr>
<tr>
<td>Flame Spread Index E84-94 10</td>
</tr>
<tr>
<td>Smoke Developed Index E84-94 580</td>
</tr>
<tr>
<td>Average Flame Spread Index E162-94 22.73</td>
</tr>
<tr>
<td>Average Optical Density of Smoke E662-94 472.32</td>
</tr>
<tr>
<td>Flaming mode Non-flaming mode</td>
</tr>
<tr>
<td>Average Time of Burn D435-91 sec</td>
</tr>
<tr>
<td>Average Extent of Burn D635-91 mm</td>
</tr>
<tr>
<td>Final Oxygen Index D2863 %volume</td>
</tr>
</tbody>
</table>
4.2 Top and bottom rail
4.3 Posts

Posts are a min SPF #2 (minimum) 4x4 treated wood member.

4.4 Bracket

5 Design criteria

5.1 Building codes/standards/project specifications

1) IBC 2018
2) Aluminum Design Manual 2015
3) ATI report no. I0418.01-119-19 R0 dated 05/09/18-05/29/18
4) NDS 2012

Note: That this calc package also meets IRC 2018 code requirements.

5.2 Design loads

Per IBC section 1607.8.1, 50 plf linear load along the top rail.

Per IBC section 1607.8.1.1, 200 lb concentrated load applied at the top of the guardrail at any location.
6 Glass analysis

6.1 4.25’ wide by 42” tall panel

6.1.1 ¼” thick monolithic glass

6.1.1.1 Wind load
Max wind for allowable stress and deflection on glass was found to be 65 psf

\[
\text{Stress} = 13.5 \text{ ksi} = 13.5 \text{ ksi limit, OK}
\]

6.2 4.25’ wide by 36” tall panel

6.2.1 ¼” thick monolithic glass

6.2.1.1 Wind load
Max wind for allowable stress and deflection on glass was found to be 90 psf

\[
\text{Stress} = 13.5 \text{ ksi} = 13.5 \text{ ksi limit, OK}
\]
6.3 4' wide by 42" tall panel

6.3.1 ¼” thick monolithic glass

6.3.1.1 Wind load
Max wind for allowable stress and deflection on glass was found to be 65 psf

Stress = 13.5 ksi = 13.5 ksi limit, **OK**

6.4 4' wide by 36" tall panel

6.4.1 ¼” thick monolithic glass

6.4.1.1 Wind load
Max wind for allowable stress and deflection on glass was found to be 90 psf

Stress = 13.5 ksi = 13.5 ksi limit, **OK**
6.5  3’ wide by 42” tall

6.5.1 ¼” thick monolithic glass

6.5.1.1 Wind load
Max wind for allowable stress on glass was found to be 65 psf

\[
\text{Stress} = 13.5 \text{ ksi} = 13.5 \text{ ksi limit, OK}
\]

6.6  3’ wide by 36” tall

6.6.1 ¼” thick monolithic glass

6.6.1.1 Wind load
Max wind for allowable stress on glass was found to be 90 psf

\[
\text{Stress} = 13.5 \text{ ksi} = 13.5 \text{ ksi limit, OK}
\]
7 Calculations

7.1 Applied loads for analysis
Considering a 200 lb force applied at the center of the 8’ span:

\[ M = \frac{PL}{4} = \frac{0.2 \, k \times 51''}{4} = 2.6 \, k\, \text{in} \quad (4.08 \, k\, \text{in LRFD}) \]

\[ V = 50 \, \text{plf} \times 4.25 \, \text{ft} = 212.5 \, \text{lbs} \]

Considering a 50 plf force at top rail:

\[ M = PL = 50 \, \text{plf} \times 4.25 \, \text{ft} \times 42 \, \text{in} = 8.925 \, k\, \text{in} \quad (13.44 \, k\, \text{in LRFD}) \]
7.2 Posts

Check 4x4 wood post (#2 SPF or better)

S = 7.15 in$^3$

Allowable stress per NDS 2012, $F_b = 775$ psi min.

Bending capacity per 2012 NDS:

$$F_b' = F_b C_D C_M C_t C_L C_F C_{fu} C_I C_r$$

All values = 1.0 except $C_D$

$C_D = 1.6$ (short term loading)

$$F_b' = 775 \text{ psi} \times 1.6 = 1240 \text{ psi}$$

$$M_n = 1240 \text{ psi} \times 7.15 \text{ in}^3 = 8.9 \text{ k-in} = 8.925 \text{ k-in applied load as shown in section 5.1}$$
7.2.1 Allowable post wind loads

\[ M_n = 8.4 \text{ kip-in} \]

**Post spacing**

**Glass height**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 38 \text{ psf} \]

**spacing = 3 ft**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 29 \text{ psf} \]

**spacing = 4 ft**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 27 \text{ psf} \]

**spacing = 4.25 ft**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 32 \text{ psf} \]

**spacing = 3 ft**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 39 \text{ psf} \]

**spacing = 4 ft**

\[ X_{psf} = \frac{M_n}{\text{spacing} \cdot (h) \cdot \frac{h}{2}} = 37 \text{ psf} \]

**spacing = 4.25 ft**
### 7.2.2 Vertical load

\[
C_M = 0.75 \quad \text{Wet service factor}
\]

\[
C_t = 0.9 \quad \text{Temperature service factor}
\]

\[
C_d = 1.0 \quad \text{Duration service factor}
\]

\[
E_{\text{min}} = 400 \text{ ksi} \quad \text{Spruce-Pine Fur}
\]

\[
E_{\text{min}} = 400 \text{ ksi} C_M C_t C_d = 270 \text{ ksi}
\]

\[
c = 0.8
\]

\[
l_e = 42.5 \text{ in}
\]

\[
d = 4 \text{ in}
\]

\[
F_{cE} = \frac{0.822 E_{\text{min}}}{l_e^2} = 1.966 \text{ ksi}
\]

\[
F_c = 1 \text{ ksi} C_M C_t C_d = 0.573 \text{ ksi}
\]

\[
C_p := \frac{F_{cE}}{2c} - \sqrt{\frac{1 \left( \frac{F_{cE}}{F_c} \right)}{2c} + \frac{\frac{F_{cE}}{F_c}}{c}} = 0.916
\]

\[
F_c = F_c C_p = 0.615 \text{ ksi}
\]

\[
P_{\text{allowable}} := F_c l_e^2 = 9892.356 \text{ lbf}
\]
8 Test results

8.1 Universal rail (bottom rail)

Conservatively, the minimum ultimate value will be used.

Minimum ultimate load = 1038 lbs
Allowable load = 1038 lbf / 2.5 = 420 lbs

Allowable moment = PL/4 = 420 lbs * 42 in / 4 = 4.4 k-in
8.1.1 Allowable wind load

**Universal Rail**

\[ M_a = 4.4 \text{ kip in} \]

**Allowable moment per test results**

**Wind equivalent load at 42'' tall and 4.25 ft post spacing**

\[ b_{glass} = \frac{42.5 \text{ in}}{2} \]

(half the height since a single extrusion is checked)

\[ X = \frac{M_a}{\text{spacing}^2} = 162 \frac{\text{lbf}}{\text{ft}} \]

\[ X_{psf} = \frac{X}{b_{glass}} = 92 \text{ psf} \]

**Wind equivalent load at 36'' tall and 4.25 ft post spacing**

\[ b_{glass} = \frac{36 \text{ in}}{2} \]

(half the height since a single extrusion is checked)

\[ X = \frac{M_a}{\text{spacing}^2} = 162 \frac{\text{lbf}}{\text{ft}} \]

\[ X_{psf} = \frac{X}{b_{glass}} = 103 \text{ psf} \]

**Wind equivalent load at 42'' tall and 4 ft post spacing**

\[ b_{glass} = \frac{42.5 \text{ in}}{2} \]

(half the height since a single extrusion is checked)

\[ X = \frac{M_a}{\text{spacing}^2} = 183 \frac{\text{lbf}}{\text{ft}} \]

\[ X_{psf} = \frac{X}{b_{glass}} = 104 \text{ psf} \]

**Wind equivalent load at 36'' tall and 4 ft post spacing**

\[ b_{glass} = \frac{36 \text{ in}}{2} \]

(half the height since a single extrusion is checked)

\[ X = \frac{M_a}{\text{spacing}^2} = 183 \frac{\text{lbf}}{\text{ft}} \]

\[ X_{psf} = \frac{X}{b_{glass}} = 123 \text{ psf} \]
Wind equivalent load at 42" tall and 4 ft post spacing

\[
\text{spacing} := 4 \text{-ft}
\]

\[
h_{\text{glass}} := \frac{42.5 \text{-in}}{2}
\]

(half the height since a single extrusion is checked)

\[
X := \frac{M_a \cdot \frac{8}{2}}{\text{spacing}} = 183 \text{-lbf} \text{/ ft}
\]

\[
X_{\text{psf}} := \frac{X}{h_{\text{glass}}} = 104 \text{-psf}
\]

Wind equivalent load at 36" tall and 4 ft post spacing

\[
h_{\text{glass}} := \frac{36 \text{-in}}{2}
\]

(half the height since a single extrusion is checked)

\[
X := \frac{M_a \cdot \frac{8}{2}}{\text{spacing}} = 183 \text{-lbf} \text{ / ft}
\]

\[
X_{\text{psf}} := \frac{X}{h_{\text{glass}}} = 122 \text{-psf}
\]
8.2 Transcend crown rail (top rail)

**TEST REPORT FOR TREX COMPANY, INC.**

Report No.: I0418.01-119-19 R0
Date: 07/16/19

**Transcend Top Rail**
Support Span = 42 in
Crosshead Speed = 1.33 in/min
Orientation: Reference Product Drawing in Section 11
Test Date: 05/18/18

<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>SAMPLE COLOR</th>
<th>WEIGHT PER LINEAL FOOT (lb)</th>
<th>ULTIMATE LOAD (lb)</th>
<th>SLOPE (lbf/in)</th>
<th>MU (in-lb)</th>
<th>EL (lb-in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>White</td>
<td>1.41</td>
<td>901</td>
<td>691</td>
<td>6307</td>
<td>909200</td>
</tr>
<tr>
<td>2</td>
<td>White</td>
<td>1.41</td>
<td>889</td>
<td>687</td>
<td>6223</td>
<td>902800</td>
</tr>
<tr>
<td>3</td>
<td>White</td>
<td>1.38</td>
<td>871</td>
<td>684</td>
<td>6097</td>
<td>899300</td>
</tr>
<tr>
<td>4</td>
<td>White</td>
<td>1.41</td>
<td>901</td>
<td>694</td>
<td>6307</td>
<td>912700</td>
</tr>
<tr>
<td>5</td>
<td>White</td>
<td>1.41</td>
<td>898</td>
<td>690</td>
<td>6286</td>
<td>907400</td>
</tr>
<tr>
<td>6</td>
<td>White</td>
<td>1.41</td>
<td>903</td>
<td>689</td>
<td>6321</td>
<td>905900</td>
</tr>
<tr>
<td>7</td>
<td>White</td>
<td>1.41</td>
<td>914</td>
<td>694</td>
<td>6398</td>
<td>912200</td>
</tr>
<tr>
<td>8</td>
<td>White</td>
<td>1.36</td>
<td>828</td>
<td>663</td>
<td>5796</td>
<td>871500</td>
</tr>
<tr>
<td>9</td>
<td>White</td>
<td>...1</td>
<td>860</td>
<td>672</td>
<td>6020</td>
<td>884200</td>
</tr>
<tr>
<td>10</td>
<td>White</td>
<td>1.41</td>
<td>907</td>
<td>691</td>
<td>6349</td>
<td>908600</td>
</tr>
<tr>
<td>11</td>
<td>White</td>
<td>1.41</td>
<td>912</td>
<td>692</td>
<td>6384</td>
<td>910200</td>
</tr>
<tr>
<td>12</td>
<td>White</td>
<td>1.42</td>
<td>918</td>
<td>691</td>
<td>6426</td>
<td>908300</td>
</tr>
<tr>
<td>13</td>
<td>White</td>
<td>1.42</td>
<td>905</td>
<td>694</td>
<td>6335</td>
<td>913000</td>
</tr>
<tr>
<td>14</td>
<td>White</td>
<td>1.41</td>
<td>883</td>
<td>692</td>
<td>6181</td>
<td>910000</td>
</tr>
<tr>
<td>15</td>
<td>White</td>
<td>1.32</td>
<td>770</td>
<td>637</td>
<td>5390</td>
<td>837800</td>
</tr>
</tbody>
</table>

Minimum: 637 5390
Maximum: 694 6426
Average: 684 6188
Standard Deviation: 16 277
Coefficient of Variation: 2% 4%

1Weight per lineal foot was not documented for this specimen.

Conservatively, the minimum ultimate value will be used (other than the 770 lb load which is considered an outlier).
Minimum ultimate load = 828 lbs
Allowable load = 828 lbs / 2.5 = 331 lbs

Allowable moment = PL/4 = 331 lbs * 42 in / 4 = 3.5 k-in
8.2.1 Allowable wind load

**Crown Rail**

\[ M_a = 3.5 \text{kip-in} \]  
Allowable moment per test results

**Wind equivalent load at 42" tall and 4.25 ft post spacing**

\[ h_{glass} = \frac{42.5 \text{ in}}{2} \]  
(half the height since a single extrusion is checked)

\[ X := \frac{M_a}{\text{spacing}^2} = 129 \frac{\text{in}^3}{\text{ft}} \]

\[ \sigma_{psf} = \frac{X}{h_{glass}} = 73 \text{ psf} \]

**Wind equivalent load at 36" tall and 4.25 ft post spacing**

\[ h_{glass} = \frac{36 \text{ in}}{2} \]  
(half the height since a single extrusion is checked)

\[ X := \frac{M_a}{\text{spacing}^2} = 129 \frac{\text{in}^3}{\text{ft}} \]

\[ \sigma_{psf} = \frac{X}{h_{glass}} = 83 \text{ psf} \]

**Wind equivalent load at 42" tall and 4 ft post spacing**

\[ h_{glass} = \frac{42.5 \text{ in}}{2} \]  
(half the height since a single extrusion is checked)

\[ X := \frac{M_a}{\text{spacing}^2} = 146 \frac{\text{in}^3}{\text{ft}} \]

\[ \sigma_{psf} = \frac{X}{h_{glass}} = 92 \text{ psf} \]

**Wind equivalent load at 36" tall and 4 ft post spacing**

\[ h_{glass} = \frac{36 \text{ in}}{2} \]  
(half the height since a single extrusion is checked)

\[ X := \frac{M_a}{\text{spacing}^2} = 146 \frac{\text{in}^3}{\text{ft}} \]

\[ \sigma_{psf} = \frac{X}{h_{glass}} = 97 \text{ psf} \]
Wind equivalent load at 42" tall and 3 ft post spacing

\[
\text{spacing} := 3\text{-ft} \\
\left(h_{\text{glass}} := \frac{42.5\text{-in}}{2}\right) \quad \text{(half the height since a single extrusion is checked)}
\]

\[
X := \frac{M_a 8}{\text{spacing}^2} = 259\text{-lbf} \text{ ft}
\]

\[
X_{\text{psf}} := \frac{X}{h_{\text{glass}}} = 146\text{-psf}
\]

Wind equivalent load at 36" tall and 3 ft post spacing

\[
\left(h_{\text{glass}} := \frac{36\text{-in}}{2}\right) \quad \text{(half the height since a single extrusion is checked)}
\]

\[
X := \frac{M_a 8}{\text{spacing}^2} = 259\text{-lbf} \text{ ft}
\]

\[
X_{\text{psf}} := \frac{X}{h_{\text{glass}}} = 173\text{-psf}
\]
8.2.2  **Vertical load**  
See test report ATI no. I0418.01-119-19 R0 dated 05/09/18-05/29/18

### 8.3  Brackets

<table>
<thead>
<tr>
<th>LOAD LEVEL</th>
<th>TEST LOAD (lb)</th>
<th>E.T. (min:sec)</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 lb (2.5 x D.L.) x 2</td>
<td>1003</td>
<td>00:59</td>
<td>Each end withstood load equal to or greater than 500 lb without failure</td>
</tr>
</tbody>
</table>

*Load was imposed on both ends of rail using a spreader beam; therefore, loads were doubled.*

500 lbs / 2.5 = 200 lb allowable shear force at each bracket location.
8.3.1 Allowable wind load

**Bracket**

\[ F_a = 200 \text{ lbf} \]  
Allowable force per test results

Wind equivalent load at 42" tall and 4.25 ft post spacing

\[ \text{spacing} = \frac{4.25 \text{ ft}}{2} \]  
(half the width since a single bracket is checked)

\[ b_{\text{glass}} = \frac{42.5 \text{ in}}{2} \]  
(half the height since a single bracket is checked)

\[ X = \frac{F_a}{\text{spacing} \times b_{\text{glass}}} = \frac{200 \text{ lbf}}{\left(\frac{4.25 \text{ ft}}{2}\right) \times \left(\frac{42.5 \text{ in}}{2}\right)} = 53 \text{ psf} \]

\[ X_{\text{psf}} = X = 53 \text{ psf} \]

Wind equivalent load at 36" tall and 4.25 ft post spacing

\[ b_{\text{glass}} = \frac{36 \text{ in}}{2} \]  
(half the height since a single bracket is checked)

\[ X = \frac{F_a}{\text{spacing} \times b_{\text{glass}}} = \frac{200 \text{ lbf}}{\left(\frac{4.25 \text{ ft}}{2}\right) \times \left(\frac{36 \text{ in}}{2}\right)} = 63 \text{ psf} \]

\[ X_{\text{psf}} = X = 63 \text{ psf} \]

Wind equivalent load at 42" tall and 4 ft post spacing

\[ \text{spacing} = \frac{4 \text{ ft}}{2} \]  
(half the width since a single bracket is checked)

\[ b_{\text{glass}} = \frac{42.5 \text{ in}}{2} \]  
(half the height since a single bracket is checked)

\[ X = \frac{F_a}{\text{spacing} \times b_{\text{glass}}} = \frac{200 \text{ lbf}}{\left(\frac{4 \text{ ft}}{2}\right) \times \left(\frac{42.5 \text{ in}}{2}\right)} = 56 \text{ psf} \]

\[ X_{\text{psf}} = X = 56 \text{ psf} \]

Wind equivalent load at 36" tall and 4 ft post spacing

\[ b_{\text{glass}} = \frac{36 \text{ in}}{2} \]  
(half the height since a single bracket is checked)

\[ X = \frac{F_a}{\text{spacing} \times b_{\text{glass}}} = \frac{200 \text{ lbf}}{\left(\frac{4 \text{ ft}}{2}\right) \times \left(\frac{36 \text{ in}}{2}\right)} = 67 \text{ psf} \]

\[ X_{\text{psf}} = X = 67 \text{ psf} \]
Wind equivalent load at 42" tall and 3 ft post spacing

\[
\text{spacing} = \frac{3\text{ ft}}{2} \quad \text{(half the width since a single bracket is checked)}
\]

\[
h_{\text{glass}} = \frac{42.5\text{ in}}{2} \quad \text{(half the height since a single bracket is checked)}
\]

\[
X := \frac{F_a}{\text{spacing} \cdot h_{\text{glass}}} = 75.5 \text{ lbf ft}^{-2}
\]

\[
X_{\text{psf}} = X = 73 \text{ psf}
\]

Wind equivalent load at 36" tall and 3 ft post spacing

\[
h_{\text{glass}} = \frac{36\text{ in}}{2} \quad \text{(half the height since a single bracket is checked)}
\]

\[
X := \frac{F_a}{\text{spacing} \cdot h_{\text{glass}}} = 89 \text{ lbf ft}^{-2}
\]

\[
X_{\text{psf}} = X = 89 \text{ psf}
\]
8.3.2 Vertical load
See test report ATI no. I0418.01-119-19 R0 dated 05/09/18-05/29/18

9 Conclusions

For IBC guardrail loading, the limiting post spacing is 4.25ft based on the post strength, and the limiting wind load is 27 psf.

➢ Railing meet the requirements of IRC 2018 and IBC 2018.
**TRANSCEND® SERIES RAILING SYSTEM**

**ESR-3947**

**Issued September 2016**

This report is subject to renewal September 2017.

---

**DIVISION:** 06 30 00—WOOD, PLASTICS AND COMPOSITES  
**Section:** 06 50 00—STRUCTURAL PLASTIC  
**Section:** 06 52 00—PLASTIC RAILINGS

---

**REPORT HOLDER:**

**TREX COMPANY INC.**  
100 EXETER DRIVE  
WINCHESTER, VIRGINIA 22602  
(540) 542-6300  
www.trex.com

---

**EVALUATION SUBJECT:**

**TREX® TRANSCEND® SERIES RAILING SYSTEM**  
**TREX® SELECT® SERIES RAILING SYSTEM**

---

**1.0 EVALUATION SCOPE**

Compliance with the following codes:
- 2015, 2012 and 2009 International Residential Code® (IRC)

Property evaluated:
- Structural
- Durability
- Surface-burning Characteristics

---

**2.0 USES**

The TREX® TRANSCEND® Series Railing System and TREX® SELECT® Series Railing System described in this report are limited to exterior use as guard for balconies, porches, and decks in Residential Group R buildings of Type V-B construction and other types of construction in applications where untreated wood is permitted by IBC Section 1406.3 or in buildings constructed in accordance with the IRC.

---

**3.0 DESCRIPTION**

**3.1 General:**

TREX® TRANSCEND® Series Railing System and TREX® SELECT® Series Railing System are guard consisting of top and bottom rails, balusters, baluster spacers, rail-to-post brackets, foot blocks, with decorative post sleeves, post sleeve caps and post sleeve skirts. The top and bottom rails, post sleeves, and the TRANSCEND and SELECT balusters are composed of extruded wood-plastic composite core material, with a polyvinyl chloride (PVC) or acrylic cap layer.

---

**3.2 Guards:**

**3.2.1 TREX® TRANSCEND® Series Railing System:** The height of the railing assembly is 38 inches (914.4 mm) above the walking surface. The top rail has overall dimensions of 3.31 inches wide by 2.45 inches tall (84.1 mm by 62.2 mm). The bottom rail has overall dimensions of 3.0 inches wide by 2.0 inches tall (76.2 mm by 50.8 mm). The balusters can be either 1.42 inch (36.1 mm) or 1.125 inch (28.6 mm) square profiles. A baluster spacer, made of PVC with a PVC or acrylic cap layer, is installed onto the top and bottom rails. Each post is covered with a 4.45 inch (113 mm) square composite post sleeve. Rails are attached to posts with nylon composite brackets.

**TRANSCEND® Series Railing System components are available in 7 colors:** Charcoal Black, Classic White, Fire Pit, Gravel Path, Rope Swing, Tree House, and Vintage Lantern.

**3.2.2 TREX® SELECT® Series Railing System:** The height of the railing assembly is 38 inches (914.4 mm) above the walking surface. The top rail has overall dimensions of 2.75 inches wide by 2.0 inches tall (69.9 mm by 50.8 mm). The bottom rail has overall dimensions of 2.0 inches wide by 2.75 inches tall (50.8 mm by 69.9 mm). The balusters are 1.125 inch (28.6 mm) square profiles. Balusters are installed directly into openings machined into the upper and lower rails. Each post is covered with a 4.45 inch (113 mm) square composite post sleeve. Rails are attached to posts with nylon brackets.

**SELECT® Series Railing System is available in white color.**

---

**3.3 Durability:**

When subjected to weathering, insect attack, and other decaying elements, the material used to manufacture the TREX® TRANSCEND® Railing System and TREX® SELECT® Railing System are equivalent in durability to code-complying, preservative-treated or naturally durable lumber when used in locations described in Section 2.0 of this report. **TREX® TRANSCEND® Railing System and TREX® SELECT® Railing System have been evaluated for structural performance when exposed to temperatures from -20°F (-29°C) to 120°F (52°C).**

---

**3.4 Surface-burning Characteristics:**

When tested in accordance with ASTM E84, **TREX® TRANSCEND® Railing System and TREX® SELECT® Railing System have a flame-spread index of no greater than 200.**

---

**4.0 DESIGN AND INSTALLATION**

**4.1 General:**

The TREX® TRANSCEND® Series Railing System and TREX® SELECT® Series Railing System must be installed in
accordance with the manufacturer's published installation instructions, the approved construction documents and this report. The manufacturer's published installation instructions must be available at all times on the job sites during installation.

4.2 Design:
The Trex® Transcend® Series Railing System and Trex® Select® Series Railing System are satisfactory to resist loads specified in Section 1007.1 of the 2015 and 2012 IBC, Section 1007.1 of the 2009 IBC and Table R301.5 of the IRC, when installed at the maximum clear distance between the posts as noted in Table 1. When the railing is supported on one or both ends by the supporting structure, the maximum clear distance between the post and supporting structure or between the structures must comply with the spans noted in Table 1.

4.3 Installation:
4.3.1 Trex® Transcend® Series Railing System: Composite post sleeves are installed over a conventional treated wood 4 x 4 post, having a minimum specific gravity of 0.56. The attachment of the posts to the deck structure must be adequate and is outside the scope of this report. The top and bottom rail assemblies are attached to the composite post sleeves using mounting brackets. The bracket screws are installed through the composite post sleeve, into the 4x4 wood post using two #8 x 2-inch long (50.8 mm) wood screws. Each mounting bracket attaches to the top and bottom rail using two #12 x 1.5-inch-long (38.1 mm) self-drilling flathead screws. Baluster spacers are installed in the top and bottom rails to hold the balusters in place. Foot blocks are installed at mid-span of the bottom rail between the deck surface and the rail using one #10 x 2-inch-long (50.8 mm) screw.

4.3.2 Trex® Select® Series Railing System: Composite post sleeves are installed over a conventional treated wood 4 x 4 post, having a minimum specific gravity of 0.56. The attachment of the posts to the deck structure must be adequate and is outside the scope of this report. The top and bottom rail assemblies are attached to the composite post sleeves using mounting brackets. The bracket screws are installed through the composite post sleeve, into the 4x4 wood post using four #6 x 2-inch-long (50.8 mm) wood screws. Each mounting bracket attaches to the top and bottom rail using four #10 x 1-inch-long (25.4 mm) pan-head screws. Balusters are installed directly into the holes in the rail profiles. Foot blocks are installed at mid-span of the bottom rail between the deck surface and the rail using one #10 x 2-inch-long (50.8 mm) screw.

5.0 CONDITIONS OF USE
The Trex® Transcend® Series Railing System and Trex® Select® Series Railing System described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 This Trex® Transcend® Series Railing System and Trex® Select® Series Railing System are limited to exterior use as guards for balconies, porches, and decks in Residential Group R buildings of Type V-B construction and other types of construction in applications where untreated wood is permitted by IBC Section 1400.3, or in buildings constructed in accordance with the IRC.

5.2 Installation of the Trex® Transcend® Series Railing System and Trex® Select® Series Railing System must comply with this evaluation report, the manufacturer’s published installation instructions and the applicable code. When the manufacturer’s published installation instructions differ from this evaluation report, this evaluation report governs.

5.3 Only those types of fasteners and fastening methods described in this evaluation report have been evaluated for the installation of Trex® Transcend® Railing System and Trex® Select® Railing System. The compatibility of fasteners with the supporting construction, including chemically treated wood, is outside the scope of this report.

5.4 The Trex® Transcend® Series Railing System and Trex® Select® Series Railing System must be directly fastened to supporting construction having adequate strength and stiffness. Where required by the code official, engineering calculations and construction documents consistent with this report must be submitted for approval. The calculations must verify that the supporting construction complies with the applicable building code requirements and is adequate to resist the loads imposed upon it from the products and systems discussed in this report. The documents must contain details of the attachment to the supporting structure consistent with the requirements of this report. The documents must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.5 The use of Trex® Transcend® Series Railing System and Trex® Select® Series Railing System on stairs has not been evaluated and is outside the scope of this evaluation report.

5.6 Structural posts and attachment of the posts to the supporting structure are outside the scope of this report.

5.7 The Trex® Transcend® Railing System and Trex® Select® Railing System are manufactured in Winchester, Virginia, under a quality-control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED
Data in accordance with the ICC-ES Acceptance Criteria for Deck Board Span Ratings and Guardrail Systems (Guards and Handrails) (AC174), dated January 2012 (Editorially revised December 2014).

7.0 IDENTIFICATION
The Trex® Transcend® Series Railing System and Trex® Select® Series Railing System described in this report are identified by a stamp on each individual piece or on the packaging, bearing the report holder’s name (Trex Company, Inc.), the product name (The Trex® Transcend® Series Railing System or Trex® Select® Series Railing System), the allowable span, ICC-ES evaluation report number (ESR-3047).
TABLE 1—MAXIMUM GUARDRAIL SYSTEM SPANS¹

<table>
<thead>
<tr>
<th>PRODUCT NAME / COMPONENT</th>
<th>APPLICABLE BUILDING CODE²</th>
<th>MAXIMUM SPAN³ (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trex® Transcend® Railing System</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Trex® Transcend® Railing System</td>
<td>No⁴</td>
<td>Yes</td>
</tr>
<tr>
<td>Trex® Select® Railing System</td>
<td>No⁴</td>
<td>Yes</td>
</tr>
</tbody>
</table>

For SI: 1 inch = 25.4 mm; 1 foot = 305 mm.

¹The ability of the supporting construction, including posts, to resist the reactionary loads must be justified to the satisfaction of the code official.
²Indicates compliance with the respective building codes.
³The minimum height of the top rails is 42 inches in accordance with Section 1015 of the 2015 IBC and Section 1013 of the 2012 and 2009 IBC and 36 inches in accordance with IRC Section R312.
⁴Maximum span is the clear distance measured from edge-of-post to edge-of-post, edge-of-post to edge-of-structure, or edge-of-structure to edge-of-structure.
⁵Maximum allowable span has been adjusted for durability. No further increases are permitted.
⁶Exempt in One- and Two-Family Dwellings.

A. Top Rail
B. Bottom Rail
C. Railing Bracket
D. **Assembly Guide Template
E. **Gaskets
F. Ballusters
G. Post Cap
H. Post Skirt
I. Trex® Composite Post Sleeve
J. **Trex® Decking
K. **Code-Approved Wood Joists
L. Trex® Footblock
M. Baluster Spacer

Note: Items marked with ** are outside the scope of this report.

FIGURE 1—TYPICAL TREX® TRANSCEND® SERIES RAILING ASSEMBLY

FIGURE 2—TREX® TRANSCEND® SERIES RAILING COMPONENTS
FIGURE 3—TYPICAL TREP® SELECT® SERIES RAILING ASSEMBLY

FIGURE 4—TREP® SELECT® SERIES RAILING COMPONENTS

FIGURE 5—TREP® TRANSCEND® AND SELECT® SERIES COMPOSITE POST SLEEVE

Note: Items marked with "*" are outside the scope of this report.
Appendix B - ATI report no. I0418.01-119-19 R0 dated 05/09/18-05/29/18