Engineering Report

JOB:	Route T.H. 10, class III (Local Road), Bridge No. 65
LOC:	Guilford, VT
TASK:	Component Lifting and Handling
JOB NO.	JPC-14001
CLIENT:	J.P. Carrara & Sons
DATE:	2014-02-12
DESIGN:	R. Slade, E.I.
CHECK:	R. Eriksson, P.E.

Eriksson technologies

Project Overview

A lifting and handling analysis was performed for the precast components on route T.H. 10 Bridge No. 65 in Guilford, VT. The contract drawings called for the use of five precast prestressed box beams, two precast abutments (divided into two pieces for fabrication), and four precast wing walls. This design is in accordance with the current versions of the *AASHTO LRFD Bridge Design Specifications, 6th Ed. (2012)* and the *VTrans Structures Design Manual (2010)*.

The components have already been designed for the in-place condition by the EOR, and were therefore only evaluated for lifting and handling. Lifting of the box beams is accomplished by means of four triple-strand lifting loops consisting of three 0.6” dia. 270ksi strands each. A 1’-3” x 1’-7” precast curb will be cast on each of the two exterior beams as a secondary pour. Therefore, an additional set of triple-strand lifting loops will be cast within the box beams for initial stripping.

Similar to the box beams, each portion of the precast abutments shall be lifted by means of two 4-strand lifting loops consisting of four 0.6” dia. 270ksi strands each. The precast wing walls should be lifted by the Dayton Superior inserts provided. Four P-52 Swift Lift 4 ton x 9-1/2" anchors embedded within the front-face of the wing walls should be used to support the members during stripping. Two P-52 Swift Lift 20 Ton x 19-3/4" anchors embedded within the top-face of the wing walls should be used to support the members during erection.

A rigging configuration should be selected to ensure the components are kept level during lifting and setting. The angle of the lifting cables to the horizontal shall be a minimum of 60 degrees, and spreader beams should be used to insure that all lifting devices are equally engaged. If not otherwise stated on the shop drawings, these members should be stored and shipping on hardwood dunnage placed directly beneath the lifting inserts/loops. Impact factors of ±25% and ±50% were assumed for handling and hauling, respectively.

Lifting & Handling Calculations

Description: Town of Guilford RT: T.H. 10, class III (Local Road), Bridge No. 65

Project: Guilford Bridge 65 **Location:** Guilford, VT

Client: J.P.Carrara & Sons

By: R. Slade, E.I. **Chk:** R. Eriksson, P.E. **Date:** 2014-02-11

Specifications: *AASHTO LRFD Bridge Design Specifications, 6th Ed (2012)*
VTrans Structures Design Manual, 5th ed. (2010)
PCI Design Handbook 7th Ed - Precast And Prestressed Concrete (2010)

1. Design Parameters

1.1 Materials:

Concrete: $f_c := 6.0 \cdot ksi$ $f_{ci} := 4.8ksi$ $\gamma_c := 0.150 \cdot kcf$

Strand: $f_{pu} := 270ksi$ $d_{strand} := 0.6in$ $A_{strand} := 0.217in^2$

1.2 Loads:

Lifting: $IM_{pick} := 25\%$

Shipping: $IM_{ship} := 50\%$

Safety Fact.: $FS := 4$

1.3 Geometry:

Bridge:

$W_{o2o} := (18ft + 0in)$ $b_{curb} := (1ft + 3in)$ $h_{curb} := (1ft + 7in)$

$W_{c2c} := W_{o2o} - 2 \cdot b_{curb} = 15.5\,ft$ $No_{bm} := 5$ $\theta_{skew} := 20deg$

Beam:

$L_{ovr} := (58ft + 2.25in)$ $L_{des} := (55ft + 0in)$ $h := (2ft + 3in)$

$th_{tf} := 5.5in$ $th_{wall} := 5in$ $b_{chamfer} := 3in$

Exterior: $b_{ext} := (2ft + 11.5in)$ $dph_{ext} := (4ft + 4in)$

Interior: $b_{int} := (3ft + 11.5in)$ $dph_{int} := (1ft + 3in)$

Abutment:

$th_{abt} := 2 \cdot (1ft + 6in)$ $L_{abt} := (28ft + 4in)$ $L_{abt.upper} := (4ft + 6in)$

$d_{void} := (3ft + 6in)$ $b_{void} := 2ft$

Side 1: $h_{abt.max.1} := (11ft + 4in)$ $h_{abt.min.1} := (7ft + 5in)$ $L_{abt.1} := 11ft$

Side 2: $h_{abt.max.2} := (11ft + 2in)$ $h_{abt.min.2} := (7ft + 5in)$ $L_{abt.2} := (17ft + 4in)$

Wingwalls:

$th_{ww} := (1ft + 6in)$ $L_{ww} := (10ft)$

$h_{ww.max} := (11ft + 3in)$ $L_{ww.flat} := 2ft$

$h_{ww.min.1} := (10ft)$ $h_{ww.min.2} := (9ft + 6in)$

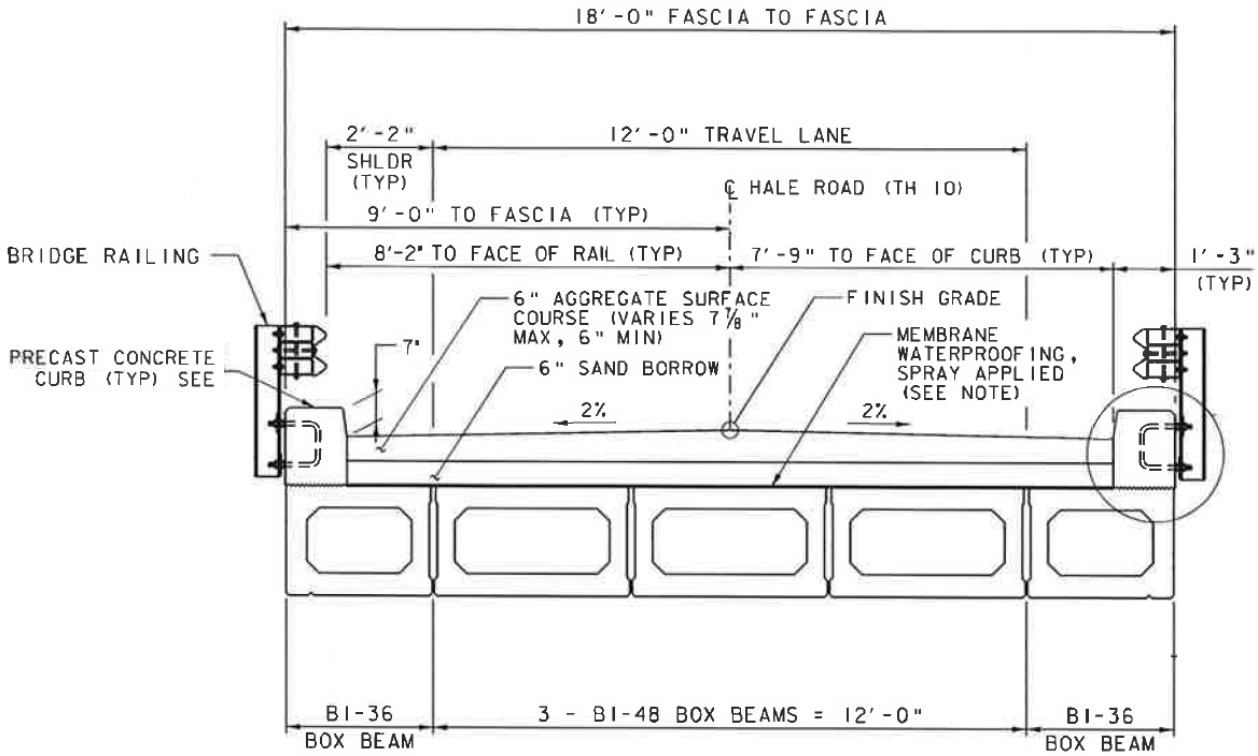


Figure 1. Bridge cross section

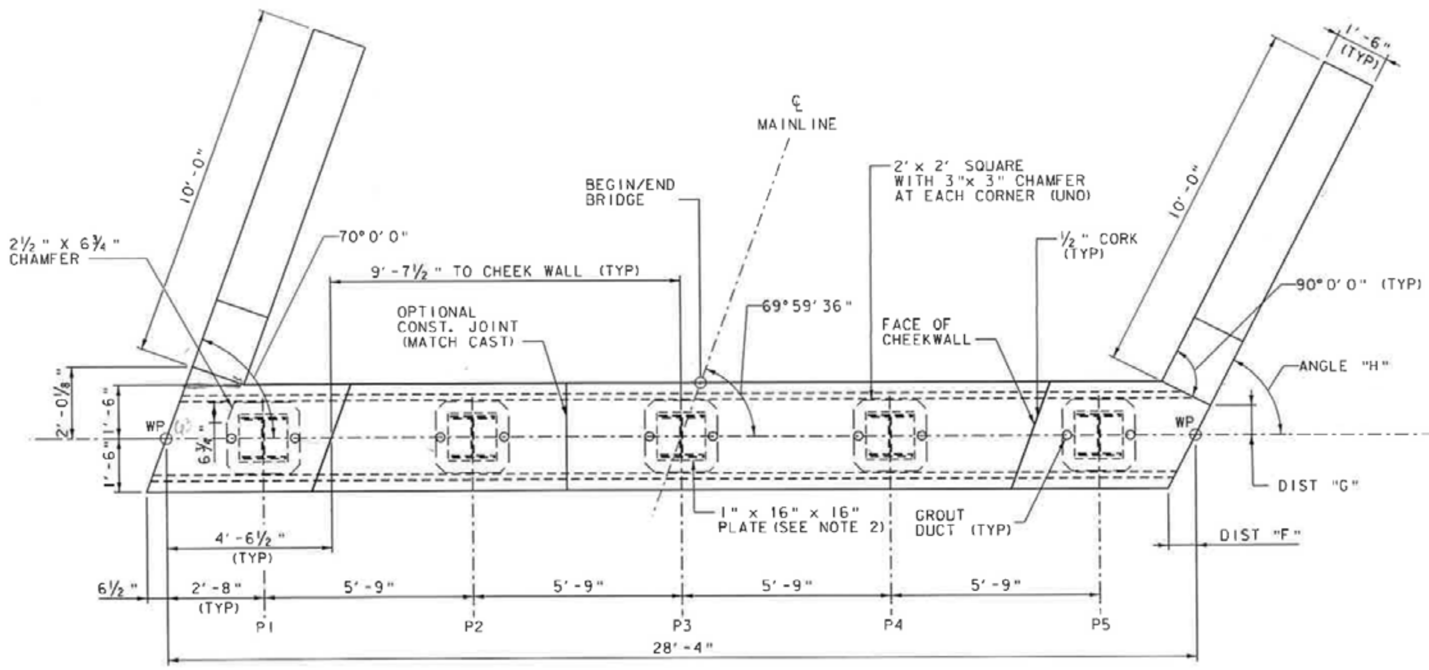


Figure 2. Abutment Plan

2. Loads

2.1 Exterior Beams

Diaphragms

$A_{void.ext} := (h - 2 \cdot th_{tf}) \cdot (b_{ext} - 2 \cdot th_{wall}) - 2 \cdot b_{chamfer}^2 = 2.7\,ft^2$

$P_{dph.int} := dph_{int} \cdot A_{void.ext} \cdot \gamma_c = 0.51 \cdot kip$ (located at 1/2 point)

$P_{dph.ext} := dph_{ext} \cdot A_{void.ext} \cdot \gamma_c = 1.76 \cdot kip$ (located at each end)

Curb

$A_{curb} := h_{curb} \cdot b_{curb} = 1.98\,ft^2$

$w_{curb} := A_{curb} \cdot \gamma_c = 0.3 \cdot klf$

Self Weight

$A_{sw.ext} := (h \cdot b_{ext} - A_{void.ext}) = 3.95\,ft^2$

$w_{sw.ext} := A_{sw.ext} \cdot \gamma_c = 0.592 \cdot klf$

$P_{sw.1} := w_{sw.ext} \cdot L_{ovr} + P_{dph.int} + 2 \cdot P_{dph.ext} = 38.5 \cdot kip$ (without curb)

$P_{sw.2} := P_{sw.1} + (w_{curb} \cdot L_{ovr}) = 55.8 \cdot kip$ (with curb)

2.2 Interior Beams

Diaphragms

$A_{void.int} := (h - 2 \cdot th_{tf}) \cdot (b_{int} - 2 \cdot th_{wall}) - 2 \cdot b_{chamfer}^2 = 4.0 \cdot ft^2$

$P_{dph.int} := dph_{int} \cdot A_{void.int} \cdot \gamma_c = 0.76 \cdot kip$ (located at 1/2 point)

$P_{dph.ext} := dph_{ext} \cdot A_{void.int} \cdot \gamma_c = 2.63 \cdot kip$ (located at each end)

Self Weight

$A_{sw.int} := (h \cdot b_{int} - A_{void.int}) = 4.86\,ft^2$

$w_{sw.int} := A_{sw.int} \cdot \gamma_c = 0.73 \cdot klf$

$P_{sw.int} := w_{sw.int} \cdot L_{ovr} + P_{dph.int} + 2 \cdot P_{dph.ext} = 48.5 \cdot kip$

2.3 Abutments

Side 1

$V_{abt.1.1} := (th_{abt} \cdot L_{abt.1}) \cdot h_{abt.min.1} = 244.75\,ft^3$

$V_{abt.1.2} := (th_{abt} \cdot L_{abt.upper}) \cdot (h_{abt.max.1} - h_{abt.min.1}) = 52.87\,ft^3$

$V_{voids} := b_{void}^2 \cdot d_{void} = 14\,ft^3$ $No_{voids.1} := 2$

$P_{abt.1} := [V_{abt.1.1} + V_{abt.1.2} - (No_{voids.1} \cdot V_{voids})] \cdot \gamma_c = 40.444\,kip$

Side 2

$V_{abt.2.1} := (th_{abt} \cdot L_{abt.2}) \cdot h_{abt.min.2} = 385.67\,ft^3$

$V_{abt.2.2} := (th_{abt} \cdot L_{abt.upper}) \cdot (h_{abt.max.2} - h_{abt.min.2}) = 50.63\,ft^3$

$V_{voids} := b_{void}^2 \cdot d_{void} = 14\,ft^3$ $No_{voids.2} := 3$

$P_{abt.2} := [V_{abt.2.1} + V_{abt.2.2} - (No_{voids.2} \cdot V_{voids})] \cdot \gamma_c = 59.144\,kip$

2.4 Wingwalls

$V_{WW.0} := (h_{ww.max} \cdot L_{ww}) \cdot th_{ww} = 168.75\,ft^3$

Side 1

$V_{WW.1.2} := 0.5 \cdot (L_{ww} - L_{ww.flat}) \cdot (h_{ww.max} - h_{ww.min.1}) \cdot th_{ww} = 7.5\,ft^3$

$P_{WW.1} := (V_{WW.0} - V_{WW.1.2}) \cdot \gamma_c = 24.2\,kip$

Side 2

$V_{WW.2.2} := 0.5 \cdot (L_{ww} - L_{ww.flat}) \cdot (h_{ww.max} - h_{ww.min.2}) \cdot th_{ww} = 10.5\,ft^3$

$P_{WW.2} := (V_{WW.0} - V_{WW.2.2}) \cdot \gamma_c = 23.7\,kip$

3. Lifting

3.1 Exterior Beams

Place lifting loops longitudinally to coincide approximately with the bearing location. Therefore, the longitudinally bending stresses are not expected to exceed that of the in-place condition.

3.1.1 Loop Placement

Transverse CG $CG_1 := \frac{A_{sw.ext} \cdot \left(\frac{b_{ext}}{2}\right)}{A_{sw.ext}} = 17.75 \cdot in$

Lifting Loops $x_{LL.1} := 7in$ $x_{LL.2} := 2 \cdot CG_1 - x_{LL.1} = 28.5 \cdot in$ (without curb)

Transverse CG $CG_2 := \frac{A_{sw.ext} \cdot \left(\frac{b_{ext}}{2}\right) + A_{curb} \cdot \left(\frac{b_{curb}}{2}\right)}{A_{sw.ext} + A_{curb}} = 14.327 \cdot in$

Lifting Loops $x_{LL.1} = 7 \cdot in$ $x_{LL.2} := 2 \cdot CG_2 - x_{LL.1} = 21.7 \cdot in$ (with curb)

3.1.2 Loop Size

Lifting Load $No_{loops} := 4$ $\phi_{pick} := 60deg$

$$P_{lift} := \frac{\max\left(P_{sw.1}, P_{sw.2}\right) \cdot \left(1 + IM_{pick}\right)}{No_{loops} \cdot \sin\left(\phi_{pick}\right)} = 20.1\,kip$$

$$d_{embed} := h - 2in = 25\,in$$

$$P_{Loop} := \left(\frac{d_{embed}}{36in}\right) \cdot \frac{0.8 \cdot f_{pu} \cdot A_{strand}}{FS} = 8.1\,kip$$

$P_{DoubleLoop} := P_{Loop} \cdot (3) = 24.4\,kip$ > $P_{lift} = 20.1\,kip$ OK

3.2 Interior Beams

Place lifting loops longitudinally to coincide approximately with the bearing location. Therefore, the longitudinally bending stresses are not expected to exceed that of the in-place condition.

3.2.1 Loop Placement

Transverse CG $CG_1 := \frac{A_{sw.int} \cdot \left(\frac{b_{int}}{2}\right)}{A_{sw.int}} = 23.75 \cdot in$

Lifting Loops $x_{LL.1} := 9.5in$ $x_{LL.2} := 2 \cdot CG_1 - x_{LL.1} = 38 \cdot in$

3.2.2 Loop Size

Lifting Load $No_{loops} := 4$ $\phi_{pick} := 60deg$

$$P_{lift} := \frac{P_{sw.int} \cdot \left(1 + IM_{pick}\right)}{No_{loops} \cdot \sin\left(\phi_{pick}\right)} = 17.5\,kip$$

$$d_{embed} := h - 2in = 25\,in$$

$$P_{Loop} := \left(\frac{d_{embed}}{36in}\right) \cdot \frac{0.8 \cdot f_{pu} \cdot A_{strand}}{FS} = 8.1\,kip$$

$P_{DoubleLoop} := P_{Loop} \cdot (3) = 24.4\,kip$ > $P_{lift} = 17.5\,kip$ OK

3.3 Abutment (side 1)

3.3.1 Loop Placement

member CG

$$CG_{abt.1} := \frac{\left(V_{abt.1.1} \cdot \frac{L_{abt.1}}{2}\right) + \left(V_{abt.1.2} \cdot \frac{L_{abt.upper}}{2}\right)}{V_{abt.1.1} + V_{abt.1.2}} = 4.923\,ft$$

Lifting Loops

$x_{LL.1} := 1.25ft \qquad x_{LL.2} := 2 \cdot CG_{abt.1} - x_{LL.1} = 8.6 \cdot ft \qquad edge_{x1} := L_{abt.1} - x_{LL.2} = 29\,in$

3.3.2 Loop Size

Lifting Load

$No_{loops} := 2 \qquad \phi_{pick} := 60deg$

$d_{embed} := 36in$

$$\psi_{embed} := \left(\frac{d_{embed}}{36in}\right) = 1$$

$$P_{lift} := \frac{P_{abt.1} \cdot \left(1 + IM_{pick}\right)}{No_{loops} \cdot \sin\left(\phi_{pick}\right)} = 29.2\,kip$$

$d_{embed} := 36in$

$$P_{Loop} := \left(\frac{d_{embed}}{36in}\right) \cdot \frac{0.8 \cdot f_{pu} \cdot A_{strand}}{FS} = 11.7\,kip$$

$P_{QuadLoop} := P_{Loop} \cdot (4) = 46.9\,kip \qquad > \qquad P_{lift} = 29.2\,kip \qquad$ OK

3.4 Abutment (side 2)

3.4.1 Loop Placement

member CG

$$CG_{abt.2} := \frac{\left(V_{abt.2.1} \cdot \frac{L_{abt.2}}{2}\right) + \left(V_{abt.2.2} \cdot \frac{L_{abt.upper}}{2}\right)}{V_{abt.2.1} + V_{abt.2.2}} = 7.922\,ft$$

Lifting Loops

$x_{LL.1} := 2.25ft \qquad x_{LL.2} := 2 \cdot CG_{abt.2} - x_{LL.1} = 13.6 \cdot ft \qquad edge_{x2} := L_{abt.2} - x_{LL.2} = 45\,in$

3.4.2 Loop Size

Lifting Load

$No_{loops} := 2 \qquad \phi_{pick} := 60deg$

$d_{embed} := 36in$

$$\psi_{embed} := \left(\frac{d_{embed}}{36in}\right) = 1$$

$$P_{lift} := \frac{P_{abt.2} \cdot \left(1 + IM_{pick}\right)}{No_{loops} \cdot \sin\left(\phi_{pick}\right)} = 42.7\,kip$$

$d_{embed} := 36in$

$$P_{Loop} := \left(\frac{d_{embed}}{36in}\right) \cdot \frac{0.8 \cdot f_{pu} \cdot A_{strand}}{FS} = 11.7\,kip$$

$P_{QuadLoop} := P_{Loop} \cdot (4) = 46.9\,kip \qquad > \qquad P_{lift} = 42.7\,kip \qquad$ OK

3.5 Wingwalls

3.5.1 Insert Placement

member CG

$$CG_{WW.1x} := \frac{\left(V_{WW.0}\cdot\frac{L_{ww}}{2}\right) - \left[V_{WW.1.2}\cdot\frac{\left(L_{ww} - L_{ww.flat}\right)}{3}\right]}{V_{WW.0} - V_{WW.1.2}} = 5.109\,ft$$

$$CG_{WW.1y} := \frac{\left(V_{WW.0}\cdot\frac{h_{ww.max}}{2}\right) - \left[V_{WW.1.2}\cdot\frac{\left(h_{ww.max} - h_{ww.min.1}\right)}{3}\right]}{V_{WW.0} - V_{WW.1.2}} = 5.867\,ft$$

Lifting Insert

$x_1 := 3ft$ $\quad x_2 := 2\cdot CG_{WW.1x} - x_1 = 7.2\cdot ft$ $\quad edge_{x2} := L_{ww} - x_2 = 2.8\,ft$

$y_1 := 3ft$ $\quad y_2 := 2\cdot CG_{WW.1y} - y_1 = 8.7\cdot ft$ $\quad edge_{y2} := h_{ww.max} - y_2 = 2.5\,ft$

3.5.2 Insert Placement

member CG

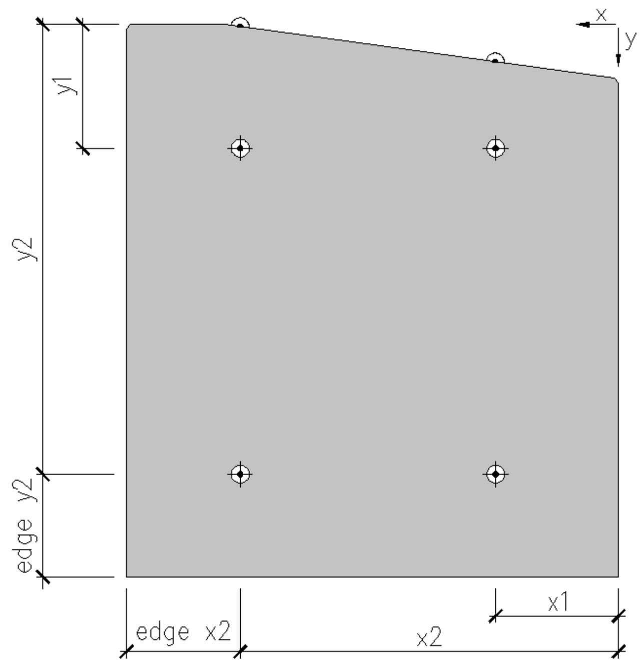
$$CG_{WW.2x} := \frac{\left(V_{WW.0}\cdot\frac{L_{ww}}{2}\right) - \left[V_{WW.2.2}\cdot\frac{\left(L_{ww} - L_{ww.flat}\right)}{3}\right]}{V_{WW.0} - V_{WW.2.2}} = 5.155\,ft$$

$$CG_{WW.2y} := \frac{\left(V_{WW.0}\cdot\frac{h_{ww.max}}{2}\right) - \left[V_{WW.2.2}\cdot\frac{\left(h_{ww.max} - h_{ww.min.2}\right)}{3}\right]}{V_{WW.0} - V_{WW.2.2}} = 5.96\,ft$$

Lifting Insert

$x_1 := 3ft$ $\quad x_2 := 2\cdot CG_{WW.2x} - x_1 = 7.3\cdot ft$ $\quad edge_{x2} := L_{ww} - x_2 = 2.7\,ft$

$y_1 := 3ft$ $\quad y_2 := 2\cdot CG_{WW.2y} - y_1 = 8.9\cdot ft$ $\quad edge_{y2} := h_{ww.max} - y_2 = 2.3\,ft$



3.5.3 Insert Size **(stripping)**

Lifting Load

$No_{inserts} := 4 \qquad \phi_{pick} := 60deg$

$$T_{lift} := \frac{\max(P_{WW.1}, P_{WW.2}) \cdot (1 + IM_{pick})}{\sin(\phi_{pick}) \cdot No_{inserts}} = 8.7\,kip$$

Use minimum of (4) P-52 Swift Lift Anchor - 4 ton x 9-1/2"

Capacity

$T_{SWL} := 8.0kip$

$$adj := \sqrt{\frac{f_{ci}}{1600psi}} = 1.73$$

$T_{SWL.eff} := adj \cdot T_{SWL} = 13.9 \cdot kip \quad > \quad T_{lift} = 8.7\,kip$ OK

$edge_{min} := 17in \quad < \quad \min(x_1, edge_{x2}, y_1, edge_{y2}) = 28\,in$ OK

3.5.4 Insert Size **(erection)**

Lifting Load

$No_{inserts} := 2 \qquad \phi_{pick} := 60deg$

$$T_{lift} := \frac{\max(P_{WW.1}, P_{WW.2}) \cdot (1 + IM_{pick})}{\sin(\phi_{pick}) \cdot No_{inserts}} = 17.5\,kip$$

Use minimum of (2) P-52 Swift Lift Anchor - 20 Tons x 19-3/4"

Capacity

$T_{SWL} := 20.1kip$

$$adj := \sqrt{\frac{f_{ci}}{4500psi}} = 1.03$$

$T_{SWL.eff} := adj \cdot T_{SWL} = 20.8 \cdot kip \quad > \quad T_{lift} = 17.5\,kip$ OK

$th_{min} := 14in \quad < \quad th_{ww} = 18\,in$ OK

$edge_{min} := 24in \quad < \quad \min(x_1, edge_{x2}, y_1, edge_{y2}) = 28\,in$ OK

3.5.5 Check Stresses **(stripping)**

Section

$$S_{min} := \frac{\min(h_{ww.min.1}, h_{ww.min.2}, L_{ww}) \cdot th_{ww}^{2}}{6} = 3.56\,ft^3$$ (Minimum Section)

Bending

$$M_{max} := \frac{\max(h_{ww.max}, L_{ww})^3 \cdot th_{ww} \cdot \gamma_c}{8} \cdot (1 + IM_{ship}) = 60.07\,kip \cdot ft$$ (Maximum Possable Bending Moment)

Stress

$$f_{max} := \frac{M_{max}}{S_{min}} = 117\,psi$$ (Maximum Possable Bending Stress)

$$f_{cr} := \frac{7.5psi}{FS} \cdot \sqrt{\frac{f_{ci}}{psi}} = 130\,psi \quad > \quad f_{max} = 117\,psi$$ OK