J. P. CARRARA & SONS, INC.

ERNEST J. BROD
11-18-14
FAIRFIELD BRIDGES
JPC #23446-014

1

LIFTING LOOP DESIGN CALCULATIONS
ELM BROOK ROAD BRIDGE

STATE OF VERMONT
ERNEST J. BROD
PROFESSIONAL ENGINEER

WT OF SLAB 27.73^{T}

THERE ARE 4 LIFT POINTS AND ASSUMING A 60° SLING ANGLE W/THE HORIZONTAL, DESIGN LOAD @ EACH LIFT POINT

$$= \frac{27.73 \times 2}{4 \times 0.866} = 16.0^{K}$$

FROM ATTACHED PCI LITERATURE (BY INTERPOLATION)

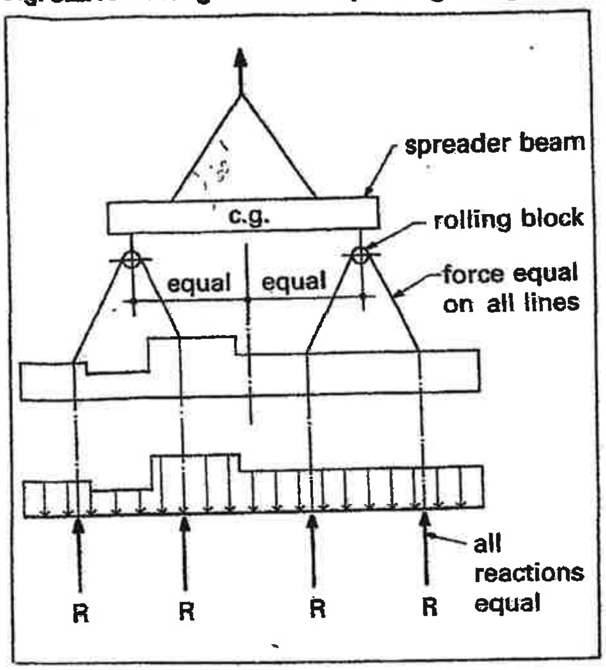
USE TRIPLE 0.600"ϕ X 270 KSI STRAND LIFTING LOOP,
MIN EMBEDMENT 19"

$$SWL = 1.1\left(\frac{11.5 + 17.5 + 16.5 + 24.5}{4}\right) = 19.3^{K} > 16.0^{K}$$

(4:1 S.F.) O.K.

TOPS 35500

Fig. 5.2.10 Arrangement for equalizing lifting loads



lines equal. The member can then be analyzed as a beam with varying load supported by equal reactions.

The force in inclined lift lines can be determined from Fig. 5.2.7.

5.2.8 Handling devices

The most common lifting devices are prestressing strand or cable loops projecting from the concrete, threaded inserts, or special proprietary devices.

Since lifting devices are subject to dynamic loads, ductility of the material is part of the design requirement. Deformed reinforcing bars should not be used since the deformations result in stress concentrations from the shackle pin. Also, reinforcing bars are often hard-grade or re-rolled rail steel with little ductility and low impact strength at cold temperatures. Smooth bars of a known steel grade may be used if adequate embedment or mechanical anchorage is provided. The diameter must be such that localized failure will not occur by bearing on the shackle pin.

Prestressing strand is often used for lifting loops. The variables involved make it almost impossible to calculate a capacity which can be used for all situations. Generally, producers will establish standard criteria for use in handling the standard products manufactured by that plant. Table 5.2.3 is an example which has been used successfully.

Reduced capacities for shorter embedment lengths may be suitable. In shallow products, providing a 90° bend can reduce the required embedment length significantly. Lightly rusted strand has better bond than bright strand.

The diameter of the bend of the loop should be at least 4 in. For smaller diameters, the loop capacities in Table 5.2.3 should be reduced to:

1 in. dia. — 70 %
2 in. dia. — 85 %
3 in. dia. — 90 %

The angle of incline of lifting has little effect on the strand lifting loop capacity if the angle from the horizontal is more than about 20°. Typical handling methods are usually such that this angle is no less than 60°.

Table 5.2.3 Capacity of ½ in. diameter, 270 ksi strands used as lifting loops

Lifting angle	Embedment length (in.)	Single loop (kips)	Double loop (kips)	Triple loop (kips)
45 degrees	16	5	8.5	11.5
	22	8	13	17.5
	28	10	18	23
	34	11	23	29
Vertical	16	7.5	12.5	16.5
	22	11.5	19	24.5
	28	15.5	25.5	33
	34	16	32.5	41

1. These values are limited by slippage rather than strand strength, with a factor of safety of 4. For other strand diameters, multiply table values by 0.75 for ⅜ in. diameter, 0.85 for 7/16 in. diameter, and 1.1 for 0.6 in. diameter.
2. Minimum f'_c = 3000 psi.
3. Multiple strand loops must be fabricated to ensure equal force on each strand.

ELM BROOK RD BRIDGE # 46 FA-AB3 ABUTMENT

$W_T = 19.2^T$

THERE ARE (2) LIFTING LOOPS, AND THE MINIMUM SLING ANGLE W/THE HORIZONTAL IS 60°

DESIGN LOAD/LIFT LOOP = $\frac{19.2 \times 2}{2 \times 0.866} = 22.2^k$

FROM ATTACHED PCI LITERATURE, P 5.28

USE (9) 0.600" ϕ X 270 KSI STRANDS/LIFT LOOP

MIN EMBED 4'-10", SWL (4:1 S.F.) = $1.1 \times \frac{(29+41)}{2}$ = $38.5^k > 22.2^k$, OK

CHECK USING ATTACHED PCI LITERATURE, FIG 5.4.?A

$\phi P_{c1} = \frac{0.85 \times 2.61 \sqrt{3500}\,(36")(58.75")}{1000} = 284^k$; 4'-10 3/4" LONG CHEEK WALLS.

FOR 4:1 S.F.

SWL = 284/4 = $71^k > 22.2^k$, OK

SEE SHT 5 FOR LIFT LOOP LOCATION

ELM BROOK RD BRIDGE #46 FA-AB4 ABUTMENT

$WT = 28.94^{T}$

THERE ARE (4) LIFTING LOOPS AND THE MINIMUM SLING ANGLE W/ THE HORIZONTAL IS 60°

$$\text{DESIGN LOAD / LIFT LOOP} = \frac{28.94 \times 2}{2 \times \sin 60} = 33.4^{K}$$

FROM ATTACHED PCI LITERATURE, 11' 5.26

USE (4) 0.600" φ × 270 KSI STRANDS/LIFT LOOP
MIN EMBED 6'-10", $SWL(4{:}1\ S.F.) = 1.1 \times \left(\frac{29 + 41}{2}\right)$
$= 38.5^{K} > 33.4^{K}$, O.K.

CHECK USING ATTACHED PCI LITERATURE, FIG 6.15.7A

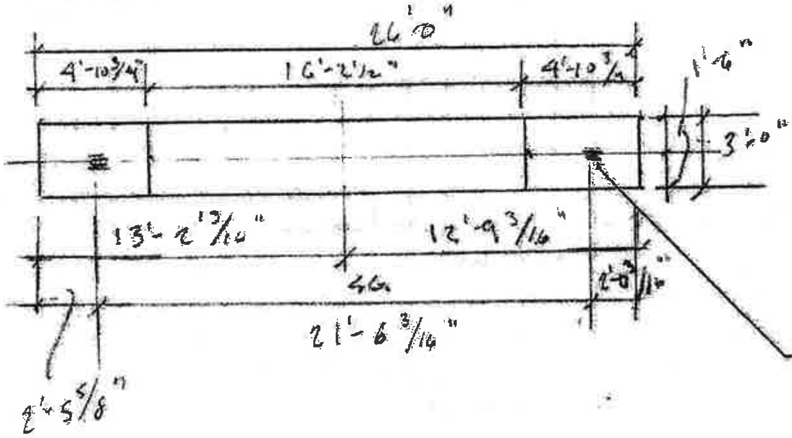
$$\phi P_{c} = \frac{0.85 \times 2.67 \sqrt{3500}\,(36")(58.75")}{1000} = 284^{K}$$; 4'-10 3/4" LONG CHECK WALL

FOR 4:1 S.F.

$$SWL = 284/4 = 71^{K} > 33.4^{K}, \text{ O.K.}$$

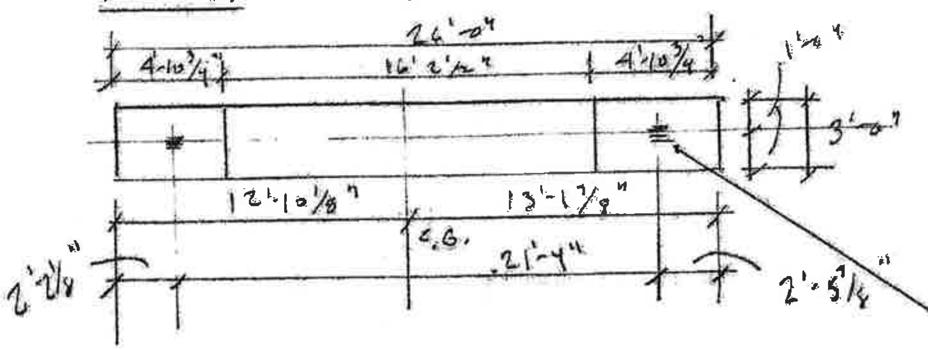
SEE SHT 5 FOR LIFT LOOP LOCATIONS

FA-AB3 WT 19.2^K PARTIAL PLAN VIEW



(4) 0.600" ϕ x 270 KSI STRAND LIFTING LOOP, MIN EMBED 4'-10", TYP 2 LOC

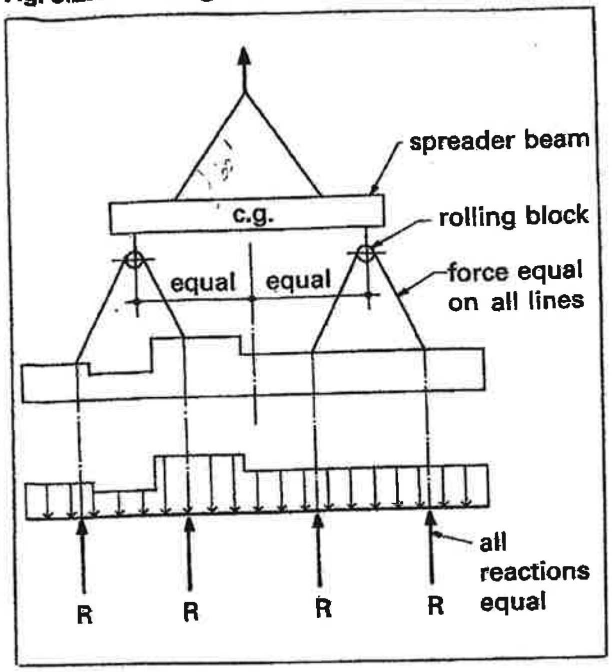
FA-AB4 WT 28.94^K PARTIAL PLAN VIEW



(4) 0.600" ϕ x 270 KSI STRAND LIFTING LOOP MIN EMBED 4'-10", TYP 2 LOC

NOTE: LIFTING LOOP LOCATIONS MAY BE ADJUSTED SLIGHTLY TO FACILITATE FABRICATION

Fig. 5.2.10 Arrangement for equalizing lifting loads



lines equal. The member can then be analyzed as a beam with varying load supported by equal reactions.

The force in inclined lift lines can be determined from Fig. 5.2.7.

5.2.8 Handling devices

The most common lifting devices are prestressing strand or cable loops projecting from the concrete, threaded inserts, or special proprietary devices.

Since lifting devices are subject to dynamic loads, ductility of the material is part of the design requirement. Deformed reinforcing bars should not be used since the deformations result in stress concentrations from the shackle pin. Also, reinforcing bars are often hard-grade or re-rolled rail steel with little ductility and low impact strength at cold temperatures. Smooth bars of a known steel grade may be used if adequate embedment or mechanical anchorage is provided. The diameter must be such that localized failure will not occur by bearing on the shackle pin.

Prestressing strand is often used for lifting loops. The variables involved make it almost impossible to calculate a capacity which can be used for all situations. Generally, producers will establish standard criteria for use in handling the standard products manufactured by that plant. Table 5.2.3 is an example which has been used successfully.

Reduced capacities for shorter embedment lengths may be suitable. In shallow products, providing a 90° bend can reduce the required embedment length significantly. Lightly rusted strand has better bond than bright strand.

The diameter of the bend of the loop should be at least 4 in. For smaller diameters, the loop capacities in Table 5.2.3 should be reduced to:

1 in. dia. — 70 %
2 in. dia. — 85 %
3 in. dia. — 90 %

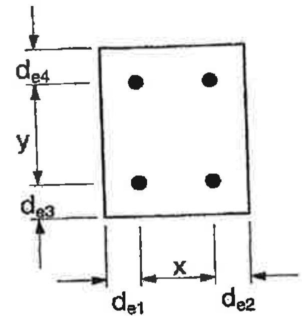
The angle of incline of lifting has little effect on the strand lifting loop capacity if the angle from the horizontal is more than about 20°. Typical handling methods are usually such that this angle is no less than 60°.

Table 5.2.3 Capacity of ½ in. diameter, 270 ksi strands used as lifting loops

Lifting angle	Embedment length (in.)	Single loop (kips)	Double loop (kips)	Triple loop (kips)
45 degrees	16	5	8.5	11.5
	22	8	13	17.5
	28	10	18	23
	34	11	23	29
Vertical	16	7.5	12.5	16.5
	22	11.5	19	24.5
	28	15.5	25.5	33
	34	16	32.5	41

1. These values are limited by slippage rather than strand strength, with a factor of safety of 4. For other strand diameters, multiply table values by 0.75 for ⅜ in. diameter, 0.85 for 7/16 in. diameter, and 1.1 for 0.6 in. diameter.
2. Minimum f'_c = 3000 psi.
3. Multiple strand loops must be fabricated to ensure equal force on each strand.

Figure 6.15.7A (continued) Design tensile strength for $h \geq h_{min}$, ϕP_{c1}—Case 6



x and y are the overall dimensions (width and length) of the stud group.

Case 6: Free edges on four adjacent sides

$\phi P_{c1} = \phi 2.67\lambda\sqrt{f'_c}\,(x_1)(y_1)$

$\phi = 0.85$

where: x_1 and y_1 are the dimensions of the flat bottom of the part of the truncated pyramid.

For Case 6: $x_1 = x + d_{e1} + d_{e2}$ $y_1 = y + d_{e3} + d_{e4}$

Note: Table values are based on $\lambda = 1.0$ and $f'_c = 5000$ psi;

for different material properties, multiply table values by $\lambda\sqrt{f'_c/5000}$

ℓ_e in.	y_1, in. \ x_1, in.	Design tensile strength, ϕP_{c1} (kips)													
		2	4	6	8	10	12	14	16	18	20	22	24	26	28
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	1	2	3	3	4	5	5	6	7	7	8	9	9
	4	1	3	4	5	7	8	9	10	11	13	14	15	17	18
	6	2	4	6	8	9	11	13	15	17	19	21	23	25	27
	8	3	5	8	10	13	15	18	21	23	25	29	31	33	36
	10	3	7	9	13	16	19	23	25	29	32	35	39	42	45
	12	4	8	11	15	19	23	27	31	35	39	42	46	50	54
	14	5	9	13	18	23	27	31	36	41	45	49	54	59	63
	16	5	10	15	21	25	31	36	41	46	51	35	61	67	72
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	1	2	3	3	4	5	5	6	7	7	8	9	9
	4	1	3	4	5	7	8	9	10	11	13	14	15	17	18
	6	2	4	6	8	9	11	13	15	17	19	21	23	25	27
	8	3	5	8	10	13	15	18	21	23	25	28	31	33	36
	10	3	7	9	13	16	19	23	25	29	32	35	39	42	45
	12	4	8	11	15	19	23	27	31	35	39	42	46	50	54
	14	5	9	13	18	23	27	31	36	41	45	49	54	59	63
	16	5	10	15	21	25	31	36	41	46	51	57	61	67	72
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	1	2	3	3	4	5	5	6	7	7	8	9	9
	4	1	3	4	5	7	8	9	10	11	13	14	15	17	18
	6	2	4	6	8	9	11	13	15	17	19	21	23	25	27
	8	3	5	8	10	13	15	18	21	23	25	28	31	33	36
	10	3	7	9	13	16	19	23	25	29	32	35	39	42	45
	12	4	8	11	15	19	23	27	31	35	39	42	46	50	54
	14	5	9	13	18	23	27	31	36	41	45	49	54	59	63
	16	5	10	15	21	25	31	36	41	46	51	57	61	67	72
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1	1	2	3	3	4	5	5	6	7	7	8	9	9
	4	1	3	4	5	7	8	9	10	11	13	14	15	17	18
	6	2	4	6	8	9	11	13	15	17	19	21	23	25	27
	8	3	5	8	10	13	15	18	21	23	25	28	31	33	36
	10	3	7	9	13	16	19	23	25	29	32	35	39	42	45
	12	4	8	11	15	19	23	27	31	35	39	42	46	50	54
	14	5	9	13	18	23	27	31	36	41	45	49	54	59	63
	16	5	10	15	21	25	31	36	41	46	51	57	61	67	72