

T.R. FELLOWS ENGINEERING

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REGISTERED PROFESSIONAL ENGINEERS
CIVIL – STRUCTURAL

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July 6, 2015

Revised July 15, 2015 (see items in red)

Marc Cote
Blow & Cote, Inc.
815 VT Rte 15E
Morrisville, VT 05661

Re: Cambridge Bridge BRO 1448(39)
Engineering Review and Certification: NEXT Beam Lift Plan
Bridge #28 on TH46 (Irish Settlement Road), Cambridge, VT

Dear Marc Cote,

As requested, I reviewed the proposed lift plan and information for the precast NEXT beams for the above referenced project. We also reviewed the project contract drawings as well as pictures taken at the site to better understand the existing site conditions of the area within and surrounding the project limits. It is acceptable to use the Bucyrus-Erie 110T Truck Crane and the 160 Ton Kobelco CK1600-II crane to lift the NEXT beams into place, as described below and per the attached documents and plan entitled "Cambridge Next Beam Lift Plan." Please refer to the attached loading charts for the two cranes, and the summary analysis outlined below for specific details.

Lift Equipment and Rigging:

Crane #1: BE 110T Truck Crane

- 60' boom
- 6 parts of line
- 30 ton 3 sheave minimum hook block weighs 2,100 lbs
- 2ea 1 1/8" cable slings with 15' legs with hook on one end weighs 900 lbs
- 2ea 13T clevis weighs 25lbs
- 1ea 35T clevis weighs 110lbs
- Crane #1 shall have both bumper counterweight (9,500 lbs) and upper counterweight (15,600 lbs) set as defined in manufacturer's literature (see attached)
- All (4) outriggers will be set on manufacturer's 30" square outrigger pads. Each outrigger pad which will be centered on a 4.5'x5'x2" thick A36 steel plate bearing on existing road surface or well compacted fill (see attached).

Crane #2: 160 Ton Kobelco CK1600-II

- 100' boom
- 4 parts of line
- 75 ton 4 sheave hook block weighs 2150lbs

- 2ea 1 1/8” cable slings with 15’ legs with hooks on one end weighs 900 lbs
- 2ea 13T clevis weighs 25lbs
- 1ea 35T clevis weighs 110lbs
- “Standard” counterweight requirements – see Section 5.3 of manufacturer’s literature (attached)

Crane Picks:

- Crane #1: Lift #1: 45,630 lbs off transport @ 40’, onto abutment @ 19’
 Lift #2: Same as Lift #1
 Lift #3: Same as Lift #1
- Crane #2: Lift #1: 45,680 lbs off transport @ 38’, onto abutment @ 46’
 Lift #2: 45,680 lbs off transport @ 38’, onto abutment @ 45’
 Lift #3: 45,680 lbs off transport @ 38’, onto abutment @ 45’

Sequence of Construction:

1. Transport arrives at project via Pleasant Valley Road with the extreme downstream (most Northerly) NEXT beam.
2. Transport backs down Irish Settlement Road to temporary road and across temporary concrete bridge stopping within 40’ of Crane #1.
3. Crane #1 is hooked to lifting eyelets on NEXT beam simultaneously with Crane #2. Both cranes simultaneously pick next beam off transport and transport leaves site.
4. Once transport is out of the way, Crane #1 swings to left and Crane #2 follows going to the right once beam is half way past Crane #1.
5. Both cranes position beam over bearing devices and lower the beam into final position.
6. Cranes are disconnected from beam and the next transport backs into position for unloading and the previous steps are repeated.

Rigging Analysis for Crane #1 (Bucyrus Erie 110T Truck Crane):

Qty	Rigging Item	Weight Each (lbs)	Weight Total (lbs)	Working Load Capacity (Each, lbs)	Required Load** (Each, lbs)	Check***
1	3 Sheave 30 ton hook block	2,100	2,100	60,000	43,530	OK
1	35 ton clevis	110	110	70,000	43,420	OK
2	15’ 24 ton 1-1/8” cable sling	900	1800	48,000*	42,211	OK
2	13 ton clevis	25	50	26,000	20,785	OK
* total capacity for 2-leg bridle 80 degree sling						
**based on maximum NEXT beam weight = 41.57 tons						
***check that Required Load < Working Load Capacity						

Lifting Analysis for Crane #1 (Bucyrus-Erie 110T Truck Crane):

According to the manufacturer’s shop drawings, the weight of the heaviest NEXT beam is 41.57 tons (83,140 lbs). Assuming balanced loading, the maximum load to be carried by the Bucyrus-Erie crane is the sum of the following: one-half the weight of the heaviest NEXT beam (83,140 lbs/2 = 41,570 lbs), one

2,100 lb sheave block, one 35 ton clevis (110 lbs), two 1-1/8" cable slings with 15' legs with hook on one end (900 lbs ea), two 13T clevises (25 lbs ea). The maximum load to be carried by the crane is therefore:

$$83,140 \text{ lbs}/2 + 2,100 \text{ lbs} + 110 \text{ lbs} + 1800 \text{ lbs} + 50 \text{ lbs} = 45,630 \text{ lbs}$$

To account for unbalanced loading, this load should be increased by 15% to just under 52,475 lbs. Each NEXT beam will be picked at (4) lift points, at the lifting eyelets located per the manufacturer's shop drawings, in accordance with the attached lifting plan.

According to the attached lifting charts for the Bucyrus-Erie 110T Truck Crane, with a 60 ft boom length, and a maximum radius of load equal to 40 ft from centerline of machine, the lift capacity of the crane is 54,700 lbs. This safely exceeds the required capacity of 52,475 lbs. In all cases, the outriggers must be set to achieve the required capacities.

The average ground pressure (taking into account unbalanced loading) under each of the (4) outriggers for the Bucyrus-Erie 110T Truck Crane is as follows:

$$[(135,800 \text{ lbs} + 52,475 \text{ lbs})/4 \text{ outriggers} + 1,838 \text{ lbs/outrigger}] / (4.5 \text{ ft} \times 5 \text{ ft per outrigger}) = 1,976 \text{ psf}$$

This ground pressure is sufficiently under typical soil bearing capacity of 3,000 psf.

Rigging Analysis for Crane #2 (160 Ton Kobelco CK1600-II):

Qty	Rigging Item	Weight Each (lbs)	Weight Total (lbs)	Working Load Capacity (Each, lbs)	Required Load** (Each, lbs)	Check***
1	4 Sheave 75 ton hook block	2,150	2,150	150,000	43,530	OK
1	35 ton clevis	110	110	70,000	43,420	OK
2	15' 24 ton 1-1/8" cable sling	900	1800	48,000*	42,211	OK
2	13 ton clevis	25	50	26,000	20,785	OK
* total capacity for 2-leg bridle 80 degree sling						
**based on maximum NEXT beam weight = 41.57 tons						
***check that Required Load < Working Load Capacity						

Lifting Analysis for Crane #2 (160 Ton Kobelco CK1600-II):

According to the manufacturer's shop drawings, the weight of the heaviest NEXT beam is 41.57 tons (83,140 lbs). Assuming balanced loading, the maximum load to be carried by the 160 Ton Kobelco CK1600-II crane is the sum of the following: one-half the weight of the heaviest NEXT beam (83,140 lbs/2 = 41,570 lbs), one 2,150 lb sheave block, one 35 ton clevis (110 lbs), two 1-1/8" cable slings with 15' legs with hook on one end (900 lbs ea), two 13T clevises (25 lbs ea). The maximum load to be carried by the crane is therefore:

$$83,140 \text{ lbs}/2 + 2,150 \text{ lbs} + 110 \text{ lbs} + 1800 \text{ lbs} + 50 \text{ lbs} = 45,680 \text{ lbs}$$

To account for unbalanced loading, this load should be increased by 15% to 52,532 lbs.

According to the attached lifting chart for the 160 Ton Kobelco CK1600-II, with a 100 ft boom length, and a maximum radius of load equal to 46 ft from centerline of machine, the lift capacity of the crane is greater than 71,800 lbs. This safely exceeds the required capacity of 52,532 lbs.

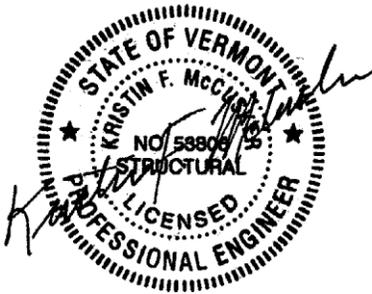
The average ground pressure (taking into account unbalanced loading) under each of the crawler tracks of the 160 Ton Kobelco CK1600-II crane is as follows:

$$(306,000 \text{ lbs} + 52,532 \text{ lbs}) / (2 \times 4 \text{ ft} \times 22.58 \text{ ft}) = 1,985 \text{ psf}$$

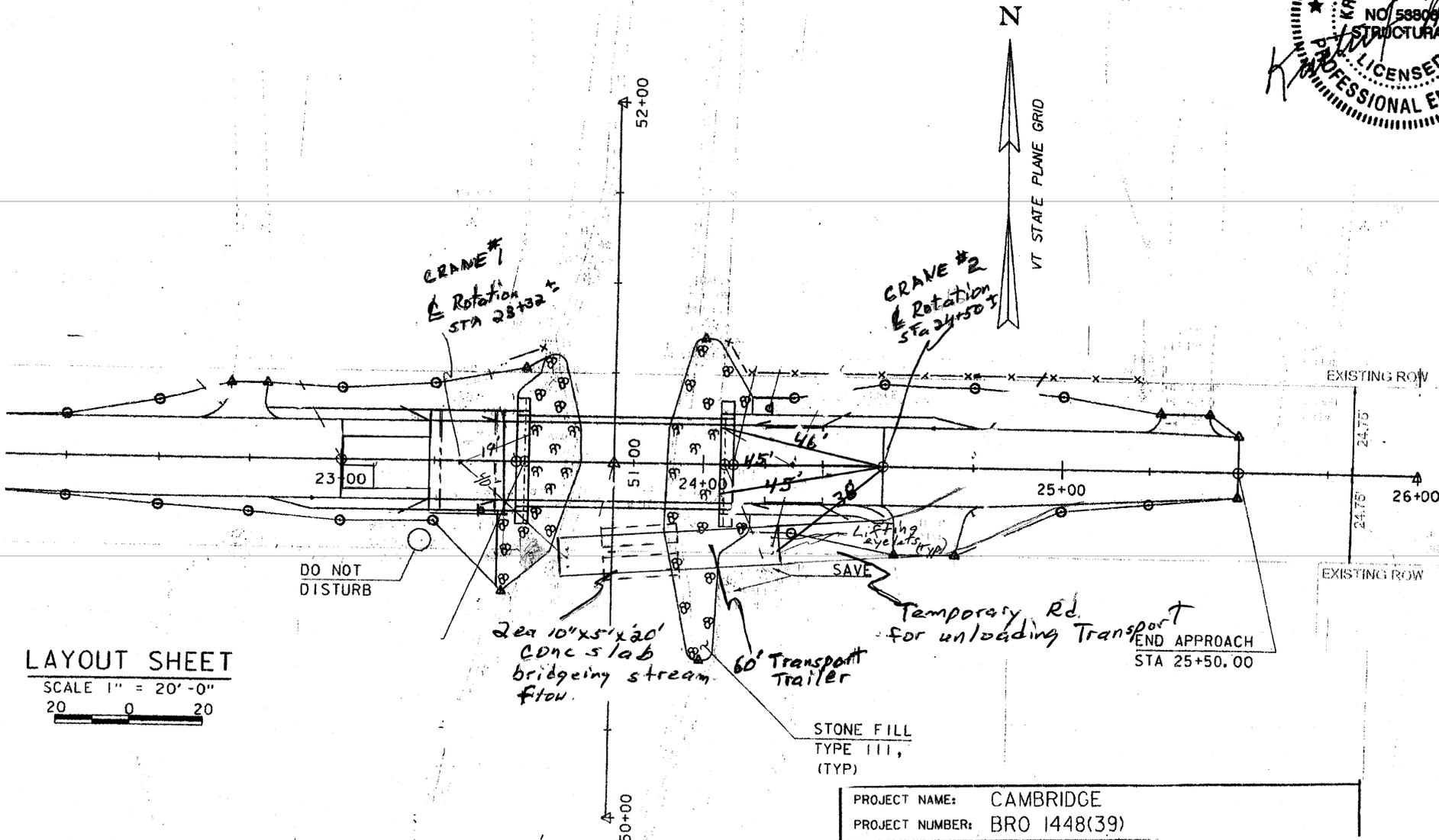
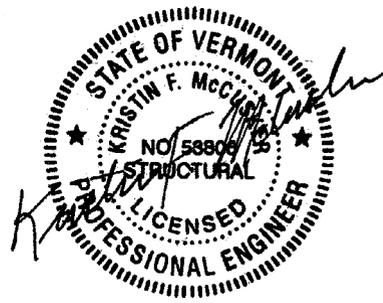
This ground pressure is sufficiently under typical soil bearing capacity of 3,000 psf.

Care shall be taken to ensure that both cranes are positioned on a firm, level, and uniform supporting surface per manufacturer's recommendations. Please let me know if you any questions or concerns.

Sincerely,



Kristin F. McCusker, P.E.



DO NOT DISTURB

LAYOUT SHEET
SCALE 1" = 20'-0"
20 0 20

Cambridge NEXT Beam Lift Plan

STONE FILL
TYPE III,
(TYP)

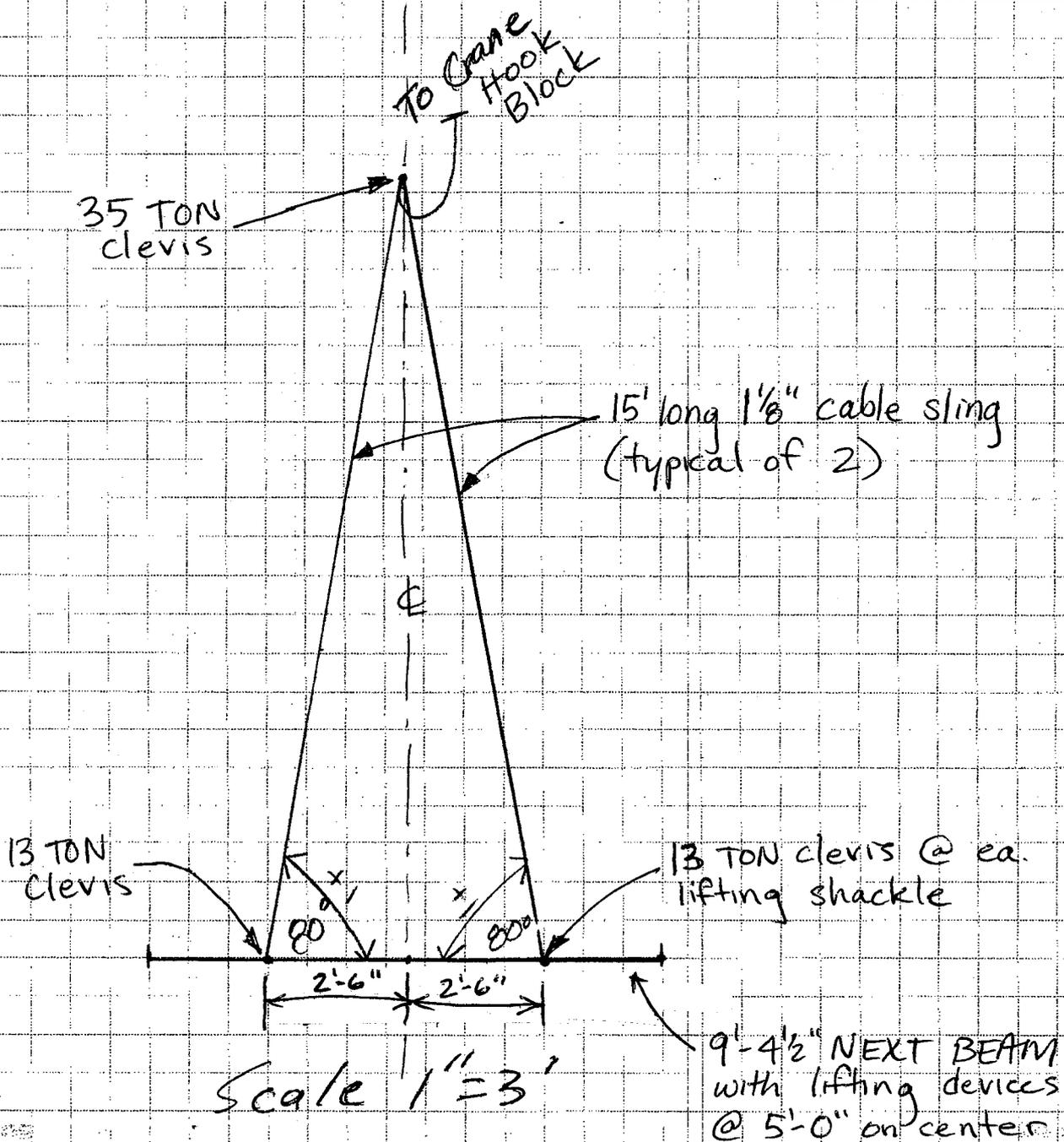
PROJECT NAME: CAMBRIDGE
PROJECT NUMBER: BRO 1448(39)

BLOW & COTE, INC
815 VT RT 15E
Morrisville, VT. 05261

END APPROACH
STA 25+50.00

Next Beam Lifting Details Typical

Typical Crane #1 and Crane #2



Drawn:
The No. 1 sheet &
Checked:

APPROVED FOR CONSTRUCTION
DATE: _____

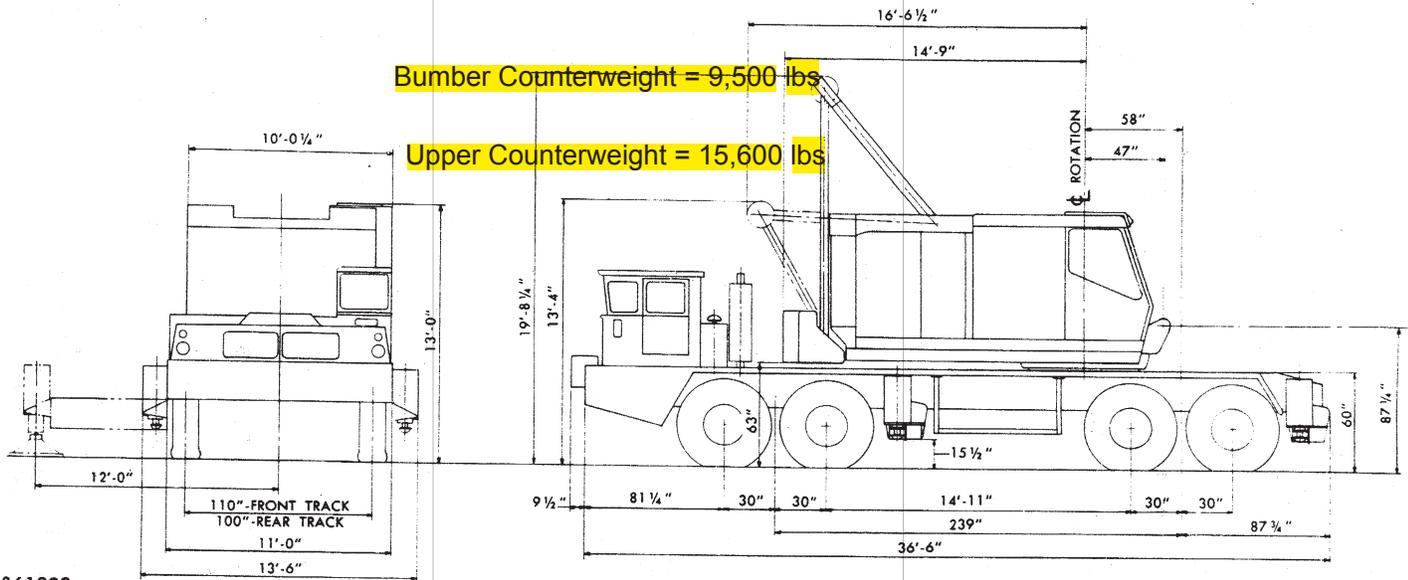
Checked by:
Date:



110-T

110 TON TRUCK CRANE SPECIFICATIONS

rotation to rear of crane 12' 2"



861099

CRANE	
Front Shaft:	
Main hoist drum, smooth	16 1/2 in. Pitch Diameter
Hoist rope	3/4 in. or 7/8 in. Diameter
Auxiliary hoist rope	3/4 in. or 7/8 in. Diameter
Auxiliary hoist drum, smooth	16 1/2 in. Pitch Diameter
Rear Shaft:	
Boom hoist drum, smooth	15 in. Pitch Diameter
Boom hoist rope	3/4 in. Diameter
Third drum, smooth	12 in. Pitch Diameter
Third drum rope	5/8 in. Diameter
Boom point sheaves (6)	18 in. Pitch Diameter
3/8 in. diameter rope required for loads over 200,000 pounds.	

LINE PULLS AND SPEEDS					
Drum Pitch Diameter	1-Part Line		2-Part Line		
	Pull in Pounds	Speed (Feet/Minute)	Pull in Pounds	Speed (Feet/Minute)	
16 1/2 in.	21,100	157	41,600	78.5	
Swing Speed:					
Standard					
Micro-Swing					
Standard					2.25 revolutions/minute
Micro-Swing					0.65 revolutions/minute
Speeds and line pulls based on engine with torque converter drive operating at full load speed of the output shaft. When torque converter is operating at full stall, line pulls are approximately 220 per cent of those shown in table.					

WEIGHTS IN POUNDS	
	Crane 40 Ft. Boom
Net weight domestic, approx.	130,150
Working weight, approx.	135,800
Export shipping weight, approx.	135,450
Ship option tons	139
Hook block included in working weight and export shipping weight for lifting crane, but not in domestic net weight.	

POWER SPECIFICATIONS	
Make - Model Type	Cummins N-855P Diesel
Type of drive	Torque Converter
Cylinders	6
Bore x stroke, inches	5 1/2 x 6
Displacement, cubic inches	855
H.P. net @ full load speed	149
Full load speed (R.P.M.)	2,000
Fuel tank capacity, gallons	75
Starting	Elec. - 12 volt
Altitude range, feet	0-9,000

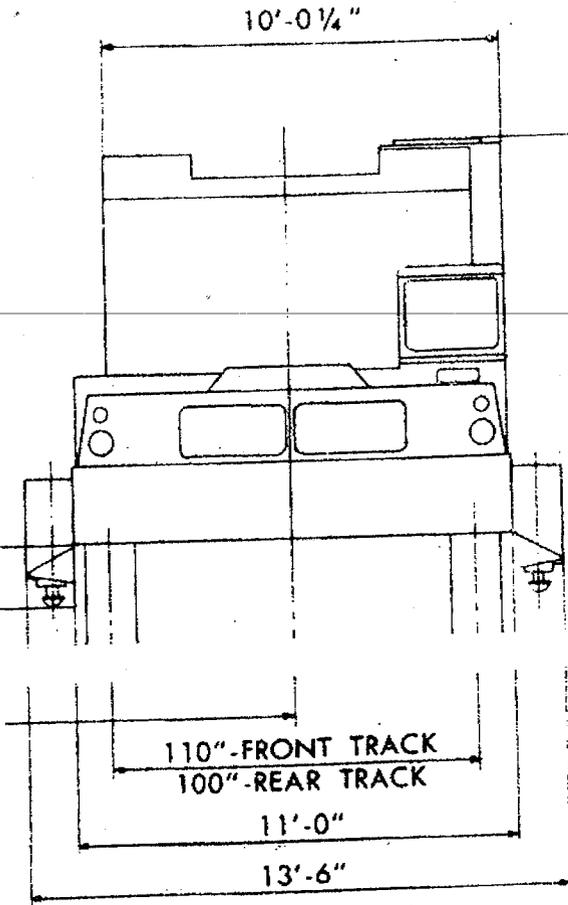
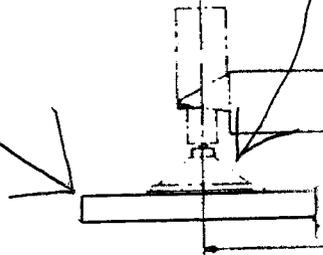
BLOW & COTE, INC.

815 VT Rte 15E
MORRISVILLE, VT 05661

Bucyrus Erie 110T Truck Crane Outrigger Detail

Crane Manufacture
Outrigger pad = 30" sq.

Steel plates to be set
under outrigger pads =
 $4\frac{1}{2}$ ft x 5 ft x 2" thick



Note: Steel plates to
be existing road surface
or on compacted fill.

NTS

110 TON TRUCK CRANE

MAXIMUM ALLOWABLE LOADS IN POUNDS — CRANE SERVICE

Boom Length In Feet	Radius In Feet	Boom Angle In Degrees	Boom Point Pin Height (Ft. -In.)	Outriggers Set Over Side or Rear	Without Outriggers On Tires		Boom Length In Feet	Radius In Feet	Boom Angle In Degrees	Boom Point Pin Height (Ft. -In.)	Outriggers Set Over Side or Rear	
					Over Side	Over Rear						
40	12	78	46-6	220,000	96,900	139,700	150	35	78	154-0	65,600	
	16	74	45-9	185,000	68,600	97,400		40	76	152-9	52,800	
	20	66	44-0	149,000	45,900	64,600		50	72	150-0	37,200	
	25	58	41-3	118,900	34,100	47,900		60	68	146-6	28,200	
	30	49	37-6	86,700	26,900	37,800		70	64	142-0	22,200	
35	39	22-6	67,900	22,100	31,100	80		60	136-6	18,000		
60	15	79	66-3	180,000	67,900	97,000		90	55	130-0	14,900	
	20	74	65-0	147,000	45,200	63,900		100	50	122-6	12,500	
	25	69	63-6	118,500	33,400	47,200		110	45	113-3	10,600	
	30	64	61-3	86,200	26,200	37,100		120	39	102-3	9,050	
	35	59	58-6	67,400	21,400	30,300		130	33	88-6	7,750	
	40	53	55-3	54,700	17,900	25,500		160	35	80	164-3	65,300
50	40	45-9	39,400	13,200	19,100	40			77	163-3	52,600	
80	20	78	96-9	145,000	44,600	63,300			50	73	160-6	37,000
	25	75	84-6	118,200	32,800	46,600			60	69	157-0	27,900
	30	71	83-0	85,900	25,600	36,500	70		66	153-0	22,000	
	35	67	81-0	67,000	20,800	29,700	80		62	148-0	17,700	
	40	63	78-9	54,300	17,300	24,900	90		57	142-3	14,600	
	50	55	72-9	38,900	12,600	18,500	100		53	135-3	12,200	
60	45	64-2	29,900	9,550	14,300	110	48		127-0	10,300		
70	34	52-3	24,000	7,550	11,500	120	43		117-6	8,750		
90	20	80	96-9	143,000	44,300	63,100	130		38	105-9	7,450	
	25	76	94-9	117,200	32,500	46,300	170		40	78	173-6	52,400
	30	73	93-6	85,700	25,300	36,200			50	74	171-0	36,800
	40	66	89-9	54,100	17,000	24,600			60	71	167-9	27,700
	50	59	84-6	38,600	12,300	18,200			70	67	164-0	21,700
60	51	77-9	29,600	9,250	14,100	80		63	159-3	17,500		
70	43	68-3	23,800	7,200	11,200	90		60	153-9	14,400		
80	32	56-3	19,600	5,650	9,150	100		56	147-6	11,900		
100	25	78	105-0	116,000	32,200	46,100		110	51	140-0	10,000	
	30	75	103-9	85,500	25,000	36,000		120	47	131-6	8,450	
	40	69	100-6	53,900	16,700	24,400		130	42	121-3	7,150	
	50	63	96-0	38,400	10,600	17,900		180	40	78	183-6	52,200
	60	56	90-0	29,400	7,950	13,800			50	75	180-3	36,500
	70	49	82-3	23,500	6,100	11,000			60	72	178-3	27,400
80	41	72-3	19,400	4,650	8,900	70			68	174-9	21,500	
90	31	56-3	16,300	3,700	7,300	80			65	170-6	17,200	
110	25	80	115-3	115,000	31,900	45,700	90		61	165-3	14,100	
	30	76	114-3	85,300	24,700	35,600	100		58	159-6	11,700	
	40	71	111-3	53,600	16,400	24,000	110		54	152-6	9,800	
	50	65	107-3	38,200	11,700	17,600	120		50	144-9	8,200	
	60	59	102-0	29,100	8,650	13,500	130		46	136-9	6,900	
	70	53	96-3	23,200	6,550	10,600	140		41	125-0	5,800	
120	80	46	86-9	19,100	5,000	8,550	190		40	79	193-9	51,900
	90	39	75-9	16,000	3,850	6,950			50	76	191-6	36,300
	100	29	60-9	13,600	2,900	5,650			60	73	188-9	27,100
	25	80	125-6	114,000	31,600	45,500			70	70	185-6	21,200
	30	77	124-6	85,100	24,400	35,400		80	66	181-3	16,900	
	40	73	121-9	53,400	16,100	23,800		90	63	176-9	13,800	
50	67	118-9	38,000	11,400	17,300	100		60	171-3	11,400		
60	62	113-3	28,900	8,400	13,200	110		56	165-0	9,450		
70	57	107-6	23,000	6,300	10,300	120		52	157-9	7,900		
80	51	100-0	18,800	4,750	8,300	130		48	149-6	6,600		
90	44	90-9	15,700	3,600	6,650	140		44	139-9	5,500		
100	37	79-3	13,300	2,650	5,400	200		50	77	201-9	36,100	
110	28	63-3	11,400	1,900	4,400			60	74	199-3	26,900	
30	78	134-6	84,900	24,100	35,100			70	71	196-0	20,900	
40	74	132-3	53,200	15,800	23,500			80	68	192-3	16,700	
50	69	128-9	37,700	11,100	17,000		90	65	187-9	13,600		
60	64	124-6	28,700	8,100	12,900		100	61	182-9	11,100		
70	59	119-3	22,800	6,000	10,000		110	58	176-9	9,250		
80	54	112-6	18,600	4,450	8,000		120	55	170-3	7,650		
90	49	104-0	15,500	3,300	6,400		130	51	162-6	6,350		
100	42	94-9	13,000	2,350	5,100		140	47	153-9	5,250		
110	35	82-6	11,100	1,600	4,100		210	50	77	212-3	35,800	
120	27	65-9	9,600	950	3,250			60	75	209-9	26,700	
30	79	144-9	84,700	23,900	34,800			70	72	206-6	20,700	
40	75	142-6	53,000	15,500	23,200			80	69	203-0	16,500	
50	71	139-6	37,500	10,800	16,800			90	66	198-9	13,300	
60	66	135-6	28,500	7,850	12,700	100		63	194-0	10,900		
70	62	130-9	22,500	5,750	9,800	110		60	188-6	8,950		
80	57	124-9	18,300	4,200	7,700	120		56	182-3	7,400		
90	52	117-9	15,200	3,000	6,100	130		53	175-3	6,050		
100	47	108-0	12,800	2,100	4,850	140		50	167-3	4,950		
110	41	98-9	10,900	1,350	3,850	220		50	78	222-3	35,600	
120	34	85-6	9,350	—	3,000			60	75	220-0	26,500	
130	26	68-3	8,050	—	2,250			70	73	217-0	20,500	
140	30	79	144-9	84,700	23,900			34,800	80	70	213-9	16,200
	40	75	142-6	53,000	15,500			23,200	90	67	209-9	13,100
	50	71	139-6	37,500	10,800		16,800	100	64	206-3	10,600	
	60	66	135-6	28,500	7,850		12,700	110	61	200-0	8,700	
	70	62	130-9	22,500	5,750		9,800	120	58	194-3	7,150	
	80	57	124-9	18,300	4,200		7,700	130	55	187-6	5,950	
	90	52	117-9	15,200	3,000		6,100	140	52	180-3	4,700	
	100	47	108-0	12,800	2,100		4,850	150	48	171-9	3,800	
	110	41	98-9	10,900	1,350		3,850	160	45	162-3	2,950	
	120	34	85-6	9,350	—		3,000					
	130	26	68-3	8,050	—		2,250					

The above ratings apply to machines that are level and standing on hard, level uniform supporting surfaces. Loads must be freely suspended. The radii specified are loaded radii. Ratings include blocks, hooks, slings or other equipment used in handling loads. Proper care must be exercised by the operator at all times to avoid shock or side loadings on the boom. Ratings apply only to machines having booms in first class condition built and recommended by Bucyrus-Erie Company.

†Entire machine supported on both outriggers with rear tires clear of ground.

*Indicates that maximum allowable load is limited by factors other than tipping.

BLOW & COTE, INC.

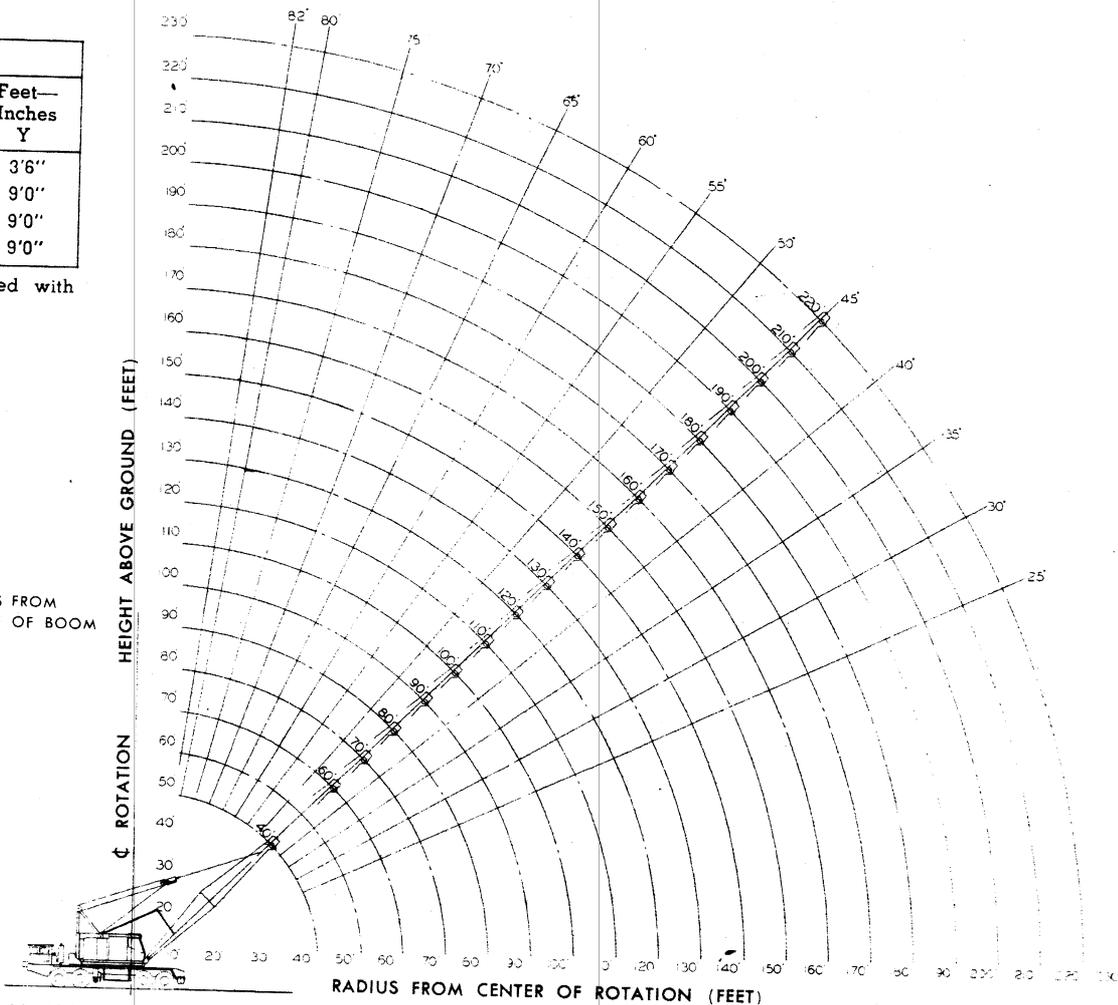
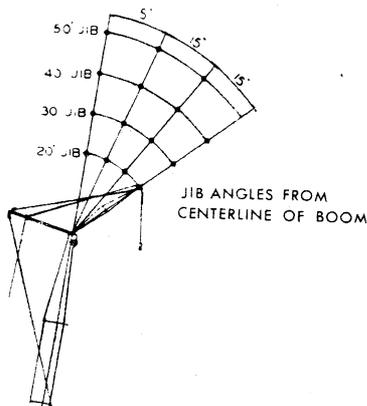
815 VT Rte 15E

MORRISVILLE, VT 05661

110 TON TRUCK CRANE

HOOK BLOCKS		
Capacity	No. Parts	Feet—Inches Y
8½ Ton	1	3'6"
25 Ton	2	9'0"
60 Ton	6	9'0"
110 Ton	12	9'0"

"Y" dimension determined with boom at 82°.



881016

CRANE SERVICE

Loads shown in table are for general crane service with the machine on firm, level ground, with tire pressures not less than 105 psi. For prolonged highway travel, reduce this pressure to 95 psi. Suspension—14 part tackle with pendants. Intermediate suspension is required on booms 170' and longer. Maximum boom angle is 82°.

RECOMMENDED HOIST TACKLE

Loads Over Part of Line	16,500	33,000	50,000	67,000	84,000	100,000
	2	3	4	5	6	7
		117,000	134,000	151,000	168,000	184,000
		8	9	10	11	12*

*For loads over 200,000 lbs. use 7/8" hoist cable. Deduct weight of hook blocks, hooks and slings from listed loads.

JIBS

Use jibs for lifting crane service only. Allowable loads on main boom sheaves, with jib attached, must be reduced as follows:

20 ft. jib.....	1900 lbs.	40 ft. jib.....	2500 lbs.
30 ft. jib.....	2100 lbs.	50 ft. jib.....	3000 lbs.

Maximum length of boom to which a jib may be attached is 200 feet. Maximum allowable jib loads are as follows:

Jib Offset* in Degrees	Jib Length			
	20-ft.	30-ft.	40-ft.	50-ft.
0	20,000	17,000	13,000	10,000
15	20,000	17,000	13,000	10,000
30	15,000	12,000	9,000	6,000
45	10,000	7,000	4,000	—

*Maximum offset (angular) from centerline of boom to centerline of jib.

The allowable load over the jib sheave, at any radius from the centerline of rotation of the machine, is the same load that may be lifted over the boom point sheave (without jib) with boom lowered to that radius, but not to exceed the loads in the jib table. For jib loads over 16,500 lbs., use 2-part line.

GENERAL

Maximum boom or boom-jib combinations that can be lifted off the ground unassisted are:

	With Outriggers		
	With Bumper Cwt.	Without Bumper Cwt.	Without Outriggers
Boom Over Side	210 ft.	200 ft.	130 ft.
Over Rear	220 ft.	210 ft.	140 ft.
Boom-Jib Over Side	190 ft. + 30 ft.	170 ft. + 50 ft.	100 ft. + 50 ft.
Over Rear	200 ft. + 50 ft.	180 ft. + 40 ft.	120 ft. 50 ft.

The maximum boom-jib combination that can be lifted off the ground unassisted over the rear of the carrier with outriggers set and with a front bumper counterweight is 200' + 50'.

Maximum boom or boom-jib combination that can be carried in a lowered position and with A-frame in the lowered position is 110 ft. or 90 ft. plus a 30 ft. jib. With boom-jib combination in a horizontal position, clearance height over the jib mast is 17' 2".

MACHINE EQUIPMENT

Alloy steel tubular "Trigon" boom, 15,600 lbs. outside counterweight, 31" high and 27½" wide, distance between center of jacks with outriggers fully extended is 24' 0", 9,500 lb. front bumper counterweight is used for erection purposes only. Remove bumper counterweight when traveling.

SPECIFICATIONS FOR CK1600-II CRAWLER CRANE

The Kobelco CK1600-II Crawler Crane is designed from the ground up for reliable operation, convenient maintenance and easy transport.

Please consult your Kobelco distributor for additional information regarding specifications, operating parameters and maintenance requirements.

1. GENERAL DESCRIPTION

Type Crawler mounted, fully revolving
Maximum lifting capacity 320,000 lbs (145,200 kg)
 (at 15' operating radius, with 50' boom)
Basic boom length 50' (15.2 m)
Maximum boom length 250' (76.2 m)
Maximum boom & jib length
 200' + 100' (61.0 m + 30.5 m)

2. GENERAL DIMENSIONS

Height to top of cab 11' 9" (3.58 m)
Width of upper machine with operator's cab
 10' 6" (3.20 m)
Radius of rear end (counterweight) 18' 1" (5.50 m)
Counterweight ground clearance 4' 5" (1.34 m)
Center of rotation to boom foot pin 4' 7" (1.40 m)
Height from ground to boom foot pin 8' 4" (2.53 m)
Height over gantry (raised) 25' 11" (7.89 m)
Overall length of crawler 25' 11" (7.90 m)
Center to center of tumbler 22' 8" (6.89 m)
Overall width of crawlers 21' 9" (6.62 m)
Shoe width 48" (1.22 m)
Ground clearance of carbody 19" (0.48 m)

3. WORKING WEIGHT

Type of Counterweight	Light	Standard
Working Weight	273,000 lbs (124,000 kg)	306,000 lbs (139,000 kg)
Ground Bearing Pressure	10.5 psi	11.7 psi
Gradeability	30%	30%

Calculations to determine working weight ground bearing pressure and gradeability include the weight of the base machine, 50' boom and hook block.

Type of Counterweight:

Light = 105,820 lbs (48,000 kg) Counterweight without carbody weight.

Standard = 116,840 lbs (53,000 kg) Counterweight with carbody weight.

4. WORKING SPEED

Line speeds based on single line, no load and first layer of rope on the drum.

Hoist line speed (front and rear drum)

390 ~ 10 ft/min (120 ~ 3 m/min)

Lowering line speed (front and rear drum)

390 ~ 10 ft/min (120 ~ 3 m/min)

Boom hoist line speed

157 ~ 7 ft/min (48 ~ 2 m/min)

2 minutes: 250 ft (76.2 m) boom raise 0 to 80 degree

Boom lowering line speed

157 ~ 7 ft/min (48 ~ 2 m/min)

Swing speed

2.1 rpm (2.1 min⁻¹)

Travel speed (High / Low)

0.81 / 0.56 mph

(1.3 / 0.9 km/hour)

5. UPPER MACHINERY

5.1 Power plant

Diesel engine, make and model

Hino P11C-UN (Comply with EPA "Tier 3")

No. of cylinders

6

Bore X stroke

4-13/16" X 5-7/8"

(122 mm X 150 mm)

Cycles

4

Total displacement

642 cu.in (10,520 cm³)

Rated output SAE GROSS

331 HP / 2,000 rpm (247 kW / 2,000 min⁻¹)

Maximum torque

959 lbs-ft / 1,500 rpm (1,300 Nm / 1,500 min⁻¹)

Starter

24 Volts / 6.0 kW

Alternator

24 Volts / 50 Amp

Batteries

Two 12 volt, 170 AH/20HR capacity series connected.

Radiator

Corrugated type core, thermostatically controlled.

Throttle

Twist grip type hand throttle, electrically controlled.

Air cleaner Dry type with replaceable paper element.

Fuel tank capacity

106 US gal. (400 liters)

Lube oil filter

Full flow and by-pass type with element type.

Fuel filter

Replaceable paper element.

Approximate fuel consumption

0.362 lb / HP-hr (220 g / kW-hr)

17.3 US gal. / hr at 100 % HP

5.2 Hydraulic pumps

All driven from heavy duty pump drive.

Load hoist and propel

2 Piston pumps, max flow rate 66.5 US gal./min x 2
(252 ℓ/min x 2)

Boom Hoist

1 Piston pump, max flow rate 66.5 US gal./min
(252 ℓ/min)

Swing

1 Piston pump, max flow rate 46.2 US gal./min
(175 ℓ/min)

Control system and auxiliary

2 Gear pumps, max flow rate
16.1 US gal./min x 10.6 US gal (61 ℓ/min x 40 ℓ/min)

Brake cooling system

2 Gear pumps, max flow rate 19.3 US gal./min x 2
(73 ℓ/min x 2)

5.3 Counterweight

Light Weight

one (1) base counterweight (A) and eight (8) side counterweights (B) 105,820 lbs(48,000 kg)

Standard Weight

one (1) base counterweight (A), eight (8) side counterweight (B) and two side counterweights (C)
116,840 lbs (53,000 kg)

two (2) carbody weight 22,050 lbs (10,000 kg)

Additional weight consists of two (2) side counterweights (C) and two (2) carbody weights.

Description		Light	Standard
Base Counterweight (A)		1	1
Side Counterweight (B)		8	8
Side Counterweight (C)		0	2
Carbody Counterweight		0	2
Total Weight	Upper	105,820 lbs (48,000 kg)	116,840 lbs (53,000 kg)
	Lower	None	22,050 lbs (10,000 kg)

5.4 Gantry

This high folding type gantry is fitted with a sheave frame for boom hoist reeving. Hydraulic lift is standard. It provides full up, full down positions with linkage.

5.5 Operator's cab

Totally enclosed from weather, this full-vision cab has safety glass all around. The adjustable, high-backed seat with armrest is standard, allowing operators to customize the position. Auxiliary controls and instruments are on a side mounted console. A signal horn, windshield wipers, air conditioner are all standard features.

5.6 Controls

At operator's right are console-mounted adjustable short levers for the front and rear drum and the boom hoist control. Beside the operator's seat on the right are two short levers for propel control, individual speed shifts for front drum, rear drum and boom drum. At the operator's left are the console mounted swing lever, knobs for front and rear drum, boom drum pawls, engine start / stop key. A swing brake control switch and signal horn button are on the swing lever.

5.7 Electric system

All wiring corded for easy serving, individual fused branch circuit.

5.8 Hydraulic system

Maximum pressure rating 4,620 psi (31.9 Mpa)

Cooling Oil to air heat exchanger

Filtration

Full flow filters with replaceable paper elements

5.9 Boom hoist

Powered by hydraulic motor through planetary reducer.

Drum

Single drum.
Grooved for 20.0 mm dia. wire rope.

Brake

A spring set, hydraulically-released, multiple-disc holding brake is mounted inside the boom hoist motor and is operated through a counter-balance valve. An external ratchet is fitted for locking the drum.

5.10 Front drum

Powered by hydraulic motor through planetary reducer.

Drum

26.2" (666 mm) P.C.D. X 26.5" (672 mm) Lg.
Grooved for 26 mm dia. wire rope.

Brake

A spring set, hydraulically-released, multiple-disc holding brake is mounted inside the hoist motor and is operated through a counter-balance valve. An external ratchet is fitted for locking the drum.

Free-Fall (Optional)

Wet-type disk brake free-fall is mounted inside the drum.

5.11 Rear drum

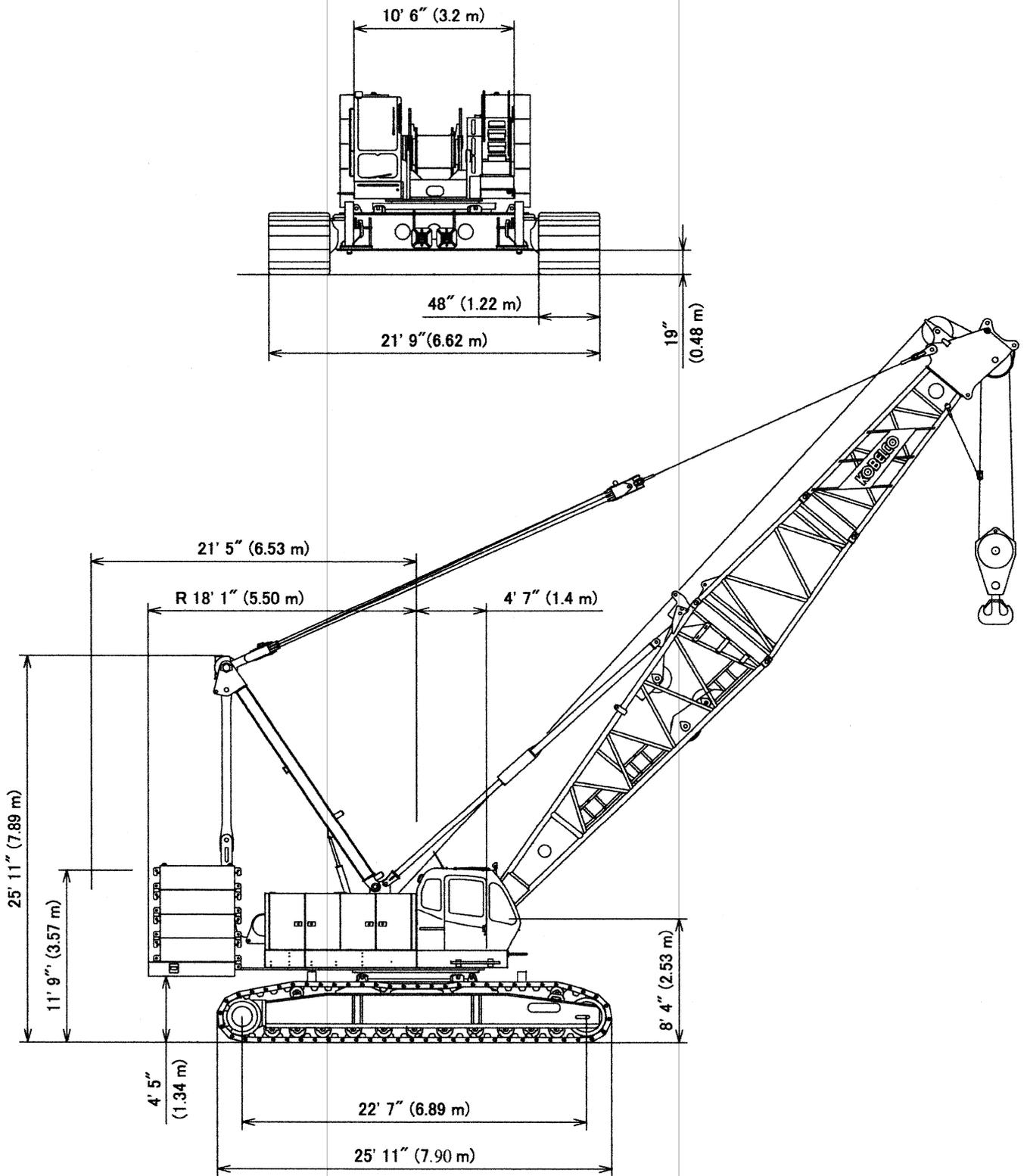
Powered by hydraulic motor through planetary reducer.

Drum

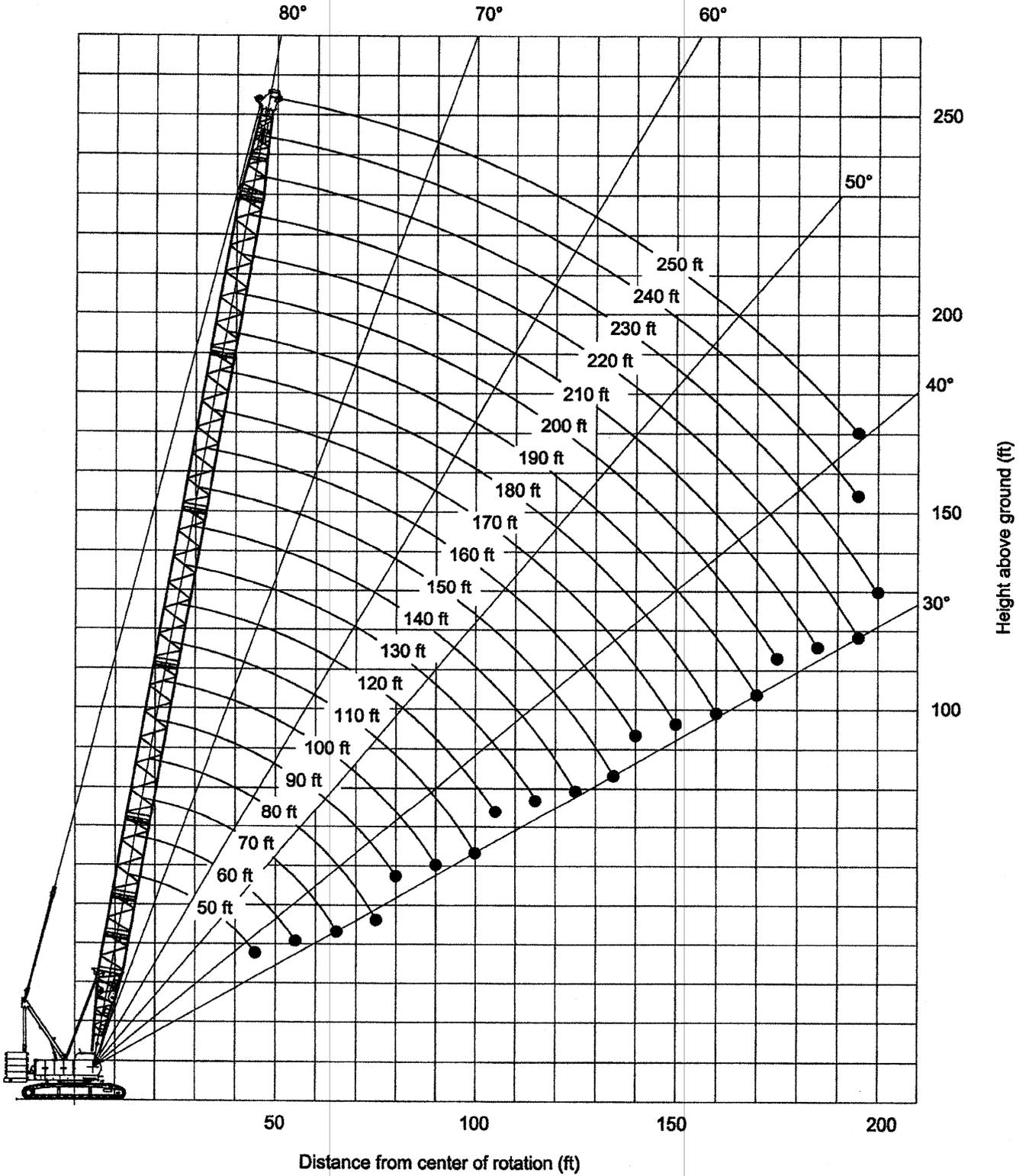
26.2" (666 mm) P.C.D. X 26.5" (672 mm) Lg.
Grooved for 26 mm dia. wire rope.

CK1600-II General Dimensions

KOBELCO



CK1600-II Main Boom Working Range



KOBELCO CK1600-II Main boom rated loads in pounds

Counterweight: 116,840 lbs (53,000 kg)

Carbody weight: 22,050 lbs (10,000 kg)

Supplemental Data

- Rated loads included in the charts are the maximum allowable freely suspended loads at a given boom length, boom angle and load radius, and have been determined for the machine standing level on firm supporting surface under ideal operating conditions. The user must limit or de-rate rated loads to allow for adverse conditions (such as soft or uneven ground, out-of-level conditions, wind, side loads, pendulum action, jerking or sudden stopping of loads, inexperience of personnel, multiple machine lifts, and traveling with a load).
- Rated loads do not exceed 75% of minimum tipping loads. Rated loads based on factors other than machine stability such as structural competence are shown by asterisk * in the charts.
- The machine must be reeved and set-up as stated in the operation manual and all the instruction manuals if these manuals are missing, obtain replacements.
 - The crane must be leveled to within 1% on a firm supporting surface.
 - Boom backstops are required for all boom length.
 - Gantry must be fully raised position for all operations.
- Do not attempt to lift where no radius on load is listed as crane may tip or collapse.
- Attempting to lift more than rated loads may cause machine to tip or collapse. Do not tip machine to determine rated loads.
- Weight of hooks, hook blocks, slings and other lifting devices are a part of the total load. Their total weight must be subtracted from the rated load to obtain the weight that can be lifted.
- When lifting over boom point with jib or auxiliary sheave, rated loads for the boom must be deducted as shown below.

Jib Length (ft)	Aux	40	60	80	100
Deductions (lbs)	1,250	7,055	8,010	8,965	9,920

- The total load that can be lifted by jib is limited by rated jib loads.
- Boom lengths for jib mounting are 90 ft (27.4 m) to 200 ft (61.0 m)
- 40 ft (12.2m) jib length with offset angle of 10 degrees, and one part of line on the hook is not allowed.

- The total load that can be lifted by the auxiliary sheave is: the rated load for the boom (without auxiliary sheave installed) minus 1,250 lbs; however, the auxiliary sheave rated load should not exceed 59,000 lbs.
- Boom lengths that can attach auxiliary sheave are from 50 ft (15.2 m) to 240 ft (73.2 m).
- The boom should be erected over the front of the crawlers, not laterally. When lifting from or lowering to the ground the boom at length of 240 ft (73.2 m) or over, the blocks must be placed at the end of crawlers.
- Least stable position is over the side.
- Maximum hoist load for number of reeving parts of line for hoist rope.

Main Load for Main Boom

No. of Parts of line	1	2	3	4	5
Maximum Loads (lbs)	29,500	59,000	88,500	118,000	147,500

No. of Parts of line	6	7	8	9	10
Maximum Loads (lbs)	177,000	206,500	236,000	265,500	295,000

No. of Parts of line	11
Maximum Loads (lbs)	320,000

Main Load For Jib Hoist

No. of Parts of line	1	2
Maximum Loads (lbs)	29,500	59,000

Main Load for Auxiliary Sheave

No. of Parts of line	1	2
Maximum Loads (lbs)	29,500	59,000

- Weight of the recommended hook block.

Hook Block	160 Ust	110 Ust	70 Ust	30 Ust	15 Ust ball hook
Weight (lbs)	5,275	3,960	2,775	2,200	1,315

- Rated loads listed apply only to the machine as originally manufactured and designed by KOBELCO CRANES CO., LTD. Modifications to this machine or use of equipment other than that specified can reduce operating capacity.
- Designed and rated to comply with ANSI Code B30.5.

Operation of this equipment in excess of rated loads or disregard of instruction voids the warranty

CK1600-II Main Boom Rated Loads

with 11 counterweights (116,840 lbs) and 2 carbody weights (22,050 lbs)

Refer to notes page 19

50' Boom			60' Boom			70' Boom			80' Boom		
Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)
15.0	79.9	320,000 *	17.0	79.6	280,000 *	19.0	79.5	251,100 *	22.0	78.6	211,800 *
16.0	78.7	300,100 *	18.0	78.7	266,000 *	20.0	78.6	238,500 *	24.0	77.1	190,200 *
17.0	77.5	282,500 *	19.0	77.7	251,900 *	22.0	76.9	217,100 *	26.0	75.7	172,600 *
18.0	76.3	266,800 *	20.0	76.7	239,300 *	24.0	75.3	194,600 *	28.0	74.2	157,800 *
19.0	75.1	252,700 *	22.0	74.7	218,000 *	26.0	73.5	176,300 *	30.0	72.7	145,500 *
20.0	73.9	240,100 *	24.0	72.7	197,500 *	28.0	71.8	160,900 *	32.0	71.1	134,400 *
22.0	71.5	218,300 *	26.0	70.7	178,300 *	30.0	70.1	147,900 *	34.0	69.6	123,000 *
24.0	69.1	197,700 *	28.0	68.6	162,200 *	32.0	68.3	134,700 *	36.0	68.1	113,300 *
26.0	66.5	177,400 *	30.0	66.5	148,300 *	34.0	66.5	123,400 *	38.0	66.5	105,100 *
28.0	64.0	160,400 *	32.0	64.4	134,900 *	36.0	64.7	113,700 *	40.0	64.9	97,800 *
30.0	61.4	145,900 *	34.0	62.2	123,600 *	38.0	62.8	105,500 *	45.0	60.8	83,300 *
32.0	58.7	133,300 *	36.0	60.0	113,900 *	40.0	61.0	98,300 *	50.0	56.6	72,300 *
34.0	55.9	122,100 *	38.0	57.7	105,800 *	45.0	56.1	83,700 *	55.0	52.1	63,900 *
36.0	53.0	112,200 *	40.0	55.4	98,500 *	50.0	50.9	72,700 *	60.0	47.4	56,800 *
38.0	50.0	103,300 *	45.0	49.3	83,900 *	55.0	45.3	64,300 *	65.0	42.2	51,300 *
40.0	46.8	95,200 *	50.0	42.4	72,000 *	60.0	39.0	57,300 *	70.0	36.3	46,700 *
45.0	38.0	76,900 *	55.0	34.4	60,100 *	65.0	31.7	48,700 *	75.0	29.5	40,300 *



90' Boom			100' Boom			110' Boom			120' Boom		
Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)	Load Radius (ft)	Boom Angle (deg.)	360° Rated Load (lbs)
22.0	79.9	207,600 *	24.0	79.8	183,400 *	26.0	79.6	164,200 *	28.0	79.5	147,000 *
24.0	78.6	186,500 *	26.0	78.6	166,400 *	28.0	78.6	150,100 *	30.0	78.6	135,500 *
26.0	77.3	169,000 *	28.0	77.4	152,300 *	30.0	77.5	138,200 *	32.0	77.6	125,600 *
28.0	76.0	154,700 *	30.0	76.2	140,400 *	32.0	76.4	128,300 *	34.0	76.6	117,000 *
30.0	74.6	142,600 *	32.0	75.0	130,200 *	34.0	75.4	119,400 *	36.0	75.6	109,500 *
32.0	73.3	132,200 *	34.0	73.8	121,400 *	36.0	74.3	111,900 *	38.0	74.6	102,900 *
34.0	72.0	122,700 *	36.0	72.6	112,800 *	38.0	73.2	104,400 *	40.0	73.6	96,700 *
36.0	70.6	113,000 *	38.0	71.4	104,700 *	40.0	72.1	97,200 *	45.0	71.1	82,200 *
38.0	69.3	104,700 *	40.0	70.2	97,400 *	45.0	69.3	82,600 *	50.0	68.6	71,200 *
40.0	67.9	97,400 *	45.0	67.1	82,800 *	50.0	66.5	71,600 *	55.0	65.9	62,600 *
45.0	64.4	82,800 *	50.0	63.9	71,800 *	55.0	63.6	63,000 *	60.0	63.3	55,500 *
50.0	60.8	72,000 *	55.0	60.7	63,200 *	60.0	60.6	56,200 *	65.0	60.6	50,000 *
55.0	57.0	63,400 *	60.0	57.3	56,400 *	65.0	57.5	50,400 *	70.0	57.8	45,100 *
60.0	53.1	56,400 *	65.0	53.8	50,700 *	70.0	54.4	45,600 *	75.0	54.9	41,200 *
65.0	48.9	50,900 *	70.0	50.1	46,000 *	75.0	51.1	41,600 *	80.0	51.9	37,600 *
70.0	44.4	46,200 *	75.0	46.2	41,800 *	80.0	47.6	38,300 *	85.0	48.7	34,800 *
75.0	39.6	42,300 *	80.0	42.0	38,500 *	85.0	43.9	35,200 *	90.0	45.4	32,100 *
80.0	34.1	38,800 *	85.0	37.4	35,700 *	90.0	39.9	32,800 *	95.0	41.9	29,900 *
			90.0	32.3	32,800 *	95.0	35.6	30,400 *	100.0	38.1	27,900 *
						100.0	30.7	27,900 *	105.0	34.0	26,000 *

1-Part Slings

MECHANICAL SPLICE IWRC

2-LEG BRIDLE

RATED CAPACITY IN TONS OF 2,000 lbs.
RATED CAPACITIES SHOWN APPLY ONLY TO 6X19 AND 6X36 CLASSIFICATION WIRE ROPE

ROPE DIA. (IN)	VERTICAL			60°			45°			30°		
	IPS	EIPS	EEIPS	IPS	EIPS	EEIPS	IPS	EIPS	EEIPS	IPS	EIPS	EEIPS
1/4	1.1	1.3	1.4	0.97	1.1	1.2	0.79	0.91	1.0	0.56	0.65	0.7
5/16	1.7	2.0	2.2	1.5	1.7	1.9	1.2	1.4	1.6	0.87	1.0	1.1
3/8	2.5	2.9	3.2	2.2	2.5	2.7	1.8	2.0	2.2	1.2	1.4	1.6
7/16	3.4	3.9	4.3	2.9	3.4	3.7	2.4	2.7	3.0	1.7	1.9	2.1
1/2	4.4	5.1	5.5	3.8	4.4	4.8	3.1	3.6	3.9	2.2	2.5	2.8
9/16	5.5	6.4	7.0	4.8	5.5	6.1	3.9	4.5	5.0	2.8	3.2	3.6
5/8	6.8	7.8	8.6	5.9	6.8	7.5	4.8	5.5	6.1	3.4	3.9	4.5
3/4	9.7	11	12	8.4	9.7	11	6.9	7.9	8.7	4.9	5.6	6.3
7/8	13	15	17	11	13	14	9.3	11	12	6.6	7.6	8.3
1	17	20	22	15	17	19	12	14	15	8.5	9.8	11
1 1/8	21	24		18	21		15	17		10	12	
1 1/4	26	30		22	26		18	21		13	15	
1 3/8	31	36		27	31		22	25		15	18	
1 1/2	37	42		32	37		26	30		18	21	
1 5/8	43	49		37	42		30	35		21	24	
1 3/4	49	57		43	49		35	40		25	28	
1 7/8	56	64		49	56		40	46		28	32	
2	64	73		55	63		45	52		32	37	
2 1/8	69	80		60	69		49	56		35	40	
2 1/4	77	89		67	77		55	63		39	44	
2 3/8	86	99		75	85		61	70		43	49	
2 1/2	94	109		82	94		67	77		47	54	
2 5/8	104	119		90	103		73	84		52	60	
2 3/4	113	130		98	113		80	92		57	65	
2 7/8	123	141		106	122		87	100		61	71	
3	133	153		115	133		94	108		67	77	
3 1/8	144	165		124	143		102	117		72	82	
3 1/4	154	177		134	153		109	125		77	89	
3 3/8	165	190		143	165		117	135		83	95	
3 1/2	177	203		153	176		125	144		88	102	

RATED CAPACITIES BASKET HITCH BASED ON D/d RATIO OF 25
RATED CAPACITIES BASED ON PIN DIAMETER NO LARGER THAN NATURAL EYE WIDTH
OR LESS THAN THE NOMINAL SLING DIAMETER
RATED CAPACITIES BASED ON DESIGN FACTOR OF 5
HORIZONTAL SLING ANGLES LESS THAN 30 DEGREES SHALL NOT BE USED

BLOW & CO., INC.
815 VT ROUTE 5E
MORRISVILLE, VT 05661

-----Original Message-----

From: "Joe Gallese" <jgallese@jpcarrara.com>

Sent: Tuesday, July 14, 2015 3:01pm

To: "bcbbridgesvt@pshift.com" <bcbbridgesvt@pshift.com>

Subject: RE: Cambridge BRO 1448(39) NEXT Beam Submittal Review

Hello Anthony,

Please share with Mark, feel free to use any or all attachment pages.

The previously submitted lifting calculations specify the operating range of the lifting loops, your erection plan depicts your pick occurring in said operating range. If any additional information is required please feel free to contact me with any questions.

Sincerely,

Joe Gallese

J.P. Carrara & Sons, Inc.

2464 Case Street

Middlebury, VT 05753

802 388-6363 phone

802 388-9010 fax

802 236-5928 cell

IRISH SETTLEMENT ROAD TU. 46 BU. 28

CAMBRIDGE, VT



LIFTING LOOP DESIGN CALCULATIONS

28'D NEXT BEAMS

$$w/t_{\text{Beam}} = 83.2 \text{ K, MAX.}$$

TURNER ARE (4) LIFT LOOPS WITH (2) AT EA. END OF BEAM

$$\text{LOAD / LIFT LOCATION} = \frac{83.2}{4} = 20.8 \text{ K}$$

ASSUME 60° MIN. SLING ANGLE WITH HORIZONTAL
FOR UNSTEERING.

$$\text{DESIGN LOAD / LIFT LOCATION} = \frac{20.8 \text{ K}}{0.866} = 24.0 \text{ K}$$

FROM ATTACHED PCI LITERATURE (SECTION 5.2.8) @ EA LIFT POINT

USE (4) 0.600" ϕ 270 KSI STEEL LIFT LOOPS, MIN. EMBED 26"

$$\text{SWL (4:1 SF)} = 1.1 \times 26 \text{ K} = 28.6 \text{ K} > 24.0 \text{ K} \quad \text{O.K.} \checkmark$$

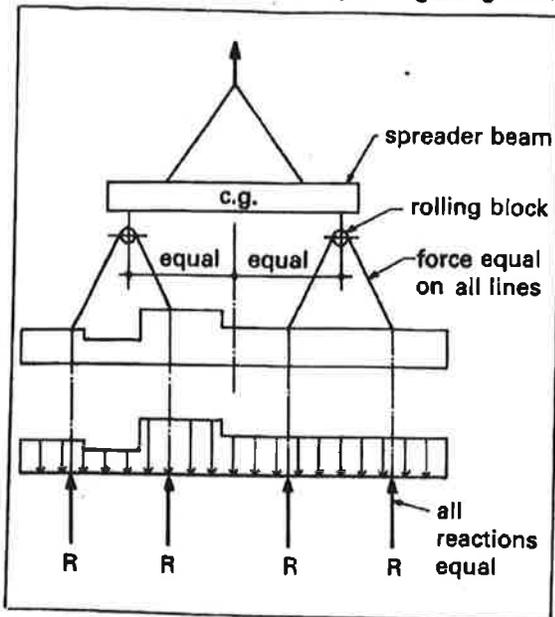
ALSO CHECK USING PCI FIG. 6.15.2A, ATTACHED

$$\begin{aligned} \phi P_c &= \phi 2.67 \lambda \sqrt{f'_{ci}} (x_1) (y_1 + 2l_e) \\ &= (0.85)(2.67)(1.0)(6000)^{0.5} \left(\frac{13.75 + 15}{2} \right) (2 \times 26") \\ &= 131.4 \text{ K} \end{aligned}$$

FOR 4:1 SF

$$\text{SWL} = \frac{131.4 \text{ K}}{4} = 32.9 \text{ K} > 24.0 \text{ K} \quad \text{O.K.} \checkmark$$

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 1/2 in. diameter, 270 ksi strands used as lifting loops

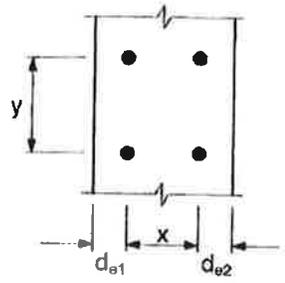
Lifting angle	Embedment length (in.)	Single loop (kips)	Double loop (kips)	Triple loop (kips)
45 degrees 	16	5	8.5	11.5
	22	8	13	17.5
	28	10	18	23
	34	11	23	29
Vertical 	16	7.5	12.5	16.5
	22	11.5	19	24.5
	28	15.5	25.5	33
	34	16	32.5	41

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 3/8 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_{o1} —Case 3



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

Case 3: Free edges on two opposite sides

$$\phi P_{o1} = \phi 2.67 \lambda \sqrt{f'_c} (x_1)(y_1 + 2\ell_e)$$

$$\phi = 0.85$$

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

For Case 3: $x_1 = x + d_{e1} + d_{e2}$ $y_1 = y$

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_{o1} (kips)														
			2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	0		2	4	6	8	9	11	13	15	17	19	21	23	25	27	29
	2		3	5	8	10	13	15	18	21	23	25	28	31	33	36	39
	4		3	7	9	13	16	19	23	25	29	32	35	39	42	45	48
	6		4	8	11	15	19	23	27	31	35	39	42	46	50	54	58
	8		5	9	13	18	23	27	31	36	41	45	49	54	59	63	67
	10		5	10	15	21	25	31	36	41	46	51	57	61	67	72	77
	12		6	11	17	23	29	35	41	46	52	58	63	69	75	81	87
4	14		7	13	19	25	32	39	45	51	58	64	71	77	83	90	96
	16		7	14	21	28	35	42	49	57	63	71	77	85	92	99	106
	0		3	5	8	10	13	15	18	21	23	25	28	31	33	36	39
	2		3	7	9	13	16	19	23	25	29	32	35	39	42	45	48
	4		4	8	11	15	19	23	27	31	35	39	42	46	50	54	58
	6		5	9	13	18	23	27	31	36	41	45	49	54	59	63	67
	8		5	10	15	21	25	31	36	41	46	51	57	61	67	72	77
6	10		6	11	17	23	29	35	41	46	52	58	63	69	75	81	87
	12		7	13	19	25	32	39	45	51	58	64	71	77	83	90	96
	14		7	14	21	28	35	42	49	57	63	71	77	85	92	99	106
	16		8	15	23	31	39	46	54	61	69	77	85	92	100	108	115
	0		4	8	11	15	19	23	27	31	35	39	42	46	50	54	58
	2		5	9	13	18	23	27	31	36	41	45	49	54	59	63	67
	4		5	10	15	21	25	31	36	41	46	51	57	61	67	72	77
8	6		6	11	17	23	29	35	41	46	52	58	63	69	75	81	87
	8		7	13	19	25	32	39	45	51	58	64	71	77	83	90	96
	10		7	14	21	28	35	42	49	57	63	71	77	85	92	99	106
	12		8	15	23	31	39	46	54	61	69	77	85	92	100	108	115
	14		8	17	25	33	42	50	59	67	75	83	92	100	109	117	125
	16		9	18	27	36	45	54	63	72	81	90	99	108	117	125	135
	0		5	10	15	21	25	31	36	41	46	51	57	61	67	72	77
8	2		6	11	17	23	29	35	41	46	52	58	63	69	75	81	87
	4		7	13	19	25	32	39	45	51	58	64	71	77	83	90	96
	6		7	14	21	28	35	42	49	57	63	71	77	85	92	99	106
	8		8	15	23	31	39	46	54	61	69	77	85	92	100	108	115
	10		9	17	25	33	42	50	59	67	75	83	92	100	109	117	125
	12		9	18	27	36	45	54	63	72	81	90	99	108	117	125	135
	14		9	19	29	39	48	58	67	77	87	96	106	115	125	135	144
16		10	21	31	41	51	61	72	82	92	103	113	123	133	143	154	

90 Degrees

