



Prepared for:

Public Works and Government Services Canada

Prepared by:



October 2007



October 18, 2007

OUR REF:BT3252

Mr. Abbas Khan, P.Eng. Project Manager PWGSC, Real Property Services - Ontario Region 4900 Yonge Steet Toronto, ON M2N 6A6

Dear Sir

Re: Burlington Canal Lift Bridge Report on Analysis of Load-Carrying Capacity / MTO Overweight Vehicle Permitting Process

Introduction

The Burlington Canal Lift Bridge was designed and constructed between 1958 to 1962 as a structure serving both road and rail traffic over the canal. The bridge has since been modified to accommodate four lanes of road traffic. The design was completed in accordance with road and rail design codes applicable at that time.

From time to time a number of oversized and overweight vehicles have been noticed crossing the bridge by PWGSC. These overweight vehicles are not currently authorized by the Ontario Ministry of Transportation (MTO) to use the crossing and the Ministry has flagged the structure to allow Highway Traffic Act (HTA) loading only as part of their permitting process. The HTA loading is also referred to as the legal load limit and is comparable to the current design truck loading. However, the Ministry does not have any means to ensure that the vehicles adhere to the route specified in the permit, and since it is possible to access the QEW from either side of the bridge, these vehicles are occasionally crossing the structure instead of using the QEW Burlington Skyway structure.

As a result of the observed exceptional vehicles using the bridge on an occasional basis, PWGSC requested Delcan to conduct an analysis of the bridge in order to determine the load-carrying capacity of the structure as well as to investigate MTO's current permitting practices with respect to overweight vehicles.

Analysis of Load-Carrying Capacity of the Bridge

A three-dimensional finite element analysis (3D FEA) model of the structure was created and analyzed. The model comprises of the main lift span, tower spans and approach spans. The geometric properties and material properties of the structural steel members and concrete deck slabs have been defined according to the original contract drawings dated in Page 2

1958, and the modification drawings dated in 1982. The steel grating was replaced in 2000 and conforms to the prevailing design code at that time. The results from the analysis have been compared with the structural section capacities calculated based on the original contract drawings and the material properties specified in the Canadian Highway Bridge Design Code (CHBDC) based on the year of construction.

Three main live load cases were considered in the analysis. The first two cases consisted of a design truck / lane load positioned in either the outside or inside lanes with the remaining lanes having a reduced loading based on the probability of consecutively loaded lanes in accordance with the CHBDC. The CHBDC design truck GVW is equivalent to the maximum legal GVW of 63,500 kg. The third case considered a single vehicle traveling down the centerline of the bridge with a GVW of 120,000kg and the same axle spacing as the design truck. The ultimate live load carrying capacity of the structure was derived from these load cases by determining the reserve capacity above the applied loading.

In order to ensure representative modeling of the bridge, the 3D FEA model was calibrated and tested using the self weight of the structure. The force effects of the truss members, obtained from the analysis, were compared with the stresses which were included on the original contract drawings, and these values have been found generally to be in agreement. The outputs from the three load cases described above have been compared with the calculated member capacities and the load carrying capacities of the various elements were derived.

It has been found that the main truss members (chords, diagonals, verticals) and floor beams of the truss and tower spans have significant reserve capacity as a result of the original design accounting for railway loading, while the concrete deck slab in the tower spans and approach spans have adequate capacities and were found to be the governing elements of the bridge with minimal reserve capacity. Hence, based on the analysis performed, it was found that the structure is adequate to resist the current design truck loading, with the stringers and deck elements of the tower and approach spans being the most sensitive to increased axle loads and spacing.

PWGSC has noted that the welds connecting the steel grating to the stringers are routinely breaking under current vehicle loads. This issue has been noted to occur with routine traffic and may or may not be an issue with overweight vehicles depending on the actual distribution of the loads. The cracking of the welds to the stringers does not affect the structural performance of the grating, and since it is occurring under current highway loading, this issue cannot be directly linked to overweight permitted vehicles and should continue to be considered as a maintenance issue rather than a load capacity issue. However, welds within the steel grating are also noted to be breaking which can lead to reduced load carrying capacity of the grating if not addressed with regular maintenance repairs. These weld failures have been noted in the annual inspection report as a result of metal fatigue from truck loads, and hence the presence of occasional overweight vehicles is not considered to be a contributing concern, provided ongoing maintenance is addressed.

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MTO Oversize / Overweight Permitting Practices

For MTO permitting purposes, vehicles exceeding the maximum legal GVW of 63,500 kg but less than 120,000 kg, are accommodated by evaluating the load effect of the actual vehicle configuration identified in the permit application by the applicant (Carrier). Based on detailed information of the axle spacing and loading, the permit vehicle is compared to the legal load limit using the modified Ontario bridge formula which compares the load effect of the actual vehicle configuration against the legal weight. The modified Ontario bridge formula was developed by MTO to assess the impact of different vehicle configurations and has been used as the basis to develop the legal load configurations provided in the current HTA. Higher GVW loads do not necessarily produce larger load effects in structures compared to the CHBDC design truck since the load is typically distributed along a longer vehicle length to keep axle and tire loads within acceptable limits.

For a vehicle that has higher weight than the maximum allowable GVW for its configuration using the modified formula, additional allowance factors are also considered to utilize the safety factors built into the bridge design. These factors take into consideration controlling the operation of the permitted vehicle, limiting traffic on the structure at the same time, adjusting the magnitude of the impact load (a function of vehicle speed), and the location of the vehicle on multi-lane structures.

Using the modified Ontario bridge formula in conjunction with certain allowance factors defined by MTO as part of the permit review process, MTO issues permits for vehicles up to a maximum GVW of 120,000 kg on their bridge structures which meet current highway traffic act loading with the appropriate traffic control and travel restrictions. Based on the above system, it should be noted that police escort is typically required for GVW in excess of 100,000 kg where strict speed and traffic control are required to be enforced.

MTO classifies GVW in excess of 120,000 kg to be "superloads" and require the Carrier to satisfactorily justify the moves, and to produce independent detailed engineering analysis and evaluation of all structures along the route. MTO also escorts these "superloads" to ensure strict compliance with the permit and route restrictions.

Conclusions and Recommendations

The Burlington Canal Lift Bridge has been found to be structurally adequate under the design truck load, lane load and maximum wheel load, as specified by the CHBDC. The main load carrying elements of the bridge can sustain larger loads than the design vehicle; however, the deck and stringers in all spans are sensitive to localized increases in vehicle loadings.

The MTO issues permits for Carriers with GVW ranging from the legal weight of 63,500 kg to a maximum weight of 120,000 kg, which is almost double the legal weight. These are justified by the MTO on a rational analysis basis and can be shown to produce a load effect on the structure well within the design limitations for these structures.

It is understood that PWGSC is concerned with the reliability of the overweight loadings which are given in applications to obtain a permit, on account of the fact that the MTO does

not have any proactive measures currently in place to ensure the permitted loadings are adhered to strictly. Accordingly, it is considered prudent that restrictions on permitted overweight vehicles crossing the Burlington Canal Lift Bridge continue to apply.

In order to better achieve the restriction of overweight vehicles and the awareness of this restriction by Carriers, we recommend that PWGSC consider one or both of the following two options:

- Request of MTO that the current restriction on MTO's database, which limits the allowable truck loadings over the Burlington Canal Lift Bridge to the legal GVW limit identified by the Highway Traffic Act, be maintained.
- Post the bridge with an appropriate sign to increase awareness and reinforce this restriction.

If PWGSC chooses to place signage on the structure, the following wording would be suggested: "MTO PERMITTED OVERWEIGHT VEHICLES NOT ALLOWED ON STRUCTURE". This conveys the message to the specific Carriers with permits without raising concern to the general public using the bridge, which may perceive that the structure may be inadequate or unsafe if a maximum load posting was used.

It should be noted that signage of the structure will not prevent overweight vehicles from crossing the Burlington Canal Lift Bridge, but is considered to be a reasonable effort to increase awareness and educate Carriers that they are not adhering to the restrictions of their MTO permit.

We trust the above report is satisfactory for your immediate needs. If you have questions concerning the report contained herein, please do not hesitate to call.

Yours very truly,

Brent Archibald, P. Eng. Technical Director

Karen Liu P.Eng. Structural Engineer

c: Joanne Crabb

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APPENDICES

- Appendix A General Arrangement
- Appendix B Finite Element Model
- Appendix C FEA Output
- Appendix D Capacity Calculation Notes

APPENDIX A

GENERAL ARRANGEMENT



Delcan

APPENDIX B

FINITE ELEMENT MODEL



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Title: BCLB Analysis of Load-Carrying Capacity

Model Units: N,m,kg,s,C **Report Units:** N,m,kg,s,C

Model Title: Burlington Bridge Model File: BCLB



Figure B01: 3D FEA Model Overview of Lift Span, Deck Structure for Tower and Approach Spans





APPENDIX C

FEA OUTPUT

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Figure C01: Lift Span Highway Truss Members Axial Forces-Combination 4-Maximum Tension



Figure C02: Lift Span Highway Truss Members Axial Forces-Combination 4-Maximum Compression







Figure C04: Lift Span Floor Beams - Maximum Shear Force



Figure C05: Lift Span Stringers - Maximum Moment





Figure C08: Tower Span Floor Beams - Maximum Shear Force



Figure C09: Tower Span Stringers - Maximum Moment



Figure C10: Tower Span Stringers - Maximum Shear Force



Figure C11: Approach Span Stringers - Maximum Moment



Figure C12: Approach Span Stringers - Maximum Shear Force

APPENDIX D

CAPACITY CALCULATION NOTES

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 Burlington Canal Lift Bridge Analysis of Load-Carrying Capacity
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Calc. Agross (iff.)	04.4/U	133.22	162.47	14.2/	0.0000	179.04	194.79	206.04	89.47	81.97	61.35	67.47	49.72	139.35	79.31	66.32	79.31	66.32	79.31	66.32
A conduct (in ²)		6000.0	0	0.4/3	7027	0011.0	/271.0	0.1329	1/cn.0	0.0529	0.0396	0.0435	0.0321	0.0899	0.0512	0.0428	0.0512	0.0428	0.0512	0.0428
Anet on dwg. (in)	54.5	112.4	137.2		14%.0	0.871	194.8	206.0	74.1	81.5	48.8	66.9 52.3	48.7 39.8	104.24	60.6	66.3	60.6	66.3	60.6	66.3
A on dwg. (m ²)	0.0352	0.0725	0.0885	0.0479	0.0961	0.1155	0.1257	0.1329	0.0478	0.0526	0.0315 (0.0432	0.0314	0.0673	0.0391	0.0428	0.0391	0.0428	0.0391	0.0428
S _{y-y} on dwg. (in [°]) S _{x-} on dwg. (in ³)	491	206	815		1550	1680	1726	1886 1761	502.0	589.0	329.0	445.0 342	269.0	744.0	512.0	555	512	555	512	555
l _{y-y} (in ⁴)	7671.875	11031.25	12734.38	:	24218.75	26250	26968.75	10529.63	7843.75 9	203.125 4	482.625 60	03.125 3	396.125	9114	6272	6798.75	6272	6798.75	6272	6798.75
l _{x-x} (in ⁴)								28506.19												
l _{y-y} (m [*]) l _{x-x} (m ⁴)	0.003193	0.004592	0.0053	1	0.010081	0.010926	0.011225	0.012707 C	0.003265 C	003831 0	0.001866 0.	002524 0	0.001414	0.003794	0.002611	0.00283	0.002611	0.00283	0.002611	0.00283
Tension/Compression	-	⊢	F		υ	v	с С	U.	Ŧ	0	⊢	υ	<u> </u>	F	⊨	0	F	0	- -	υ
Length (m)	18.796	18.796	18.796	9.42	9.436	9.402	9.402	17.297	17.297	18.732	18.732 1	9.219	19.219	13.259	14.521	15.363	16.204	16.484	16.764	16.764
F _y (MPa)	290	290	290	230	230	290	290	290	290	290	290	230	230	290	230	230	230	230	230	230
F _u (MPa)	434	434	434	420	420	434	434	434	434	434	434	420	420	434	420	420	420	420	420	420
T,/C, (kN)	9687	19978	24386		19255	28660	31068	27682	13171	9534	8674	6112	6865	18528	8543	7245	8543	6991	8543	6926
Material	4	4	Ą	Carbon	Carbon	۲ ۲	F	4	ΓA	LA L	LA C	arbon	Carbon	LA L	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon
	L0 L2		La La	n° r'	n'n'	<u>u, u, </u>	U _s U _s	Lo U1	U1L2	L ₂ U ₃	U3 L4	L4 U5	U ₆ L ₆	U ₀ L ₀	1 ¹ 1	U2 L2	U3 L3	U4 L4	U ₅ L ₅	U ₆ L ₆
	ã	ottom Chora	s		Top Ch	ords	-			Diagon	als						Verticals			

 SUBJECT:
 Burlington Canal Lift Bridge Analysis of Load-Carrying Capacity
 JOB NO.
 BT3252BTJ00

 Lift Span Railway Member Properties - with Perforation
 PAGE
 of

 MADE BY:
 KL
 DATE:
 Jun. 4, 07
 CHECKED BY:
 DATE:

DELCAN

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DELCAN	SUBJECT:	Burlington Can	al Lift Bridge A	nalysis of Load-	Carrying Capacity	JOB NO.	BT3252BTJ00	
		Properties of F	loor Beams, St	ringers - Lift, To	wer & Approach Spans	PAGE	1	1
	MADE BY:	꾹	DATE:	May. 17, 07	CHECKED BY:		DATE:	

Section Properties of Floor Beams, Stringers on Lift, Tower and Approach Spans

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		Lift Span			Tower Span		Approach Span
	Floor {	Beams	Ctringere	Floor	Beam	Ctringero	Ctrip cores
	Intermediate	End	e ingen	Front	Back	ouniders	ounigers
Web	1-78x9/16	1-71×1/2	24WF84	1-71×1/2	1-71×5/8	27WF102	33WF130
Angles	4-8x8x7/8	4-8x8x3/4		4-8x8x1/2	4-8x8x1/2		
Cover Plates	2-20x3/4	2-20×1/2		2-20×1/2	2-20×1/2		
A (m ²)	0.0817	0.0654	0.01590	0.055766	0.061492	0.01940	0.0247
l _x (m ⁴)	0.05899	0.0459	0.000985	0.031493	0.033045	0.00151	0.00278
l _y (m ⁴)	0.000697	0.00052	0.000039	0.000435	0.000439	0.000058	0.000090

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LCAN	SUBJECT:	Burlington Ca	ınal Lift Bridge	Analysis of Load	-Carrying Capacity	JOB NO.	BT3252	BTJ00
		Lift Span Tn	uss Member	- Force due to D	ead Load and Live Loa	PAGE	-	o
	MADE BY:	КL	DATE:	Jun. 12, 07	CHECKED BY:		DATE	

Axial Force F_x on Highway Truss Members under Self Weight and Factored Live Load

	_	_				_	_	-							_								
	U ₆ L ₆	υ	-227	-250	52.7	-24.8	49	-24.8	22.4	-11.1	60.4	-22	66.3	-22.2	20.5	-7.14	-275	-281	-6926	-6652		-6677	
	U ₅ L ₅	T	284	312	1110	-11.4	1070	-9.57	524	-1.19	1520	-17.4	1480	-21.1	567	-1.73	1832	1385	8543	6710		8230	
	U4 L4	υ	-208	-229	49.7	-27.8	46.5	-27.5	22.1	-13	61.6	-26.7	63.1	-24.7	21.4	-8.16	-257		-6991	-6734		-6762	
Verticals	U ₃ L ₃	L L	317	348	1130	-2.31	1090	-1.69	531	0	1580	-5.23	1470	-6.2	561	-0.0876	1928		8543	6614		8194	
	U ₂ L ₂	0	-194	-213	46.6	-8.43	45.4	-7.69	23.7	-2.94	46.9	-18.8	42.5	-16.7	17.4	-5.79	-232		-7245	-7013		-7031	
	۲ [,] L,	F	266	292	1110	-4.13	1060	4.13	521	0	1630	-5.34	1480	-6.52	551	0	1922		8543	6620		8250	
	U ₀ L ₀	т	-197	-217	9.34	-10.7	9.34	-9.37	0	-2.67	5.75	-67.4	5.74	-59.4	0	-21.8	-207	5046	18528	18735		18744	
	Us Le	Т	366	403	983	-815	949	-780	466	-380	1350	-978	1200	-853	456	-304	1753	1215	5751	3999	3.28	5349	3.96
	L4 U5	ပ	-882	-970.2	721	-1100	688	-1060	335	-523	870	-1750	756	-1570	267	-622	-2720	-2233	-5348	-2628	1.97	-4378	2.50
onals	U₃ L₄	٦	1600	1760	1270	-455	1230	-431	604	-209	2210	-562	2010	-490	820	-174	3970	3672	5892	1922	1.48	4132	1.87
Diag	L ₂ U ₃	ပ	-2130	-2343	379	-1430	359	-1380	174	-679	464	-2640	400	-2410	139	-998	4983		-6850	-1867	1.37	4507	1.71
	U1 L2	F	2940	3234	1660	-102	1600	-96	785	-45.2	3310	-119	3020	-101	1260	-33.2	6544	6287	9769	3225	1.49	6535	1.97
	L ₀ U1	υ	-4140	-4554	0	-2090	0	-2010	0	-984	0	-4390	0	-4000	0	-1670	-8944	-8836	-23170	-14226	2.59	-18616	4.24
	u _s u	υ	-6170	-6787	0	-3080	0	-3000	0	-1480	0	-6303	0	-5830	0	-2490	-13090	-13285	-20205	-7115	1.54	-13418	2.13
Chords	U3 U5	с	-5670	-6237	0	-2860	0	-2780	0	-1370	0	-5830	0	-5370	0	-2290	-12067		-19135	-7068	1.59	-12898	2.21
Top C	u, U ₃	c	-3850	-4235	0	-1940	0	-1880	0	-921	0	-4080	0	-3740	0	-1570	-8315	-8127	-12976	-4661	1.56	-8741	2.14
	u₀ U₁																						
ds	L₄ L ₆	L	5916	6508	2930	0	2870	0	1420	0	5860	0	5470	0	2370	0	12368	12927	17952	5584	1.45	11444	1.95
tottom Chor	L ₂ L ₄	L L	4741	5215	2400	0	2340	0	1150	0	4850	0	4490	0	1920	0	10065	10330	14350	4285	1.43	9135	1.88
Ш	L0 L2	F	2151	2366	1100	0	1060	0	517	0	2250	0	2070	0	874	0	4616	4747	7824	3208	1.69	5458	2.43
		Tension/Compression	Unfactored F _x (kN) (LUSAS)	Factored F _x (kN) (LUSAS)	LUSAS Comb1-Max	LUSAS Comb1-Min	LUSAS Comb2-Max	LUSAS Comb2-Min	2 LUSAS Comb3-Max	LLSAS Comb3-Min	LUSAS Comb4-Max	LUSAS Comb4-Min	LUSAS Comb5-Max	LUSAS Comb5-Min	LUSAS Comb6-Max	LUSAS Comb6-Min	Factored F _{x, ToT} (kN) (LUSAS)	Factored F _{x,ToT} (kN) (S-Frame)	Member Capacity (kN)	Remaining Capacity (kN)	Member Capacity Reserve Ratio	Live Load Capacity (kN)	Live Load Capacity Reserve Ratio
			or Force Dead ad	edmeM ot eub oʻ'					80	r Ford sto Load	ədme əub I əviJ	•M					ce Iber Ial	Toi Mên For			lember (ficende	C N	

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DATE		KL DATE: Jun. 19, 07 CHECKED BY:	I MAUE BY:	
1 of 1	PAGE	er Member Forces due to Dead Load and Live Load	Oth	
BT3252BTJ00	JOB NO.	ington Canal Lift Bridge Analysis of Load-Carrying Capacity	SUBJECT: Burl	DELCAN

<u>Moment and Sheer on Floor Beams. Stringers and Deck Slabs under Self Welght and Factored Live Load</u>

				L'H	ipan						Tower	Span					Amorad	h Snon	
		Intermedia	ate Beams	End B	eams	String	ters	Front B	leams	Back B	eams	Strinc	lers	Sla	4	Strin	uers ders	Sla	
		Ŵ	F2	Ň	'n	M.	<u> </u>	×	4	×	ľ	×	u				, L		
oj p			•		7	Å.	2.	λ	2	ĥ	2	۲ivi	12		Σ	δ	۲ <u>،</u>		¥
anber e due b Loa	Unfactored (LUSAS)	686-	-220	-567	-148	-37	-23	-921		-1094		-102.0	4	UF. 🚥	-1.3	-199	-84	UF. cone	-1.3
ead Bead	Factored (LUSAS)	-1088	-242	-624	-163	4	-25	-1013	-212	-1203	489	-112.2	44	сопс	-1.56	-219	-92	F. conc.	-1.56
	LUSAS Comb1-Max	713	1192	632	882	693	Posta		605		1174			UF. asphalt	-0.704			UF. asphatt	-0.704
	LUSAS Comb1-Min	-5294	-1790	-3744	-1332	-667	-668	-4073	-1220	-4060	-1763	-845	-295	F. asphalt	-1.056	-1359	-492	F. asphalt	-1.056
_	LUSAS Comb2-Max	650	1196	594	761				609		1180								
	LUSAS Comb2-Min	-5344	-1760	-3780	-1164	-532	-487	-4084	-1065	-4080	-1542.3	-686	-258	F. wheel load	-42.37	-1080	-379	F. wheel load	-42.37
eo.	LUSAS Comb3-Max	306	560	292	381				348		556								
e to Load	LUSAS Comb3-Min	-3580	-558	-2510	-416	-432	-438	-2593	-383	-2590	-556	-464	-130			-765	-299		
edme oub eviJ	LUSAS Comb4-Max	764	1226	751	715				575		1252				<u></u>				
M	LUSAS Comb4-Min	-5359	-1742	-4080	-1242	-588	-594	-3826	-1110	-3820	-1764	-763	-257			-1245	-466		
	LUSAS Comb5-Max	200	1239	269	849				583		1270				I <u>L.,</u>				
	LUSAS Comb5-Min	-5507	-1550	-3640	-1100	-475	-436	-3873	-984	-3870	-1574	-628	-233			-1006	-363		
	LUSAS Comb6-Max	327	593	315	405		-	4	340		611.7				0 <u></u>				
- 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10	LUSAS Comb6-Min	-3794	-592	-2460	-414	410	-448	-2510	-371	-2510	-612	-444	-131			-755.7	-319		
) BL	Factored (LUSAS)	-6595	-2032	-4704	-1495	-707	-693	-5097	-1432	-5283	-2253	-958	-339		-45.0	-1578	-584		-45.0
letoT dm9l erce	Factored (Simplifed Method)		<u></u>			485							•						
M	Factored (kN) (S-Frame)	5311	1333			538													
	Member Capacity	12497	3542	9540	2790	802	859	6477	2237	6875	2797	1093	1067	Old Slab	46.3	1665	1557	Old Slab	46.3
														New Slab	47.5			New Slab	47.5
acity nber	Sufficiency (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes		Yes
neM GeO	Live Load Capacity	11408	3300	8916	2627	761	834	5464	2025	5671	2308	980	1022		43.7	1446	1465	—	43.7
	Live Load Capacity Reserve Ratio *	2.07	1.84	2.19	1.97	1.14	1.25	1.34	1.66	1.39	1.31	1.16	3.47		1.03	1.06	2.98		1.03
	Live Load Capacity Reserve Ratio **					1.57													

Note:

Live Load Capacity/Max M_y from LUSAS analysis output
 Live Load Capacity/M_y calculated using the simplified method specified in CHBDC

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DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Load-	Carrying Capacity	JOB NO.	BT32	52BTJ00	
		Member Ca	pacity - Lift	Span - Bottom C	hord L ₀ -L ₂	PAGE	1	of	2
	MADE BY:	KL	DATE:	May. 22, 07	CHECKED BY:		DA	TE:	

LIFT SPAN

Bottom Chord L ₀ -L	2	Tension member
Built-up s Angle (4) 8x6x1/2 203x152x	ection Web (2) 30x7/16 13	Top plate (1) Bot plate (1) (23-8)x3/8 (23-8)x3/8



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Design Criteria

Member Length =	9.4206	m	dwg. 3/62						
Total width =	20 508	in mm	tal Depth =	31.25 793.75	in mm	(2-6 1/2"+2*3/	8")		
A =	Angle 4350	mm ²	w =	Web 7/16	in	t =	Top plate 3/8	in	Bot plate 3/8
y = x =	62.8 37.3	mm mm	h =	11.1125 30	mm in	b =	9.525 15	mm in	9.525 15
b == d = t =	203 152 12.7			762	mm		381	mm	381
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel	Structures", p54
F _{u, carbon} =	420	MPa		A36 Carbon from Zuzana	steel, 58-80 ks 's notes	si	Edwin H. Ga	ylord	
Ε = φ =	200000 0.95	MPa							
S _{net} =	501 323	in ² 10 ³ mm ³					dwg. 3/62		

Calculate Area

A _{angle} =4A=	17400	mm²	∖ _{web} =2*hw=	16935.45 mm ²	A _{cp} =2*ht=	7258.05	mm²
A _{gross} =	41594	mm²	0.0416	m ²			
A _{net} =	55.5	in ²			(dwg 3/62	
A _{net} =	35806	mm ²	0.03581	m ²			

DELCAN	SUBJECT: B	urlington Canal	Lift Bridge /	JOB NO. BT3252BTJ00				
	∧	lember Capa	city - Lift Sp	oan - Bottom	Chord L0-L2	PAGE	2 of	2
	MADE BY:	KL	DATE:	May. 22, 07	CHECKED BY:		DATE:	
	······				• • • • • • • • • • • • • • • • • • • •			
Class Check								
		I	o' = b/2 =	381	mm			
		h'	= h-2d =	458	mm			
Flange (treated as rec	tangular hollo	w section)						
	g		b/t =	40.0				
		670/	sqrt(F _v) =	44.2		Tab 10.9.2.1,	p451	
			Fla	nge is Clas	ss 3			
Flange (treated as per	forated cover	plates)		•				
		840/:	sqrt(F _y) =	55.4				
			Fla	nge is Clas	ss 3			
Web (in axial compres	sion)							
Web (in axial comples	3011)		h/w =	412				
		670/	sart(F.) =	44.2				
			W	eb is Class	s 3	Fig 2-7, Hand	ibook p2-21	
						-	•	
		B	oth Flang	e and web	are Class 3			
Check Tensile Resista	nce							
		$T_{r,1} = 0$	∳ _s A _{net} F _y =	7823.7	kN	Cl 10.8.2 (a),	p 447	
		$T_{r.2} = 0.85$	∮ _s A _{ne} F _u =	12143.7	kN	Cl 10.8.2 (b),	p 448	
		T _r = min(T	$T_{r,1}, T_{r,2}) =$	7823.7	kN			

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DELCAN	SUBJECT:	Burlington Ca	JOB NO.	BT32	52BTJ00				
		Member Ca	PAGE	1	of	1			
	MADE BY:	KL	DATE:	May. 23, 07	CHECKED BY:		DA	TE:	

LIFT SPAN

Bottom Chord L₂-L₄ Tension member

 Built-up section

 Angle (4)
 Web (2)
 Web (2)
 Top plate (1)
 Bot plate (1)

 8x6x1/2
 30x11/16
 30x7/16
 14x1/2
 (21-8)x3/8
 (21-8)x3/8

 203x152x13
 3
 3
 3
 3
 3



Design Criteria

Member Length = 9.4206 m dwg. 3/62 Total width = 20 tal Depth = in 31.25 in (2-6 1/2"+2*3/8") 508 793.75 mm mm Top plate Bot plate Angle Web A = 4350 mm² 11/16 7/16 1/2 3/8 3/8 t = w = in y = 62.8 17.4625 11.1125 12.7 9.525 9.525 mm mm x = 37.3 mm h = 30 30 b = 13 13 14 in b = 203 762 762 355.6 330.2 330.2 mm d = 152 t = 12.7 F_{y, carbon} = MPa 230 A36 Carbon steel, 36 ksi Table 2-2, "Design of Steel Structures", p54 F_{u, carbon} = 420 MPa A36 Carbon steel, 58-80 ksi Edwin H. Gaylord from Zuzana's notes E = 200000 MPa φ= 0.95 S_{net} = 535 in² dwg. 3/62 345 10³ mm³

Calculate Area

A _{angle} =4A=	17400	mm²	v _{web} =2*hw= 52580.54 mm²	A _{cp} =2*ht≕	6290.31	mm²
A _{gross} =	76271	mm ²	0.0763 m ²			
A _{net} =	101.8	in ²			dwg 3/62	
A _{net} =	65677	mm ²	0.06568 m ²			

Check Tensile Resistance

$T_{r.1} = \phi_s A_{net} F_y =$	14350.5	kN	Cl 10.8.2 (a), p 447
$T_{r.2} = 0.85 \phi_s A_{ne} F_u =$	22274.5	kN	Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	14350.5	kN	

DELCAN SUBJECT: Burlington Canal Lift Bridge Analysis of Load-Carrying Capacit Member Capacity - Lift Span - Bottom Chord L ₄ -L ₆ MADE BY: KL DATE: May. 23, 07 CHECKED BY	y JOB NO. BT3252BTJ00 PAGE 1 of 1 /: DATE:
Member Capacity - Lift Span - Bottom Chord L ₄ -L ₆ MADE BY: KL DATE: May. 23, 07 CHECKED BY	PAGE 1 of 1 C DATE:
MADE BY: KL DATE: May. 23, 07 CHECKED BY	/: DATE:
LIFT SPAN	
Bottom Chord L ₄ -L ₆ Tension member	LA
Built-up section	
Angle (4) Web (2) Web (2) Web (2) Top plate (1) Bot plate (1) 8x6x1/2 30x11/16 30x7/16 14x1/2 (20-8)x3/8 (20-8)x3/8 203x152x13	
Design Criteria	
Member Length = 9.4206 m dwg. 3/62	
Total width = 20 in tal Depth = 31.25 in (2-6 508 mm 793.75 mm	1/2"+2*3/8")
AngleWebA = 4350 mm^2 w = $11/16 7/16 1/2$ y = 62.8mm $17.4625 11.1125 12.7$ x = 37.3mm h = $30 30 14$ b = $203 762 762 355.6$ d = $152 12.7$ t = 12.7	Top plateBot plate $t = 3/8$ $3/8$ in 9.525 9.525 mm $b = 12$ 12 in 304.8 304.8 mm
$E_{v \text{ order}} = 290$ MPa $low 4llow$	Table 2.2 "Design of Steel Structures" = 54
$F_{u, carbon} = 434$ MPa from Zuzana's notes	Edwin H. Gaylord
E = 200000 MPa φ = 0.95	
$S_{net} = 649 ext{ in}^2$ 419 $10^3 ext{ mm}^3$	dwg. 3/62
Calculate Area	
$A_{angle} = 4A = 17400 \text{ mm}^2$ $V_{web} = 2^* \text{hw} = 52580.54 \text{ mm}^2$ A_{cp}	=2*ht= 5806.44 mm ²
$A_{gross} = 75787 \text{ mm}^2 0.0758 \text{ m}^2$	
$A_{net} = 101.0$ in ²	dwg 3/62
A _{net} = 65161 mm ² 0.06516 m ²	
Check Tensile Resistance	

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$T_{r.1} = \phi_s A_{net} F_y =$	17951.9	kN	Cl 10.8.2 (a), p 447
$T_{r.2} = 0.85\phi_s A_{ne} F_u =$	22836.1	kN	 Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	17951.9	kN	

DELCAN	SUBJECT: B	urlington Ca	JOB NO. BT3252BTJ00						
	N	Member Capacity - Lift Span - Top Chord U_1 - U_3						of	1
	MADE BY:	KL	DATE:	May. 23, 07	CHECKED BY:		DA	TE:	

<u>LIFT SPAN</u>

Top Chord U_1 - U_3

Compression Member

 Built-up section

 Angle (2)
 Angle (2)
 Web (2)
 Top plate (1)
 Bot plate (1)

 4x4x7/16
 8x6x9/16
 30x11/16
 38x11/16
 (42-14)x5/8

 102x102x11
 203x152x14



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<u>Design Criteria</u>	
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<u>.</u>							(2-6 1/2"+2*3	3/8")	
Member Length =	9436	mm	otal width =	20	in	tal Depth =	31.25	in	dwg. 3/62
				508	mm		793.75	mm	
A _{gross} =	100.5	in²	S =	1025	in ³	1 =	6666.2	10 ⁶ mm⁴	dwg 3/62
A _{gross} =	64838.6	mm²		16796.74	*10 ³ mm ³				
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel Str	uctures", p54
F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 k	si	Edwin H. Ga	iylord	
				from Zuzana	's notes				
Ε = φ =	200000 0.9	MPa							

Check Compressive Resistance (CI 10.9.3)

$C_{r.1} = \phi_s A_g F_y$	(1+λ ²ⁿ) ^{-1/t}	า	Cl 10.9.3.1, p452
$\lambda = (KL/r)[F_{y}]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n = `	1.34		fabricated shapes
K =	1.0		
r = (I/A) ^{0.5} =	320.6	mm	
λ =	0.32		
C _{r,1} =	12976	kN	

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Load-	Carrying Capacity	JOB NO. BT3252BTJ00			
	Member Capacity - Lift Span - Top Chord U ₃ -U ₅						1	of	1
	MADE BY:	KL	DATE:	May. 23, 07	CHECKED BY:	DATE:			

LIFT SPAN

Top Chord U₃-U₅ Compres

Compression Member

 Built-up section

 Angle (2)
 Angle (2)
 Web (2)
 Top plate (1)
 Bot plate (1)

 4x4x7/16
 8x6x3/4
 30x1
 38x1
 (42-14)x7/8

 102x102x11
 203x152x19
 30x1
 38x1
 (42-14)x7/8

Design Criteria

							(2-6 1/2"+2*3	3/8")	
Member Length =	9402	mm	otal width =	20	in	tal Depth =	31.25	in	dwg. 3/62
				508	mm	-	793.75	mm	
A _{gross} =	148.0	in ²	S =	1547	in ³	I =	10061.1	10 ⁶ mm⁴	dwg 3/62
A _{gross} =	95483.7	mm ²		25350.79	*10 ³ mm ³				
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel Sti	ructures", p54
F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 ks	si	Edwin H. Ga	ylord	
				from Zuzana'	s notes				
E =	200000	MPa							
φ =	0.9								

Check Compressive Resistance (CI 10.9.3)

$C_{r.1} = \phi_s A_g F_y$	_/ (1+λ ²ⁿ) ^{-1/i}	Cl 10.9.3.1, p452	
$\lambda = (KL/r)[F_y]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	324.6	mm	
λ=	0.31		
C _{r.1} =	19135	kN	



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DELCA	N	SUBJECT:	Burlington C	anal Lift Bridge	Analysis of Loa	ad-Carrying C	apacity	JOB NO.	BT3252BT	J00
			Member C	apacity - Lift S	pan - Top Ch	nord U ₅ -U ₆		PAGE	1 c	of 1
		MADE BY:	KL	DATE:	May. 23, 07	CHECK	ED BY:		DATE:	
<u>LIFT SPAN</u>	<u>I</u>									
Top Chord	1 U ₅ - U ₆		Compress	sion Member	•				c	;]]
	Built-up s Angle (2) 4x4x7/16 102x102x11	ection Angle (2) 8x6x3/4 203x152x19	Web (2) 30x1/2	Top plate (1) 38x1	Bot plate (1) (42-14)x7/8	8				
Design Crit	eria									
								(2-6 1/2"+2*3	3/8")	
Membe	er Length =	9398	mm	otal width =	20 508	in mm	tal Depth =	31.25 793.75	in mm	dwg. 3/62
	A _{gross} =	156.5	in ²	S =	1581	in ³	I =	10282.2	10 ⁶ mm⁴	dwg 3/62
	A _{gross} =	100967.5	mm ²		25907.95	*10 ³ mm ³				
	F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel St	ructures", p54
	F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 ks	si	Edwin H. Ga	ylord	
	E = 	200000 0.9	MPa		from Zuzana'	's notes				

Check Compressive Resistance (CI 10.9.3)

$C_{r.1} = \phi_s A_g F_y$,(1+λ ²ⁿ) ^{-1/r}	ו	CI 10.9.3.1, p452
$\lambda = (KL/r)[F_y]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	319.1	mm	
λ =	0.32		
C _{r.1} =	20205	kN	

DELCAN		SUBJECT:	Burlington C	anal Lift Bridge	Analysis of Lo	ad-Carrying Ca	apacity	JOB NO.	BT3252BT	J00
			Member Ca	apacity - Lift S	pan - Diagon	al L₀-U₁		PAGE	1 o	f 1
		MADE BY:	KL	DATE:	May. 24, 07	CHECK	ED BY:		DATE:	
									•	
LIFT SPAN							1			_
										-
Dia			•							
Diagonal Memb	per L _o	-01	Compress	sion Member	•				С	
Built	-up s	ection								
Angle	e (2)	Angle (2)	Web (4)	Web (2)	Top plate (1)	Bot plate (1)				- .
4x4x	7/16	8x6x3/4	30x3/4	18x3/4	38x1	(42-14)x7/	8		······································	J
102210	02811	2038152819								
<u>Design Criteria</u>										
Memberlen	nath =	17297	mm	stal width =	20	in	tal Denth -	32 375	in	dwa 2/62
thember Lon	gai	11201			508	mm	a Depti -	822.325	mm	uwy. 5/02
_						_				
A	gross =	206.0	in ²	S =	1886	in ³	=	12707.4	10 ⁶ mm⁴	dwg 3/62
A,	gross ⁼⁼	132903.0	mm ²		30906	*10 ³ mm ³				
F _{v. ca}	arbon =	230	MPa		A36 Carbon s	steel, 36 ksi		Table 2-2, "De	sign of Steel Str	uctures", p54
F _{u. ca}	arbon =	420	MPa		A36 Carbon s	steel, 58-80 ks	i	Edwin H. Ga	vlord	
-,					from Zuzana's	s notes			-	
	E =	200000	MPa							
	φ=	0.9								

Check Compressive Resistance (CI 10.9.3)

$C_{r,1} = \phi_s A_g F$	_y (1+λ ²ⁿ) ^{-1/i}	ו	Cl 10.9.3.1, p452
$\lambda = (KL/r)[F_{\tau}]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	309.2	mm	
λ =	0.60		
C _{r.1} =	23170	kN	

DELCAN	SUBJECT:	Burlington C	anal Lift Bridge	Analysis of Loa	ad-Carrying C	apacity	JOB NO.	BT3252B	TJOO
		Member C	apacity - Lift S	Span - Diagon	al U₁-L₂		PAGE	1	of 1
	MADE BY:	KL.	DATE:	Jun. 6, 07	CHECK	ED BY:	· · · · · · · · · · · · · · · · · · ·	DATE:	
LIFT SPAN									
Diagonal Member U 1	-L 2	Tension N	<i>lember</i>					c	
Built-up se	ection								
Angle (4)		Web (2)		Bot plate (1)				In	nll
4x4x3/6 102x102x9.5		3021		(22-8)X3/8					
Design Criteria									
Member Length =	17297	mm	dwg. 3/62						
Total width =	20	in	tal Depth =	- 31.25	in				
	508	mm		793.75	mm				
F. =	230	MDo		A26 Corton o	taal 26 kai		Table 9.9 PDa	ains of Staal S	Stavatura of pE4
F . =	420	MPa		A30 Carbon s	teel, 30 KSI		Table 2-2, Del	sign or Steel 3	structures", po4
u, carbon	420	IVIFa		from Zuzana's	aeer, 56-60 ks s notes	ii	Euwin H. Gaj	yiora	
E =	200000	MPa							
φ =	0.95								
A _{cross} =	82.0	in ²		A =	69.3	in ²	dwa 3/62		
A _{omen} =	52884	mm ²		Anet =	44710	mm ²	ung 0.02		
- gross	02004			• net	1110	11111			

Check Tensile Resistance

$T_{r.1} = \phi_s A_{net} F_y =$	9769.0	kN	Cl 10.8.2 (a), p 447
$T_{r,2} = 0.85\phi_s A_{ne} F_u =$	15163.3	kN	Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	9769.0	kN	

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DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	JOB NO. BT3252BTJ00					
		Member Ca	PAGE	1	of	1			
	MADE BY:	KL	DATE:	Jun. 6, 07	CHECKED BY:		DATE:		

LIFT SPAN

Design Criteria

Diagonal Member L₂-U₃

Compression Member

Web (2)

30x3/4

Built-up section Angle (4) 4x4x3/8 102x102x9.5

Plate (2) (22-8)x3/8



dwg. 3/62

dwg 3/62

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(2-6 1/2"+2*3/8") Member Length = 18732 mm otal width = 20 in tal Depth = 31.25 in 508 mm 793.75 mm 66.6 in² S = in³ Agross = 517 | = 3362.4 10⁶ mm⁴ $A_{gross} = 42967.7 \text{ mm}^2$ 8472.112 *10³ mm³ F_{y, carbon} = 230 MPa A36 Carbon steel, 36 ksi Table 2-2, "Design of Steel Structures", p54 F_{u, carbon} = 420 MPa A36 Carbon steel, 58-80 ksi Edwin H. Gaylord from Zuzana's notes E = 200000 MPa

Check Compressive Resistance (CI 10.9.3)

φ=

$C_{r,1} = \phi_s A_g F_s$	_y (1+λ ²ⁿ) ^{-1/}	n	Cl 10.9.3.1, p452
$\lambda = (KL/r)[F_{y}]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	279.7	mm	
λ =	0.72		
C _{r.1} =	6850	kN	

DELCAN	SUBJECT:	Burlington (Canal Lift Bridge	Analysis of Los	ad-Carrying	Canacity		
		Member C	Capacity - Lift 9	Snan - Diagon	al L.	oupuoliy	DACE	1
	MADE BY:	KL	DATE:	Jun. 6, 07		KED BY:	FAGE	DATE:
							-, <u>.</u>	
LIFT SPAN								
Diagonal Member U ₃	-L₄	Tension I	Member					с
Built-up se	ection							
Angle (4)		Web (2)		Plate (2)	<u> </u>			
102x102x9.5		20,9/10		(ZZ.5-8)X3/	8			
Design Criteria								
Member Length =	18732	mm	dwg. 3/62					
Total width =	20	in	tal Depth =	27.25	in			
	508	mm		692.15	mm			
F _{y, carbon} =	230	MPa		A36 Carbon st	teel, 36 ksi		Table 2-2, "Des	ign of Steel Structures", p54
F _{u, carbon} =	420	MPa		A36 Carbon st	teel, 58-80 k	si	Edwin H. Gay	lord
E =	200000	MPa		from Zuzana's	notes			
φ =	0.95							
A _{gross} =	51.6	in ²		A _{net} =	41.8	in ²	dwg 3/62	
		2				•	-	

Check Tensile Resistance

$T_{r.1} = \phi_s A_{net} F_y =$	5892.4	kN	Cl 10.8.2 (a), p 447
$T_{r,2} = 0.85\phi_s A_{ne} F_u =$	9146.1	kN	Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	5892.4	kN	

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DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	JOB NO.	BT32	52BTJ00			
		Member Capacity - Lift Span - Diagonal L ₄ -U ₅						of	1
	MADE BY:	KL	DATE:	Jun. 6, 07	CHECKED BY:	DATE:			

LIFT SPAN

Diagonal Member L₄-U₅ Compression Member

Web (2) 26x11/16

Built-up section Angle (4) 4x4x3/8 102x102x9.5

Plate (2) **(22-8)x**3/8



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Design Criteria

Member Length =	19219	mm	otal width =	20 508	in mm	tal Depth =	(2-6 1/2"+2*3 27.25 692.15	3/8") in mm	dwg. 3/62
A _{gross} = A _{gross} =	57.1 36838.6	in² mm²	S =	405 6636.761	in ³ *10 ³ mm ³	1 =	2296.8	10 ⁶ mm ⁴	dwg 3/62
F _{y, carbon} = F _{u, carbon} =	230 420	MPa MPa		A36 Carbon s A36 Carbon s from Zuzana'	steel, 36 ksi steel, 58-80 ks	si	Table 2-2, "De Edwin H. Ga	sign of Steel Str ylord	uctures", p54
Ε = φ =	200000 0.9	MPa		nom zuzana	3 110183				

Check Compressive Resistance (CI 10.9.3)

$C_{r.1} = \phi_s A_g F_y$	(1+λ ²ⁿ) ^{-1/}	Cl 10.9.3.1, p452	
$\lambda = (KL/r)[F_y]$	/(π ² E _s)] ^{0.5}	i	Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	249.7	mm	
λ=	0.83		
C _{r.1} =	5348	kN	

DELCAN	SUBJECT:	Burlington C	Canal Lift Bridge	Analysis of Lo	ad-Carrying C	apacity	JOB NO. BT3252BTJ00
		Member C	apacity - Lift S	Span - Diagor	nal U ₅ -L ₆		PAGE 1 of 1
	MADE BY:	KL	DATE:	Jun. 6, 07	CHECK	ED BY:	DATE:
<u>LIFT SPAN</u>							الوحد حطوا
Diagonal Member U ₅	-L 6	Tension N	Member				с
Built-up se	ection						
Angle (4) 4x4x3/8 102x102x9.5		Web (2) 24x9/16		Bot plate (1) (23-8)x3/8			
<u>Design Criteria</u> Member Length =	19219	mm	dwg. 3/62				
Total width =	20 508	in mm	tal Depth =	= 25.25 641.35	in mm		
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "Design of Steel Structures", p54
F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 ki	si	Edwin H. Gaylord
Ε = φ =	200000 0.95	MPa		nom zuzana	s notes		
A _{gross} =	48.7	in ²		A _{net} =	40.8	in ²	dwg 3/62
A _{gross} =	31419	mm²		A _{net} =	26323	mm ²	
Check Tensile Resista	nce						
			T _{r.1}	$= \phi_s A_{net} F_y =$	5751.5	kN	Cl 10.8.2 (a), p 447

 $T_{r.2} = 0.85\phi_s A_{ne}F_u = 8927.3 \text{ kN} \qquad Cl 10.8.2 (a), p 447$ $T_{r.2} = 0.85\phi_s A_{ne}F_u = 8927.3 \text{ kN} \qquad Cl 10.8.2 (b), p 448$ $T_r = \min(T_{r.1}, T_{r.2}) = 5751.5 \text{ kN}$

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DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Load	d-Carrying Capacity	JOB NO.	JOB NO. BT3252BTJ00			
		Member Capacity - Lift Span - Vertical Member U ₀ -L ₀						of	1	
	MADE BY:	KL	DATE:	May. 23, 07	CHECKED BY:	DATE				

LIFT SPAN

Vertical Member U₀-L₀ Tension Member

Built-up s	Built-up section											
Angle (4)	Angle (4)	Web (2)	Web (1)	Web (2)	Top plate (1) Bot plate (1)							
5x5x3/4	4x4x3/4	23x1/2	23x7/8	13x3/4	(23-8)x3/8 (23-8)x3/8							
203x152x19	102x102x19											



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Design Criteria

Member Length = 13258.8 m dwg. 3/62 Total width = in tal Depth = 24.5 in 0 622.3 mm mm F_{y, carbon} = 290 MPa Low Alloy Table 2-2, "Design of Steel Structures", p54 F_{u, carbon} = 434 MPa Edwin H. Gaylord from Zuzana's notes E = 200000 MPa 0.95 φ= in² 104.2 in² dwg 3/62 139.35 A_{net} = A_{gross} = mm² A_{gross} = 89903 mm² A_{net} = 67251

Check Tensile Resistance

$T_{r.1} = \phi_s A_{net} F_y =$	18527.8	kΝ	Cl 10.8.2 (a), p 447
$T_{r.2} = 0.85\phi_sA_{ne}F_u =$	23568.6	kΝ	Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	18527.8	kN	

DELCAN	SUBJECT:	Burlington C	anal Lift Bridge Ar	nalysis of Lo	ad-Carrying Ca	pacity	JOB NO. BT3252BTJ00		
	SUBJECT: Burlington Canal Lift Bridge Analysis of Load-Carrying Capacity Member Capacity - Lift Span - Vertical Member U1,3,5 ⁻ L1,3,5MADE BY:KLDATE:May. 23, 07CHECKED BY:mber U1-L1, U3L3, U5L5Tension MemberBuilt-up section Angle (4)Meb (1)Web (2)Top plate (1) Bot plate (1) ix5x5/8Top			PAGE	1 of	1			
	MADE BY:	KL	DATE: N	<i>l</i> lay. 23, 07	CHECKE	D BY:		DATE:	
<u>LIFT SPAN</u>							Π		
Vertical Member U ₁ -	$L_{1}, U_{3}L_{3},$	U_5L_5	Tension Mer	nber			Ľ	c	Ľ
Built-up s Angle (4) 5x5x5/8 127x127x16	e ction Angle (4) 4x4x1/2 102x102x13	Web (1) 23x1/2	Web (2) (23-10)x3/8		Top plate (1) 19 1/2x1/2	Bot plate (1) 20 1/2x1/2			
Design Criteria									
Total width =	0	in mm	tal Depth =	24.5 622.3	in mm				
F _{y, carbon} =	230	MPa	A	36 Carbon s	steel, 36 ksi		Table 2-2, "De	sign of Steel Stru	ıctures", p54
F _{u, carbon} =	420	MPa	A fr	36 Carbon : rom Zuzana'	steel, 58-80 ksi s notes		Edwin H. Ga	nylord	
Ε = φ =	200000 0.95	MPa							
A _{gross} = A _{gross} =	79.31 51168	in ² mm ²		A _{net} = A _{net} =	: 60.6 : 39097	in ² mm ²	dwg 3/62		

Check Tensile Resistance

T _{r.1} = φ _s A _{net} F _y =	8542.6	kN	CI 10.8.2 (a), p 447
$T_{r.2} = 0.85 \phi_s A_{ne} F_u =$	13259.6	kN	Cl 10.8.2 (b), p 448
$T_r = min(T_{r,1}, T_{r,2}) =$	8542.6	kΝ	

DELCAN	SUBJECT:	Burlington C	anal Lift Bridge	Analysis of Lo	ad-Carrying C	apacity	JOB NO. BT3252BTJ00				
		Member C	apacity - Lift S	pan - Vertica	i Member U	2-L2	PAGE	1 o	f 1		
	MADE BY:	KL	DATE:	May. 23, 07	CHECK	ED BY:		DATE:			
<u>LIFT SPAN</u>											
Vertical Member U 2-	L 2		Compressi	on member		ſ			נ ר		
Built-up se	ection										
Angle (2) 4x4x7/16 102x102x11	Angle (2) 8x6x3/4 203x152x19	Web (2) 30x1/2	Top plate (1) 38x1	Bot plate (1) (42-14)x7/5	8	l]		
Design Criteria											
Member Length =	15363	mm	otal width =	20 508	in mm	tal Depth =	24.5 622.3	in mm	dwg. 3/62		
A _{gross} = A _{gross} =	66.3 42774.1	in² mm²	S =	555 9094.821	in ³ *10 ³ mm ³	i =	2829.9	10 ⁶ mm⁴	dwg 3/62		
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel Sti	uctures", p54		
F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 ks	si	Edwin H. Ga	ylord			

from Zuzana's notes

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Check Compressive Resistance (CI 10.9.3)

E = 200000 MPa φ = 0.9

$C_{r.1} = \phi_s A_g F_y$.(1+λ ²ⁿ) ^{-1/}	n	Cl 10.9.3.1, p452
λ = (KL/r)[F _γ	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	257.2	mm	
λ =	0.64		
C _{r.1} =	7245	kN	

mber Capacity - Lift Span - Vertical Member U ₄ -L ₄ PAGE 1 of 1
KL DATE: May. 23, 07 CHECKED BY: DATE:
KL DATE: May. 23, 07 CHECKED BY: DATE:

Vertical Member U₄-L₄

Compression member

 Built-up section

 Angle (2)
 Angle (2)
 Web (2)
 Top plate (1)
 Bot plate (1)

 4x4x7/16
 8x6x3/4
 30x1/2
 38x1
 (42-14)x7/8

 102x102x11
 203x152x19
 30x1/2
 30x1
 30x1/2



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Design Criteria

Member Length =	16484	mm	otal width =	20 508	in mm	tal Depth =	24.5 622.3	in mm	dwg. 3/62
A _{gross} = A _{gross} =	66.3 42774.1	in ² mm ²	S =	555 9094.821	in ³ *10 ³ mm ³	=	2829.9	10 ⁶ mm⁴	dwg 3/62
F _{y, carbon} =	230	MPa		A36 Carbon	steel, 36 ksi		Table 2-2, "De	sign of Steel Sti	uctures", p54
F _{u, carbon} =	420	MPa		A36 Carbon	steel, 58-80 ks	si	Edwin H. Ga	ylord	
Ε = φ =	200000 0.9	MPa		from Zuzana	's notes				

Check Compressive Resistance (CI 10.9.3)

$C_{r.1} = \phi_s A_g F_y$,(1+λ ²ⁿ) ^{-1/}	'n	Cl 10.9.3.1, p452
$\lambda = (KL/r)[F_y]$	/(π ² E _s)] ^{0.5}	i	Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	257.2	mm	
λ=	0.69		
C _{r.1} =	6991	kN	

DELCAN	SUBJECT: B	urlington Ca	JOB NO. BT3252BTJ00					
	N	lember Ca	pacity - Lift	PAGE	1 of	1		
	MADE BY:	KL	DATE:	May. 23, 07	CHECKED BY:		DATE:	

LIFT SPAN

Vertical Member U₆-L₆

Compression member

 Built-up section

 Angle (2)
 Angle (2)
 Web (2)
 Top plate (1)
 Bot plate (1)

 4x4x7/16
 8x6x3/4
 30x1/2
 38x1
 (42-14)x7/8

 102x102x11
 203x152x19



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Design Criteria

Member Length =	16764	mm	otal width =	20 508	in mm	tal Depth =	24.5 622.3	in mm	dwg. 3/62
A _{gross} = A _{gross} =	66.3 42774.1	in ² mm ²	S =	555 9094.821	in ³ *10 ³ mm ³	1 =	2829.9	10 ⁶ mm⁴	dwg 3/62
F _{y, carbon} =	230	MPa		A36 Carbon s	steel, 36 ksi		Table 2-2, "De	sign of Steel Sti	uctures", p54
F _{u, carbon} =	420	MPa		A36 Carbon s	steel, 58-80 ks	si	Edwin H. Ga	ylord	
			1	from Zuzana'	s notes				
E=	200000	MPa							

Check Compressive Resistance (Cl 10.9.3)

$C_{r.1} = \phi_s A_g F_y$,(1+λ ²ⁿ) ^{-1/}	n	Cl 10.9.3.1, p452
$\lambda = (KL/r)[F_y]$	$/(\pi^2 E_s)]^{0.5}$		Cl 10.9.3.1, p452
n =	1.34		fabricated shapes
K =	1.0		
$r = (I/A)^{0.5} =$	257.2	mm	
λ =	0.70		
C _{r.1} =	6926	kN	

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	JOB NO. BT3252BTJ00					
	Member Properties - Top Laterals						1	of	1
	MADE BY:	MADE BY: KL DATE: Jun. 4, 07 CHECKED BY:						TE:	

<u>LIFT SPAN</u>

<u> </u>							
Top Laterals (Carbon)							
Built-up see	ction		Angle (4) [7x4x7/16 2	D. Lace 2 3/4x1/2			
<u>Design Criteria</u>			178X102X11				
Total width =		in	Total Depth =	30.5	in	(2-6 1/2")	
	229.4	mm		774.7	mm		
	Angle			Lace			
A =	2980	mm ²	t =	1/2	in		
y =	60.8	mm		12.7	mm		
x =	22.8	mm	w =	2 3/4	in		
b =	102			69.85	mm		
d =	178						
t =	11.1						
i _x =	9.88	10 ⁶ mm ²					
1 _v =	2.45	10^{6}mm^{2}					

Calculate Area

A _{angle} =4A=	11920	mm²
A _{double lacing} =	0.0254	m²/m
A _{gross} =	0.03732	m ²

Calculate Moment of Inertia

 $y_{x-x} = h/2 = 387.35 \text{ mm}$ $d_{x-x, \text{ angle}} = y_{x-x}-y = 364.55 \text{ mm}$ $l_{x-x, \text{ tot}} = 0.001594 \text{ m}^4$ $y_{y-y} = b/2 = 114.7 \text{ mm}$ $d_{y-y, \text{ angle}} = x+y_{y-y} = 73.05 \text{ mm}$ $l_{y-y, \text{ tot}} = 0.000103 \text{ m}^4$

DELCAN	SUBJECT:	Burlington C	anal Lift Bridge Ana	lysis of Load	Carrying	Capacity	JOB NO.	BT3252	BTJ00	
		Member P	roperties - Bottom	Laterals			PAGE	1	of	1
	MADE BY:	KL	DATE:	Jun. 4, 07	Cŀ	IECKED BY:		DAT	E:	
<u>LIFT SPAN</u>										
Bottom Laterals (Car	bon)							į		
Built-up se	ection		Angle (4)	D. Lace						
			7X4X7/16	2 3/4x1/2						
Desian Criteria			1702102211							
Total width -		in	Total Danth w	24.05	in	(0.7.4/4W)				
Total width -	365.5	mm	rotai Deptii -	793.75	mm	(2-7 1/4")				
								![
	Angle	_		Lace						
A =	2980	mm ²	t =	1/2	in					
y =	60.8	mm		12.7	mm					
x =	22.8	mm	w =	2 3/4	in					
b =	102			69.85	mm					
d =	1/8									
t=	11.1	6 2								
I _x =	9.88	10° mm²	9.656							
I _y =	2.45	10 ⁶ mm ²								
Calculate Area										

<u>ouloululo / irou</u>

 $A_{angle}=4A= 11920 \text{ mm}^2$ $A_{double lacing}= 0.0254 \text{ m}^2/\text{m}$ $A_{gross}= 0.03732 \text{ m}^2$

Calculate Moment of Inertia

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 $\begin{array}{rcl} y_{x \cdot x} = h/2 = & 396.875 & mm \\ d_{x \cdot x, \ angle} = y_{x \cdot x} \cdot y = & 374.075 & mm \\ l_{x \cdot x, \ tot} = & 0.001678 & m^4 \end{array}$ $\begin{array}{rcl} y_{y \cdot y} = b/2 = & 182.75 & mm \\ d_{y \cdot y, \ angle} = x + y_{y \cdot y} = & 73.05 & mm \\ l_{y \cdot y, \ tot} = & 0.000103 & m^4 \end{array}$

DELCAN	SUBJECT:	Burlington Ca	nai Lift Bridge	Analysis of Loa	JOB NO.	BT32	52BTJ00		
		Member Properties - Top Strut						of	1
	MADE BY:	KL	KL DATE: Jun. 4, 07 CHECKED BY:			•	DA	TE:	

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LIFT SPAN

Top Strut (Carbon) Built-up sed	ction		Angle (4) [5x5x3/8 2 127x127x9.5	D.Lsides 2 3/4x1/2 5	D.Ltop 8 3 3/4x1/2	bot.	
<u>Design Criteria</u>							
		_					
Total width =	22	in	tal Depth =	31.5	in	(2'-6 1/2"+2*1/2)	t.
	558.8	mm		800.1	mm		1
	Angle			Lace			
A =	2330	mm ²	t =	1/2	in		
y =	35.3	mm		12.7	mm		
x =	35.3	mm	w =	2 3/4	in		
b =	127			69.85	mm		
d =	127						
t =	9.53						
I _x =	3.64	10 ⁶ mm ²					
l _y =	3.64	10 ⁶ mm ²					

Calculate Area

A _{angle} =4A=	9320	mm ²			
A _{double lacing} =	0.0254	m²/m	A _{single lacing} =	0.0127	m²/m
A _{gross} =	0.08552	m²			

Calculate Moment of Inertia

	y _{x-x} = h/2 =	400.05	mm
d _{x-x, ang}	_{gle} = y _{x-x} -y =	364.75	mm
	$l_{x-x, tot} =$	0.001255	m ⁴
	y _{y-y} = b/2 =	279.4	mm
d _{y-y, ang}	_{le} = x+y _{y-y} =	244.1	mm
	I _{y-y, tot} =	0.00057	m ⁴

	SUBJECT	Burlington Ca	nal Lift Bridge	Analysis of Los	d-Carrying Ca	apacity	JOB NO.	BT3252BTJ00
	0000000	Momber Co			diata Elaar E	Boome	PACE	1 of 3
		KI KI	DATE	May 22 07	CHECKE	ED BY:		DATE:
L	WADE DT.	۲۸L		way. 22, 01				
LIFT SPAN Intermediate Floor B	eam	dwa. 5/62					I	
Built-up section	Angle 4 8x8x7/8	Web 1 78x9/16	Cover plate 2 20x3/4	Long. Traction Bracing 6x4x1/2	Stiffener 7x4x5/8			
<u>Design Criteria</u> Total width, b =	203x203x22	in	Depth, d =	152x102x13 80	in	(6-6 1/2+2*3/4	4)	
	508	mm		2032	mm			
A = y = x = t = b = d =	Angle 8520 58.9 58.9 22.2 203 203	mm ² mm mm mm mm	w = h =	Web 9/16 14.2875 78 1981.2	in mm in mm	t = b =	Cover plate 3/4 19.05 20 508	e in mm in mm
A _{one leg} = I _{angle, x} = I _{angle, y} =	4506.6 33 33	mm ² 10 ⁶ mm ⁴ 10 ⁶ mm ⁴	I _{web, x} = I _{web, y} =	9258.91 0.481522	10 ⁶ mm ⁴ 2 10 ⁶ mm ⁴	l _{cover, x} = I _{cover, y} =	0.2927 208.1157	10 ⁶ mm ⁴ ′ 10 ⁶ mm ⁴
Cqlculate Section Pro	<u>perties</u>							
Calculate Area						A _{cp} =ht=	9677.4	mm ²
A _{angle} =4A=	34080	mm²	A _{web} =hw=	28306.4	mm ²	2A _{cp} =	19354.8	mm²
A _{total} =	81741	mm ²	0.0817	mm ²	2			
Calculate Centroid	taken abo	ut the botto	m of the sec	tion				
Y _{top angles} ≕ Y _{bot angles} =	· 1954.1 · 78.0	mm mm	y _{web} =	• 1016.0	mm	Ytop cover = Ybot cover =	= 2022.5 = 9.5	mm mm
y _{centroid} =	• 1016	mm						
Calculate Moment of	Inertia							
I _{x-x} = 1/12* I = 1/12*	[bd ³ -(b-w)([2th ³ -(d-2t)	d-2t) ³] w ³ 1	$S_{x-x} = 1/(6)$	d)*[bd ³ -(b-v b)*[2tb ³ -(d-'	/)(d-2t) ³] 2t)w ³ 1			
i _{y-y} - i/12	: 29045 0	•• J 10 ⁶ mm ⁴	S=	= 28.588	$10^6 \mathrm{mm}^3$			
'×-× l _{y-y} =	• 415.75	$10^{6} \mathrm{mm}^{4}$	S _{y-y} =	= 1.637	10 ⁶ mm ³			

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DELCAN	SUBJECT: Burlington Canal Lift Bridge Analysis of Load-Carrying Capacity	JUB NO. BT3252BTJ00
	Member Capacity - Lift Span - Intermediate Floor Beams	PAGE 2 of 3
	MADE BY: KL DATE: May. 22, 07 CHECKED BY:	DATE:
G _{steel} = E = F. =	77000 MPa ∳ = 0.95 200000 MPa 230 MPa	
I _{angles, t-x} = I _{angles, t-y} =	$30120 ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{web, t-x} = ext{ 9258.91 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-x} = ext{ 281 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{web, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } ext{ 10}^{6} ext{ mm}^{4} ext{ l}_{cover, t-y} = ext{ 0.4815 } e$	19606.84 10 ⁶ mm ⁴ 416.231 10 ⁶ mm ⁴
I _{total, x} = I _{total, y} =	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
S _{total, x} = I _x /y = S _{total, y} = I _y /y =	58057.1 10° mm° 0.000058 m° 686.38 10 ³ mm ³	
<u>Check Class</u>	b' = b/2 = 254 mm t' = $t_{cp}+t_{angle}$ = 41.25 mm h'_web = $h_{web}-2*d_{angle}$ = 1575.2 mm	
Elange (Top and Botto	m the same)	
ange (rep and bollo	b'/ť = 6.2	
	$200/sqrt(F_y) = 13.2$	Tab 10.9.2.1, p451
	Flange is Class 3	
Web	h' _{web} /w _{web} = 110.3 1900/sqrt(F _y) = 125.3 Web is Class 3	Tab 10.9.2.1, p451
Check Moment Capaci	<u>ity</u>	
Note: Flange Clas	ss is 3 and web is Class 3 , Stiffened plate girder, laterally unsuppor	ted
Check Width-to-Thickn	ess Ratios Webs	
	$3150/sqrt(F_y) = 207.7$	Cl. 10.10.4.2(a)
Moment Required	n/w ratio is OK M _f = 12000.0 kNm	treated as longitudinal unstittened from LUSAS Model
<u>Moment Resistance (C</u>	<u>31. 10.10.4.3)</u>	
a. Treat as girder witho b. Check if 2d _c /w > 19	but longitudinal stiffeners $00/F_y^{0.5}$ $2d_c/w = 142.2$	Cl . 10.10.4.3, p 458
	1900/Fy ^{0.5} = 125.3	01 40 40 40 - 450
c. Calculate reduction	2dc/w>1900/sqrt(Fy), need to reduce the moment	CI . 10.10.4.3, p 458
Reduction I	Factor = 1.0-1/[300+(1200A _{cf})/A _w]*[2d _c /w-1900/(M _f / ϕ_s S) ^{0.5}] A _{cf} = A _{cp} +2*A _{angle} = 18690.6 mm ²	Cl . 10.10.4.3, p 458

DELCAN	SUBJECT: Burlington Canal Lift Bridge	ad-Carrying Capacity	Capacity JOB NO. BT3252BTJ00				
	Member Capacity - Lift S	Span - Interm	ediate Floor Beams	PAGE 3 of 3			
	MADE BY: KL DATE:	May. 22, 07	CHECKED BY:	DATE:			
				-			
	$A_w = A_{web} + 2^* A_{angle} =$	37319.6	mm ²				
	$d_c = h_{tot}/2 =$	1016.0	mm				
	Reduction Factor =	0.985					
	RD =	0.985					
d. Calculate $M_r = \phi_s$	$S_x F_v$ (10.10.3.2)			Cl. 10.10.3.2, p458			
. , ,	$M_r = \phi_s S_x F_y =$	12685.5	kNm	treat as laterally supported			
	-						
e. Calculate Reduced	Moment Resistance	: 12406 7	kNm				
	wr, final – i ti wr	12430.1	KNIII				
Shoar Resistance	d 10 10 5 1						
eneur rieenstande	0.10.0.1						
a/h ratio		4005 4					
	a = b =	- 1295.4	mm				
	a/h =	· 0.654					
		a/h<1		cl. 10.10.5.1, p459			
use kv = 4+5.3	4/(a/h)^2						
	k _v =	= 16.51					
	h/w =	= 138.7					
	502(k /F) ^{0.5} =	- 134 51					
	$621(k/F)^{0.5}$	= 166.40					
	502(kv/Fv)	^0.5 <h td="" w<6<=""><td>21(kv/Ev)^0.5</td><td></td></h>	21(kv/Ev)^0.5				
			_ (())				
	$F_{cr} = 290(F_yk_v)^{0.5}/(h/w) =$	= 128.9	MPa				
F	^τ _t = (0.5F _y -0.866F _{cr})*{1/[1+(a/h) ²]} =	2.83	MPa				
	$F_s = F_{cr} + F_t$	= 131.72	MPa				
	A _w = h*w =	= 28306.4	mm ²				
	$V_r = \phi_s A_w F_s =$	- 3542	kN				

DELCAN	SUBJECT:	Burlington Ca	anal Lift Bridge	apacity	JOB NO.	BT3252BTJ00		
		Member C	apacity - Lift	m	PAGE	/ of 3		
	MADE BY:	KL	DATE:	May. 22, 07	CHECKE	D BY:		DATE:
LIFT SPAN							I	
End Floor Beam		dwg. 6/62						
Built-up section	Angle	Web	Cover plate	Long. Traction Bracing	Stiffener			
	4 8x8x3/4 203x203x1	71x1/2 9	2 20x1/2	6x4x1/2 152x102x13	7x4x5/8 172x102x16			
<u>Design Criteria</u> Total width, b =	20 508	in mm	Depth, d =	80 2032	in mm	(6-6 1/2+2*3/4)	
$A =$ $y =$ $x =$ $t =$ $b =$ $d =$ $A_{one leg} =$ $I_{angle, x} =$ $I_{angle, y} =$ $Cglculate Section Prop$ $Calculate Area$	Angle 7390 57.8 57.8 19.1 203 203 3877.3 29 29 29	mm ² mm mm mm mm mm ² 10 ⁶ mm ⁴ 10 ⁶ mm ⁴	w = h = I _{web, x} = I _{web, y} =	Web 1/2 12.7 71 1803.4 6207.24 0.307838	in mm in mm 10 ⁶ mm ⁴ 10 ⁶ mm ⁴	t = b = I _{cover, x} = I _{cover, y} =	Cover plate 1/2 12.7 20 508 0.0867 138.7438	e in mm in mm 10 ⁶ mm ⁴ 10 ⁶ mm ⁴
A _{angle} =4A=	29560	mm²	A _{web} =hw=	22903.18	mm²	A _{cp} =ht= 2A _{cp} =	6451.6 12903.2	mm ² mm ²
A _{total} =	65366	mm ²	0.0654	mm ²				
Calculate Centroid	taken abou	it the bottor	n of the sec	tion				
y _{top angles} = y _{bot angles} =	1961.5 70.5	mm mm	y _{web} =	1016.0	mm	y _{top cover} = y _{bot cover} =	2025.7 6.4	mm mm
y _{centroid} ≕	1016	mm						
Calculate Moment of Ir	<u>nertia</u>							
I _{x-x} = 1/12*[I _{y-y} = 1/12*[bd ³ -(b-w)(d 2tb ³ -(d-2t)w	-2t) ³] / ³]	S _{x-x} = 1/(60 S _{x-x} = 1/(60	l)*[bd ³ -(b-w))*[2tb ³ -(d-2)(d-2t) ³] t)w ³]			

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 $I_{x-x} = 21704.4 \ 10^{6} \text{ mm}^{4} \qquad S_{x-x} = 21.363 \ 10^{6} \text{ mm}^{3}$ $I_{y-y} = 277.15 \ 10^{6} \text{ mm}^{4} \qquad S_{y-y} = 1.091 \ 10^{6} \text{ mm}^{3}$

DELCAN	SUBJECT:	Burlington Canal Lift Bridge An	alysis of Loa	d-Carrying Capa	icity	JOB NO.	BT3252BTJ00	
		Member Capacity - Lift S	PAGE	2 of	3			
	MADE BY:	KL DATE: M	lay. 22, 07	CHECKED	BY:		DATE:	
<u> </u>	77000	ND.		0.05				
G _{steel} =	200000	мРа мРа	φ =	0.95				
F,=	230	MPa						
y								
l _{angles, t-x} =	26542	$10^6 \text{ mm}^4 \qquad \text{l}_{\text{web, t-x}} =$	6207.24	10 ⁶ mm ⁴	l _{cover, t-x} =	13153.61	10 ⁶ mm⁴	
l _{angles, t-y} =	238	10 ⁶ mm ⁴ I _{web, t-y} =	0.3078	10 ⁶ mm⁴	I _{cover, t-y} =	277.488	10 ⁶ mm ⁴	
	- a - ta Tukun							
l _{total, x} =	45902.6	10 ⁶ mm ⁴ 0.0459 m	14					
I _{total, y} =	515.44	10 ⁶ mm⁴ 0.00052 m	14					
S -1/v-	45170.7	403 3 0 000045	4					
$S_{total, x} = I_{x}y =$	40179.7 507.22	10 mm 0.000045 m	1					
	307.32	IV mm						
Check Class								
		D' = D/2 =	254	mm				
		$i = i_{cp} \cdot i_{angle} =$ b' = b -2*d =	31.0 1207 4	111111 mm				
		Tweb Thweb Z Uangle -	1397.4					
Flange (Top and Botto	m the sam	e)						
		b'/ť =	8.0					
		200/sqrt(F _y) =	13.2	_		Tab 10.9.2.1	. p451	
		Flan	ge is Clas	s 3				
Web								
		h' _{web} /w _{web} =	110.0					
		1900/sqrt(F _y) =	125.3					
		We	b is Class	3		Tab 10.9.2.1	p451	
Chock Momont Consoi	+1 <i>7</i>							
Check Moment Capaci	<u>cy</u>							
Note: Flange Clas	ss is 3 and	web is Class 3 , Stiffened	l plate girc	ler, laterally ι	Insupport	əd		
Check Width to Thickn	oss Patios	Woho						
Oneck Widan-to-Thickn	<u>533 Mail03</u>	3150/sart(F.,) =	207.7			Cl. 10.10.4.2	(a)	
		h/w	ratio is O	к		treated as lo	ngitudinal unstiffened	
,								
Moment Pequired								
Moment Required		M. =	9000 0	kNm		from LUSAS	Model	
		ivit –	3000.0			10111 20040	Model	
Moment Resistance (C	<u>I. 10.10.4.3</u>	<u>3)</u>						
- T								
a. Treat as girder witho	ut iongitua no <i>i</i> e ^{0.5}	inal sumeners				CL 10 10 A	2 - 159	
$D. OHECK \ ZU_{c}/W \ge 190$	JUIF'y	2d /w -	160.0			GL 10.10.4.	ο, μ 4 00	
		200/10-5 -	100.0					
		2dc/w>1900/sart(Fv)	, need to i	educe the m	oment	CI. 10.10.4.	3, p 458	
c. Calculate reduction f	actor							
Reduction F	actor = 1.0	0-1/[300+(1200A _{cf})/A _w]*[2	d _c /w-1900	/(M _f /φ _s S) ^{0.5}]		CI. 10.10.4.	3, p 458	

DELCAN		SUBJECT:	Burlington Ca	nal Lift Bridge	ad-Carrying Capaci	ity JOB NO. BT3252BTJ00					
			Member C	apacity - Lift	Span - En	d Floor Beam		PAGE	3	of	3
l <u></u>		MADE BY:	KL	DATE:	May. 22, 07	CHECKED B	Y:		DA	TE:	
			A _{cf} = A _c A _w = A _{we} Reducti	$_{p}$ +2*A _{angle} = $_{b}$ +2*A _{angle} = d _c = h _{tot} /2 = on Factor = RD =	14206.2 30657.8 1016.0 0.966 0.966	mm ² mm ² mm					
d. Calculate Mr	$= \phi_s S$,	Fy	(10.10.3.2)	I				Cl. 10.10.3.2	2, p458		
			М	$_{r} = \phi_{s}S_{x}F_{y} =$	9871.8	kNm		treat as late	rally sup	ported	
e. Calculate Red	luced M	loment Re	es <i>istance</i> M _{r, fina}	ı = RF*M _r =	9539.8	kNm					
Shear Resistan	ce c	l 10.10.5.	1								
a/h ratio					1005 4	10.0 10.0					
				a = h =	1295.4	mm					
				a/h =	0.718						
uso ky =	1+5 31/	(a/b)^2			a/h<1						
use kv - 4	4+0.04/	(a/11)*2		k _v =	14.37						
				h/w =	142.0						
			50	2(k,/F,) ^{0.5} =	125.47						
			62	$1(k_v/F_v)^{0.5} =$	155.22						
			:	502(kv/Fy)^	0.5 <h td="" w<62<=""><td>21(kv/Fy)^0.5</td><td></td><td></td><td></td><td></td><td></td></h>	21(kv/Fy)^0.5					
		F) ^{0.5} /(h/w) =	117 4	MPa					
	F, =	• (0.5F _v -0.	866F _{cr})*{1/[$1+(a/h)^{2}$]} =	10.82	MPa					
	•	. ,	F _s	$= F_{cr} + F_{t} =$	128.23	MPa					
				A _w = h*w =	22903.18	mm²					
			Vr	$= \phi_s A_w F_s =$	2790	kN					

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DELCAN	SUBJECT:	Burlington Car	nal Lift Bridge	Analysis of Load	-Carrying Capacity	JOB NO.	BT32	252BTJ00	
		Member Cap	acity - Lift S	Span - Stringer	24WF84	PAGE	/	of	2
	MADE BY:	MADE BY: KL DATE: May. 15, 07 CHECKED BY:						ATE:	

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<u>LIFT SPAN</u>

Stringer	Imperial 24WF84	Metric <i>W610x125</i>						
Design Cri	teria							
	d =	= 612 mm	I _x =	985	10 ⁶ mm⁴	J =	1540	10 ³ mm ⁴
	b =	= 229 mm	$l_y =$	39.3	10 ⁶ mm⁴	C _w =	3450	10 ⁹ mm ⁶
	t =	= 19.6 mm	S _x =	3220	10 ³ mm ³	G _{steel} =	77000	MPa
	w =	= 11.9 mm	Z _x =	3670	10 ³ mm ³			
	F _y =	= 230 N	MPa $\phi = \phi$	0.95		E =	200000	MPa
	L =	= 3150 mm						
Class Che	<u>ck</u>		b' - b/2 -	114 5	mm			
			h = d-2t =	572.8	mm			
Flange (To	p and Bott	om the same)						
			b'/t =	5.8			T	
			145/Sqrt(Fy) =	9.6 190 is Cl			Tad 10.9.2.1	, p451
			1 101	iye is Ci	ass I			
Web								
			h/w =	48.1				
			1100/Sqlt(Fy) =	72.3 ah ie Cla	ee 1		Tah 10021	n451
			***	50 13 014	331		100 10.0.2.1	, p-01
Check Mor	nent Capac	<u>city</u> Clas	ss 1, Laterally unsup	ported m	ember			
Chook if M	>0.67M							
Calculate M	<u>µ20.071М</u> р Л							
Oalculate h	"p	Г	M. = 7F. =	844	kNm		Class 1 sect	ion. cl 10, 10, 2, 2, p457
		L	0.67M _p =	566	kNm			, e. 101101212, p 101
Calculate N	A u	for doubly symn	netric sections					
	-		M _μ =(ω ₂ π/L)[E _s I _v G _s J+	(πE/L) ² I _v C _w] ^{0.5}		cl 10.10.2.3	
			$\omega_2 =$	1.0			cl 10.10.2.3	
			M _u =	2509	kNm			
Case (a)		Mu>0.67Mp			case a applies			
Calculate N	Л _г							
			M _r = 1.15φM	_p (1-0.28	M _p /M _u) <φM _p			
			• M _r =	835.3	kNm			
			φM _p =	801.9	kNm			
$M_{r, final} = m_{l}$	in(M _r , φM	رم ارم	这些正常的,这些时候的是不可能把 这些					
			M∕∓.	802	KNM			

DELCAN	SUBJECT: Burlington Cana	al Lift Bridge A	nalysis of Lo	ad-Carryin	ying Capacity JOB NO. BT3252BTJ00				
	Member Capa	acity - Lift Sp	an - Stringe	er 24WF8	4	PAGE	2Of		
	MADE BY: KL	DATE:	May. 15, 07	7 CHE	ECKED BY:		DATE:		
Simplified Method	CI 5.7.1.2.1,	p174							
	F _m = SN/(F(1	l+μC _f /100)							
		F =	9.5			Tab A 5.7.1.2	.1, p215		
		C _f =	0						
		S= N=	1.2954	m		# of stringers			
Calculate µ									
		W _c =	13.4112	m					
	10/	n =	4			# of design la	nes		
	vv = /\//	e - W/II -	3.3528	m <=1.0					
	μ – (44e	<=1.0)K							
Calculate F _m			ilu - 1.0, C						
	F _m = SN/(F(1+ ₁	μC _f /100) =	1.64	>=1.05	i				
Claculate Reduction	Factor								
chaodhaic i toddollon		R1 =	0.70		Reduction fac	ctor for multilar	e loading, 3.8.4.2, p55		
		-			4 lanes				
	Reduction Factor = F	m*nRi/N =	0.38						
		Μ _T =	598	kNm	LUSAS resul	ts "BCLB-string	jer.mdl"		
	M _g =	= RF*Μ _τ =	228	kNm					
	L	L Factor =	1.7						
	_	DLA =	0.25						
	Fac	tored M _f =	485	kNm					
Shear Resistance	ci 10.10.5.1, p459								
a/h ratio	unstiffened, a/h=infinity,	k _v = 5.34				cl. 10.10.5.1,	p459		
		k _v =	5.34			no stiffene	rs, a/h is infinity		
		h/w =	48.1						
	502	$(k_v/F_y)^{0.5} =$	76.49						
	621	$(k_v/F_y)^{0.5} =$	94.62						
		h/w<	<502(kv/Fy	/)^0.5					
	F _{cr} =	0.577F _y =	132.7	MPa					
		F _t =	0	MPa					
	F _s =	$F_{cr} + F_{t} =$	132.71	MPa					
	Α	\ _w = h*w =	6816.32	mm ²					
	V _r =	=	859	kN					

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DELCAN	SUBJECT:	Burlington Ca	anai Lift Bridge	Analysis of Loa	ad-Carrying Ca	apacity	JOB NO.	BT3252BTJ00	
		Member Ca	pacity - Towe	er Span - Froi	nt Face Floor	r Beam	PAGE	/ of	3
	MADE BY:	KL	DATE:	May. 22, 07	CHECK	ED BY:		DATE:	
<u>LIFT SPAN</u>									
End Floor Beam		dwg. 14/62	2						
Built-up section									
	Angle	Web	Cover plate	Long. Traction Bracing	Stiffener				ב
	4 8x8x1/2 203x203x1	71x1/2 3	2 20x1/2	6x4x1/2 152x102x13	7x4x5/8 172x102x16				
<u>Design Criteria</u> Total width, b =	20 508	in mm	Depth, d =	72.375 1838.325	in mm	(5-11 3/8+2*)	1/2)		
	Angle			Web			Cover plat	e	
A =	4990	mm²	w =	: 1/2	in	t =	: 1/2	in	
y =	55.5	mm		12.7	mm		12.7	mm ·	
x =	55.5	mm	h =	· 71	in mm	b =	: 20 508	in mm	
t=	203	mm		1005.4	120111		500	11111	
d =	203	mm							
A _{one leg} =	2578.1	mm ²							
l _{angle, x} =	20.2	10 ⁶ mm ⁴	l _{web, x} =	6207.24	10 ⁶ mm ⁴	I _{cover, x} =	0.0867	10 ⁶ mm ⁴	
l _{angle, y} =	20.2	10 ⁶ mm⁴	l _{web, y} =	0.307838	10 ⁶ mm ⁴	I _{cover, y} =	138.7438	3 10 ⁶ mm⁴	
Calculate Section Prop	<u>perties</u>								
Calculate Area								-	
4	40000	2	Ah		2	A _{cp} =ht=	= 6451.6	mm ²	
A _{angle} =4A=	19960	mm ²	A _{web} =nw=	22903.18	mmf	ZA _{cp} =	= 12903.2	mm	
A _{total} =	55766	mm ²	0.0558	mm²					
Calculate Centroid	taken abou	ut the bottor	m of the sec	tion					
y _{top angles} =	1770.1	mm	y _{web} =	919.2	mm	Y _{top cover} =	= 1832.0	mm	
y _{bot angles} =	68.2	mm				ybot cover	= 6.4	mm	
y _{centroid} =	919	mm							
Calculate Moment of I	<u>nertia</u>								
l _{x-x} = 1/12*	[bd ³ -(b-w)(d	-2t) ³]	S _{x-x} = 1/(6	d)*[bd ³ -(b-w	/)(d-2t) ³]				
I _{v-v} = 1/12*[2tb ³ -(d-2t)v	v ³]	S _{x-x} = 1/(6	b)*[2tb ³ -(d-2	2t)w ³]				
I _{x-x} =	17057.6	10 ⁶ mm ⁴	S _{x-x} =	18.558	10 ⁶ mm ³				
1 _{y-y} =	277.18	10 ⁶ mm⁴	S _{y-y} =	= 1.091	10 ⁶ mm ³				

Page 1 of 3

DELCAN	SUBJECT:	Burlington Canal Lift Bridge A	nalysis of Loa	d-Carrying Cap	acity	JOB NO.	BT3252BTJ00	
		Member Capacity - Tower	Span - Fror	t Face Floor E	Beam	PAGE	2 of	3
	MADE BY:	KL DATE: N	May. 22, 07	CHECKED	BY:		DATE:	
G _{steel} = E = F _y =	77000 200000 230	MPa MPa MPa	φ =	0.95				
l _{angles, t-x} = I _{angles, t-y} =	14535 157	10^{6} mm^{4} $I_{\text{web, t-x}} = 10^{6} \text{ mm}^{4}$ $I_{\text{web, t-y}} =$	6207.24 0.3078	10 ⁶ mm ⁴ 10 ⁶ mm ⁴	I _{cover, t-x} = I _{cover, t-y} =	10751.46 277.488	10 ⁶ mm ⁴ 10 ⁶ mm ⁴	
I _{total, x} = I _{total, y} =	31493.3 434.95	10 ⁶ mm ⁴ 0.0315 r 10 ⁶ mm ⁴ 0.00043 r	n ⁴ n ⁴					
$S_{total, x} = I_x/y =$ $S_{total, y} = I_y/y =$	34263.0 473.20	10 ³ mm ³ 0.000034 r 10 ³ mm ³	m ⁴					
S _{net} =	1840 30152	in ² 10 ³ mm ³				from dwg. 13	/62	
Check Class								
		$b' = b/2 =$ $t' = t_{cp} + t_{angle} =$ $h'_{web} = h_{web} - 2^* d_{angle} =$	254 25.4 1397.4	mm mm mm				
Flange (Top and Botto	m the sam	e)						
		b'/t' = 200/sqrt(F _y) = Fla	10.0 13.2 nge is Clas	ss 3		Tab 10.9.2.1	, p451	
Web		h' _{web} /w _{web} = 1900/sqrt(F _y) = W	110.0 125.3 eb is Class	33		Tab 10.9.2.1	¹ , p451	
Check Moment Capac	itv							
Note: Flange Cla	ss is 3 and	web is Class 3 , Stiffene	ed plate gir	der, laterally	unsuppor	ted		
<u>Check Width-to-Thickr</u>	ess Ratios	<u>s Webs</u> 3150/sqrt(F _y) = h/	207.7 w ratio is 0	Ж		Cl. 10.10.4. treated as lo	2(a) ongitudinal unstiffen	ed
Moment Required		M _f =	6000.0	kNm		from LUSAS	S Model	
<u>Moment Resistance (C</u>	<u>. 10.10.4.</u>	<u>3)</u>						
a. Treat as girder withc b. Check if 2d _c /w > 19	out longitud 00/F _y ^{0.5}	linal stiffeners 2d _c /w = 1000/⊑v ^{0.5} –	144.8 125.3			Cl . 10.10.4	.3, p 458	
		2dc/w>1900/sqrt(F	y), need to	reduce the	moment	CI. 10.10.4	.3, p 458	

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Load	-Carrying Capacity	JOB NO.	BT32	52BTJ00	
		Member Ca	oacity - Tow	ver Span - Front	Face Floor Beam	PAGE	3	of	3
	MADE BY:	KL	DATE:		DA	TE:			

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c. Calculat	te reduction factor	D 4/[2001/4000A \/A 1*[od <i>ku</i> 1000	0//M /4 C\0.5	CL 10 10 4 3 p 458
	Reduction Factor - 1.	- 1/[300+(1200A _{cf})/A _w] [/ Λ - Λ ±2*Λ -	20 ₀ /w-1900	J/(Νιμφ _s S)]	Gr. 10.10.4.3, p 430
		$\Lambda_{cf} = \Lambda_{cp} + 2 \Lambda_{angle} =$	29050 /	mm 	
		$\Lambda_w = \Lambda_{web} + 2 \Lambda_{angle} =$	20009.4	mm	
		$a_c = n_{tot}/2 =$	919.2	mm	
		Reduction Factor =	0.903		
			0.000		
d. Calcula	$te M_r = \phi_s S_x F_y$	(10.10.3.2)			Cl. 10.10.3.2, p458
		$M_r = \phi_s S_x F_y =$	6588.3	kNm	treat as laterally supported
o Calcula	te Reduced Moment Re	sistanco			
e. Calculat		M _{r feel} ≃ RF*M _r =	6476 8	kNm	
			• • • • • •		
Shear Res	sistance cl 10.10.5.	1			
a/h ratio					
amrado		a =	971.55	mm	
		h =	1397.4	mm	
		a/h =	0.695		
			a/h<1		cl. 10.10.5.1, p459
use	kv = 4+5.34/(a/h)^2				
		k _v =	15.07		
		h/w =	110.0		
		$502(k/F)^{0.5} =$	128 /0		
		$621(k/F)^{0.5}$	150.43		
		$021(K_y/\Gamma_y) = b/wc$	100.90	M0 5	
		1/W5	-302(KV/F)	// 0.5	
		F _{cr} =0.577F _y =	132.7	MPa	
		F _t =	0.00	MPa	
		$F_s = F_{cr} + F_t =$	132.71	MPa	
		A _w = h*w =	17746.98	3 mm ²	
		$V_r = \phi_s A_w F_s =$	2237	kN	

DELCAN	SUBJECT:	Burlington Ca	anal Lift Bridge /	Analysis of Loa	d-Carrying Ca	apacity	JOB NO.	BT3252BTJ00
		Member Ca	pacity - Towe	r Span - Bac	k Face Floor	Beam	PAGE	/ of 3
·	MADE BY:	KL	DATE:	May. 22, 07	CHECKE	ED BY:		DATE:
LIFT SPAN							I	
End Floor Beam		dwg. 15/62	2					
Built-up section								
	Angle	Web	Cover plate	Long. Traction Bracing	Stiffener			
	8x8x1/2 203x203x	71x5/8 13	20x1/2	6x4x1/2 152x102x13	7x4x5/8 172x102x16			
<u>Design Criteria</u> Total width, b =	20 508	in mm	Depth, d =	72.375 1838.325	in mm	(5-11 3/8+2*1	/2)	
	Angle			Web			Cover plate	e
A =	4990	mm ²	w =	5/8	in	t =	1/2	in
y = x =	55.5 55.5	mm mm	h =	15.875 71	mm in	h =	12.7 20	mm in
t=	12.7	mm		1803.4	mm	Ľ	508	mm
b =	203	mm						
a = A . =	203	mm						
Cone leg longio y =	20.2	$10^{6} \mathrm{mm}^{4}$	web v =	7759.05	10^{6}mm^{4}	loover v =	0.0867	$10^{6} \mathrm{mm}^{4}$
l _{angle, y} =	20.2	10 ⁶ mm ⁴	l _{web, y} =	0.601246	10 ⁶ mm ⁴	I _{cover, y} =	138.7438	10 ⁶ mm ⁴
Calculate Section Pro	perties							
Calculate Area								
A -4A-	40000	2	۸ <u></u>	00000.00	2	A _{cp} =ht=	6451.6	mm ²
A _{angle} ≕4A~	19900	mm-	Aweb-IIW-	28628.98	mm	2A _{cp} -	12903.2	mm
A _{total} =	61492	mm ²	0.0615	mm ²]			
Calculate Centroid	taken abo	ut the botto	m of the sec	tion				
$y_{top angles} =$	1770.1	mm	, y _{web} ≕	919.2	mm	y _{top cover} =	1832.0	mm
y _{bot angles} ≕	68.2	mm				Ybot cover =	6.4	mm
y _{centroid} =	919	mm						
Calculate Moment of I	<u>nertia</u>							
I _{x-x} = 1/12* I _{x-y} = 1/12*∣	[bd ³ -(b-w)(d [2tb ³ -(d-2t))	I-2t) ³] v ³]	S _{x-x} = 1/(6c S _{x-x} = 1/(6t	d)*[bd ³ -(b-w o)*[2tb ³ -(d-2)(d-2t) ³] !t)w ³]			
,-y	18634.1	- 10 ⁶ mm⁴	S _{x-x} =	20.273	10 ⁶ mm ³			
I _{у-у} =	276.88	10 ⁶ mm⁴	S _{y-y} =	1.090	10 ⁶ mm ³			

DELCAN	SUBJECT:	Burlington Can	al Lift Bridge	Analysis of Lo	ad-Carrying Ca	apacity	JOB NO.	BT3252BTJ00
		Member Cap	acity - Towe	r Span - Bac	k Face Floo	r Beam	PAGE	2 of 3
	MADE BY:	KL	DATE:	May. 22, 07	CHECK	ED BY:		DATE:
G _{steel} =	77000	MPa		φ=	0.95			
E =	200000	MPa						
r _y =	230	мРа						
I _{angles, t-x} =	14535	10 ⁶ mm ⁴	l _{web t-x} =	7759.05	10 ⁶ mm ⁴	l _{cover t-x} =	10751.46	10 ⁶ mm⁴
I _{angles, t-y} =	161	10 ⁶ mm ⁴	I _{web, t-v} =	0.6012	10 ⁶ mm ⁴	I _{cover. t-v} =	277.488	10 ⁶ mm⁴
					3	· •		
I _{total, x} =	33045.1	10 ⁶ mm ⁴	0.0330	m⁴				
I _{total, y} =	439.21	10° mm⁴	0.00044	_m*]			
$S_{total} = 1 / v =$	35951.3	10 ³ mm ³	0.000036	m ⁴]			
$S_{\text{total; }v} = I_v/y =$	477.84	10 ³ mm ³						
				<u>, and de 1988</u>	-			
S _{net} =	1920	in ²					from dwg. 13	/62
	31463	10 [°] mm [°]						
Check Class								
			b' = b/2 =	254	mm			
		ť =	t _{cp} +t _{angle} =	25.4	mm			
		h' _{web} = h _{we}	_b -2*d _{angle} =	1397.4	mm			
Flange (Top and Botto	m the sam	e)						
		-,	b'/ť =	10.0				
		20	0/sqrt(F _y) =	13.2			Tab 10.9.2.1	, p451
			Fla	ange is Cla	ss 3			
Web								
		ł	n' _{web} /w _{web} =	88.0				
		1900)/sqrt(F _y) =	125.3				
			v	Veb is Clas	s 3		Tab 10.9.2.1	, p451
<u>Check Moment Capaci</u>	ťχ							
Note: Flange Clas	ss is 3 and	web is Class	s 3 , Stiffen	ed plate gil	rder, lateral	ly unsupport	ed	
Check Width-to-Thickn	ess Ratios	Webs						
		3150)/sqrt(F _y) =	207.7			Cl. 10.10.4.2	2(a)
			ĥ	/w ratio is (ЭК		treated as lo	ngitudinal unstiffened
Moment Required								
			M _f =	6500.0	kNm		from LUSAS	Model
<u>Moment Resistance (C</u>	<u>I. 10.10.4.3</u>	<u>3)</u>						
a. Treat as girder witho	ut longitud	inal stiffener	s					
b. Check if 2d _c /w > 19	00/F _y ^{0.5}						CI. 10.10.4.	3, p 458
			2d _c /w =	115.8				
		1	900/Fy ^{0.5} =	125.3				
		2dc/w<19	00/sqrt(Fy), no need	to reduce ti	he moment	CI. 10.10.4.	3, p 458

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Loa	d-Carrying Capacity	JOB NO. BT3252BTJ00			
		Member Ca	pacity - Tow	er Span - Bac	K Face Floor Beam	PAGE	3	of	3
	MADE BY:	E BY: KL DATE: May. 22, 07 CHECKED BY:						ATE:	

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c. Calculat	e reduction factor	0 1/5200+/12000 \/A 1*5	od <i>hu</i> 1000)////// (4 S) ^{0.5} 1	CI 10 10 4 3 p 458
		$- 1/[300+(1200A_{cf})/A_w] [1$	44607 9	J/(Ινι _f /ψ _s -3)] 2	Gr. 10.10.4.3, p 430
		$\Lambda_{cf} = \Lambda_{cp} + 2 \Lambda_{angle} =$	11007.0	mm 2	
		$A_w - A_{web} + 2 A_{angle} - $	33785.2	mm-	
		$d_c = n_{tot}/2 =$	919.2	mm	
		Reduction Factor =	1.018		
		Kr =	1.000		
d. Calculat	te $M_r = \phi_s S_x F_y$	(10.10.3.2)			Cl. 10.10.3.2, p458
		$M_r = \phi_s S_x F_y =$	6874.7	kNm	treat as laterally supported
e. Calculat	e Reduced Moment R	esistance			
		M _{r, final} = RF*M _r =	6874.7	kNm	
Shear Res	sistance cl 10.10.5	.1			
a/h ratio			074 66		
		a=	971.55	mm	
		n – a/h =	0.695	11011	
		am –	a/h<1		cl. 10.10.5.1, p459
use	kv = 4+5.34/(a/h)^2				
		k _v =	15.07		
		h/w =	88.0		
		502(レノニン ^{0.5} ー	129 10		
		$502(K_V/F_y) =$	120.49		
		0∠1(K _V /F _y) −	108.95	140 E	
		11/W<	-502(KV/Fy	/)*0.5	
		F _{cr} =0.577F _y =	132.7	MPa	
		F _t =	0.00	MPa	
		$F_s = F_{cr} + F_t =$	132.71	MPa	
		A _w = h*w =	22183.73	, mm²	
		$V_r = \phi_s A_w F_s =$	2797	kN	

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	e Analysis of Load	-Carrying Capacity	JOB NO.	BT32	252BTJ00	
		Member Ca	pacity - Tow	ver Span - String	er 27WF102	PAGE	1	of	2
	MADE BY:	KL		D	ATE:				

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TOWER SPAN

Stringer	Imperial 27WF102	Metric W690x15 2	2						
<u>Design Cri</u>	teria								
	d =	688	mm	I _x =	1510	10 ⁶ mm ⁴	J =	2200	10 ³ mm⁴
	b =	254	mm	$I_y =$	57.8	10 ⁶ mm ⁴	C _w =	6420	10 ⁹ mm ⁶
	t =	21.1	mm	S _x =	4380	10 ³ mm ³	G _{steel} =	77000	MPa
	w =	13.1	mm	Z _x =	5000	10 ³ mm ³			
	F _y =	230	MP	a	0.95		E =	200000	MPa
	L=	3230	mm						
Class Che	<u>ck</u>				407				
				b = b/2 = b/2 = b + b + b + b + b + b + b + b + b + b	645.8	mm			
Flange (To	p and Botto	om the sam	e)						
				b'/t =	6.0			T 1 10 0 0 1	
				145/sqπ(F _y) = Fla	9.6 nge is Cla	ass I		Tab 10.9.2.1	1, p451
Web									
				h/w =	49.3				
				$1100/sqrt(F_y) =$	72.5				
				W	eb is Cla	ss I		Tab 10.9.2.1	I, p451
Check Mor	nent Capac	<u>sity</u>	Class	1, Laterally unsup	oported n	nember			
<u>Check if M</u> Calculate N	<u>">0.67М</u> р Мр								
				$M_p = ZF_y =$	1150	kNm		Class 1 sec	tion, cl 10.10.2.2, p457
			•	0.67M _p =	771	kNm			
Calculate I	1 _u	for doubly	symme	tric sections					
				M _u =(ω ₂ π/L)	[E _s I _y G _s J+	(πE/L) ² l _y C _w] ^{0.5}		cl 10.10.2.3	1
				ω ₂ =	1.0			cl 10.10.2.3	1
				M _u =	3891	kNm			
Case (a)		Mu>0.67M	р	(Case a app	lies			
Calculate N	A,								
				M _r = 1.15φΝ	1 _p (1-0.28	M _p /M _u) <∳M _p			
				M _r =	1152.4	kNm			
M= m	in(M &M	}		φM _p =	1092.5	kNm			
ייי r, final – 111	, φw	ρ/		M _r =	1093	kNm			

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	Analysis of Load	I-Carrying Capacity	JOB NO.	BT32	252BTJ00	
		Member Ca	pacity - Tow	er Span - String	ger 27WF102	PAGE	2	of	2
	MADE BY:	KL	DATE:		D	ATE:			

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Shear Resistance cl 10.10.5.1, p459

a/h ratio	unstiffened, a/h=infinity, k _v = 5.34			cl. 10.10.5.1, p459
	k _v =	5.34		no stiffeners, a/h is infinity
	h/w =	49.3		
	502(k _v /F _y) ^{0.5} = 621(k _v /F _y) ^{0.5} = h/w<	76.49 94.62 502(kv/Fy)	^0.5	
	F _{cr} =0.577F _y = F _t = F _s = F _{cr} + F _t =	132.7 0 132.71	MPa MPa MPa	
	A _w = h*w =	8459.98	mm²	
	$V_r = \phi_s A_w F_s =$	1067	kN	

DFI CA	N	SUBJECT:	Burlington Cana	al Lift Bridge /	Analysis of Lo	ad-Carrying Ca	apacity	JOB NO.	JOB NO. BT3252BTJ00		
			Member Capa	acity - Appro	bach Span -	Stringer 33W	/F130	PAGE	/ of	2	
		MADE BY:	KL	DATE:	May. 15, 07	CHECK	ED BY:		DATE:		
APPROAC	H SPAN										
Stringer	33WF130	W840x19	3								
Design Cri	torio										
Design On	<u>d =</u>	840	mm	1 _x =	2780	10 ⁶ mm⁴	J =	3050	10 ³ mm ⁴		
	b =	292	mm	I _v =	90.3	10 ⁶ mm ⁴	C _w =	15100	10 ⁹ mm ⁶		
	t =	21.7	mm	S _x =	6630	10 ³ mm ³	G _{steel} =	77000	MPa		
	w =	14.7	mm	Z _x =	7620	10 ³ mm ³					
	F _y =	230	MPa	φ =	0.95		E =	= 200000	MPa		
	L =	3150	mm								
Class Che	<u>ck</u>										
			b' = b/2 =	146	mm						
			n = d-2t =	796.6	mm						
Flange (To	op and Botto	om the sam	ne)								
		4	b'/t = 45/cert/도) =	6.7			Tab 10 0 2 1	0/51			
		. I	45/sqn(F _y) = Fla	9.0 nge is Cla	ssi		140 10.9.2.1	, µ451			
			T IG	nge is ela	001						
Web			b /w -	E4 0							
		11	n/w = 00/sart(E) =	04.Z 72.5							
			W	eb is Clas	s I		Tab 10.9.2.1	1, p451			
Check Mol	ment Capac	<u>sity</u>	Class 1, Lai	terally uns	upported n	nember					
Chook if M	0 67M										
Calculate I	<u>и 20.07М</u> р Ма										
Calculate .	•• p		$M_p = ZF_v =$	1753	kNm	7	Class 1 sec	tion, cl 10.10.	2.2, p457		
			0.67M _p =	1174	kNm						
Calculate I	M _u			for doubly	symmetric	sections					
			M _u =(ω ₂ π/L)	[E _s l _y G _s J+(πE/L) ⁻ I _y C _w	0.0	CI 10.10.2.3	1			
			$\omega_2 = \omega_2 = \omega_1 = \omega_2$	1.0	k N Ima		GI 10.10.2.3				
Caso (a)			IVI _u –	7020 Mu>0.67M	n nini nini nini nini nini nini nini n		case a appl	lies			
Case (a)			•		·P						
Calculate I	Mr										
			M _r = 1.15φΝ	И _р (1-0.28N	И _р /М _u) <фМ	p					
			M _r =	1791.5	kNm						
			φM _p =	1665.0	kNm						
M _{r, final} = n	nın(M _r , φM	p)									
			M _r =	1665	kNm						

1.4.1.4

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DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	Analysis of Load	I-Carrying Capacity	JOB NO.	BT32	52BTJ00	
		Member Capacity - Approach Span - Stringer 33WF130						of	2
	MADE BY:		D/	ATE:					

Required Moment

M _f =	1223.4	kNm	from Zuzana's notes
V _f =	113.2	kN	"SARESS63.MCD"

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Shear Resistance	cl 10.10.5.1, p459
	or ro.ro.o.r, proo

a/h ratio	unstiffened, $k_v = 5.34$			cl. 10.10.5.1, p459
	k _v =	5.34		no stiffeners, a/h is infinity
	h/w =	54.2		
	502(k _v /F _y) ^{0.5} =	76.49		
	621(k _v /F _y) ^{0.5} =	94.62		
	h/w<	502(kv/Fy	/)^0.5	
	F _{cr} =0.577F _y =	132.7	MPa	
	F _t =	0	MPa	
	$F_s = F_{cr} + F_t =$	132.71	MPa	
	A _w = h*w =	12348	mm ²	
	$V_r = \phi_s A_w F_s =$	1557	kN	

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DELCAN	SUBJECT:	Burlington C	anal Lift Bridge	Analysis of Load-C	arrying Capacity	JOB NO.	BT3252BT	J00
		Tower Spa	n and Approa	ich Span New Sla	b Capacity	PAGE /	/ (of 3
	MADE BY:	KL	DATE:	Jun. 18, 07	CHECKED BY:		DATE:	
Tower Span-Transve	rse Reinforce	ment						
Bottom Re	einforcement				Top Reinf	orcement		
	f' _c =	20	MPa	14.6.3.2, p651		f' _c =	20	MPa
α ₁ =0.8	5-0.0015f _c =	0.82			α ₁ =0.85	5-0.0015f _c =	0.82	
β ₁ =0.9	7-0.0025f' _c =	0.92			β ₁ =0.97	-0.0025f_ =	0.92	
	φ _s =	0.9				φ _s =	0.9	
	f _v =	350	MPa	Tab 14.6.3.3, p65	1	f, =	350	MPa
	φ _c =	0.75				φ ₀ =	0.75	
	b =	1000	mm			b =	1000	mm
15mm Reba	r Diameter =	15	mm		15mm Rebar	Diameter =	15	mm
	A _{s-15M} =	176.7	mm ²			A _{s-15M} =	176.7	mm ²
Slab thic	kness, t _{slab} =	7.5	in		De	oth of Cap =	7.5	in
		190.5	mm				190.5	mm
C	lear Cover =	1.5	in, bot		CI	ear Cover =	2	in, top
		38.1	mm				50.8	mm
	d =	144.9	mm			d =	132.2	mm
	Spacing =	6	in, bot			Spacino =	6	in, top
		152.4	mm				152.4	mm
# of	f 15M bars =	6.562	per metre		# of	15M bars =	6.562	per metre
	A _{trans.} =	1160	mm ²			A _{trans.} =	1160	mm²
	$T_s = \phi_s A_s f_y =$	365.3	kN			$T_s = \phi_s A_s f_y =$	365.3	kN
a = T	$f_{s}/(\phi_{c}\alpha_{1}f_{c}b) =$	29.70	mm		a = T	$s/(\phi_c \alpha_1 \mathbf{f}_c \mathbf{b}) =$	29.70	mm
	Lever arm =	130	mm	_		Lever arm =	117	mm
$M_r = T_s(L)$	_ever arm) =	47.5	kNm/m		$M_r = T_s(L)$.ever arm) =	42.9	kNm

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Tower Span-Longitudinal Reinforcement

Bottom Reinforcement						
f' _c =	20	MPa	14.6.3.2, p651	f' _c =	20	MPa
$\alpha_1 = 0.85 - 0.0015 f_c =$	0.82			α_1 =0.85-0.0015f _c =	0.82	
$\beta_1 = 0.97 - 0.0025 f_c =$	0.92			β ₁ =0.97-0.0025f' _c =	0.92	
$\phi_s =$	0.9			φ _s =	0.9	
f _y =	275	MPa	Tab 14.6.3.3, p651	f _v =	400	MPa
$\phi_{c} =$	0.75			φ _c =	0.75	
b =	1000	mm		b =	1000	mm
15mm Rebar Diameter =	15	mm		15mm Rebar Diameter =	15	mm
A _{s-15M} =	176.7	mm²		A _{s-15M} =	176.7	mm²
Slab thickness, t _{siab} =	7.5	in		Depth of Cap =	7.5	in
	190.5	mm			190.5	mm
Clear Cover =	1.5	in, bot		Clear Cover =	2	in, top
	38.1	mm			50.8	mm
d =	144.9	mm				
Spacing =	9	in, bot		Spacing =	9	in ton
- F	228.6	mm		opdollig	228.6	mm
# of 15M bars =	4.374	per metre		# of 15M bars =	4.374	per metre
A _{long.} =	773	mm ²				•
$T_s = \phi_s A_s f_y =$	191.3	kN		$T_s = \phi_s A_s f_y =$	278.3	kN

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		Tower Span	and Approa	ach Span New S	Slab Capacity	PAGE	2	of	3
	MADE BY:	MADE BY: KL DATE: Jun. 18, 07 CHECKED BY:						ATE:	

$a = T_s/(\phi_c \alpha_1 f_c b) =$	15.55	mm	$a = T_s/(\phi_c \alpha_1 f_c b) =$	22.63	mm
Lever arm =	137	mm	Lever arm =	121	mm
$M_r = T_s(\text{Lever arm}) =$	26.2	kNm/m	$M_r = T_s(\text{Lever arm}) =$	33.6	kNm

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Empirical Design Method - cl 8.18.4

(b) Ratio of the spacing of the supporting beams to the thickness of the slab <=18 S_{beams} = 1.8795 m $S_{beams}/t_{slab} =$ 9.9 ratio<=18, OK

(c) the spacing of the supporting beams does not exceed 4.0 m spacing < 4.0 m, OK

Cast-in-Place Deck Slabs

(a) Calculate p

 $\rho_{transverse} = A_{s.transverse} / A = 0.008$ rho, trans.>0.003, OK $\rho_{\text{long.}} = A_{s.\text{long.}} / \text{A} = -0.005$ rho, long.>0.003, OK (b) OK (f) spacing < 300 mm, OK

Concrete Deck Slabs	14.13.1.2, p665				
t =	7.5	in			
	190.5	mm			
	t>175mm				
$d_1 = d_t = d =$	144.9	mm			
Transverse reinforcement					
spacing =	6	in			
	152.4	mm			
# of bars/m =	6.56				
A _{si} =	1160	mm ²			
Longitudinal reinforcement					
spacing =	9	in			
	228.6	mm			
# of bars/m =	4.37				
A _{si} =	773	mm ²			
$q = 50[A_{sl}/(bd_{l})+A_{st}/(bd_{t})] =$	0.667				
Read from Figure14.13.1.2.2(b)	non-compo	osite slab			
R _d =	800	kN			
$F_q =$	1.08				
F _c =	0.87				
$R_n = R_d F_q F_c =$	750	kN			

deck=190 mm, span=1.9 m, Figure 14.13.1.2.2(b), p666 approximate, using q, read from figure 14.13.1.2.2(b), p666 f'_c = 20 MPa

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	Analysis of Load	I-Carrying Capacity	JOB NO.	BT32	52BTJ00	
	Tower Span and Approach Span New Slab Capacity						3	of	3
	MADE BY:	KL	DATE:	Jun. 18, 07	CHECKED BY:		DA	ATE:	

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$$\phi_{md} = 0.5$$

R_f = ϕ_{md} R_n = 375 kN

5.7.1.7 Transverse Bending Moments in Decks Treat it as simple span deck using maximum wheel load of CL-625 Truck M = (S+0.6)P/10

S = P = M = (S+0.6)P/10 = M _f = 80%M = Live Load Factor = DLA = F. M _f =	1.9431 87.5 22.3 17.8 1.7 1.4 42.37	m kN kNm kNm	
UF. M _{f.sw} = Load factor =	1.32 1.2	kNm	LUSAS model-"BCLB-Wheel load transverse on deck.mdl"
F. M _{f.sw} = UF. M _{f.asphalt} = Load factor =	1.584 0.704 1.5	kNm kNm	LUSAS model-"BCLB-Wheel load transverse on deck.mdl"
F. M _{f.asphalt} =	1.056	kNm	
Total F. M _f =	45.01	kNm	

Conclusioin

Mr>Mf, OK

DELCAN	SUBJECT:	SUBJECT: Burlington Canal Lift Bridge Analysis of Load-Carrying Capacity						252BTJ00	
		Tower Span and Approach Span Old Slab Capacity						of	3
	MADE BY:	DE BY: KL DATE: Jun. 18, 07 CHECKED BY:						ATE:	

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Tower Span-Transverse Reinforce	ment					
Bottom Reinforcement				Top Reinforcement		
f' _c =	20	MPa	14.6.3.2, p651	f' _c =	20	MPa
$\alpha_1 = 0.85 - 0.0015 f_c =$	0.820			$\alpha_1 = 0.85 - 0.0015 f_c =$	0.820	
$\beta_1 = 0.97 - 0.0025 f_c =$	0.920			$\beta_1 = 0.97 - 0.0025 f_c =$	0.920	
$\phi_s =$	0.9			$\phi_s =$	0.9	
f _y =	275	MPa	Tab 14.6.3.3, p651	f _y =	275	MPa
$\phi_c =$	0.75			$\phi_{c} =$	0.75	
b =	1000	mm		b =	1000	mm
#5 Rebar Diameter =	15.875	mm		#5 Rebar Diameter =	15.875	mm
A _{s-15M} =	197.9	mm ²		A _{s-15M} =	197.9	mm ²
Slab thickness, t _{slab} =	7.5	in		Depth of Cap =	7.5	in
	190.5	mm			190.5	mm
Clear Cover =	1.0	in, bot	dwg. 14	Clear Cover =	1.0	in, top
	25.4	mm			25.4	mm
d =	157.16	mm		d =	157.16	mm
Spacing =	6	in, bot		Spacing =	6	in top
-pg	152.4	mm		opaoing	152.4	mm
# of #5 bars =	6.562	per metre		# of #5 bars =	6.562	per metre
A _{trans.} =	1299	mm ²		A _{trans.} =	1299	mm²
$T_s = \phi_s A_s f_y =$	321.4	kN		$T_s = \phi_s A_s f_y =$	321.4	kN
$a = T_s/(\phi_c \alpha_1 f_c b) =$	26.13	mm		$a = T_s/(\phi_c \alpha_1 f_c b) =$	26.13	mm
Lever arm =	144	mm	_	Lever arm =	144	mm
M _r = T _s (Lever arm) =	46.3	kNm/m]	M _r = T _s (Lever arm) =	46.3	kNm

Tower Span-Longitudinal Reinforcement

Bottom Reinforcement						
f_{c} =	20	MPa	14.6.3.2, p651	f' _c =	20	MPa
α_1 =0.85-0.0015f _c =	0.82			α_1 =0.85-0.0015f _c =	0.82	
β ₁ =0.97-0.0025f' _c =	0.92			β ₁ =0.97-0.0025f' _c =	0.92	
$\phi_s =$	0.9			φ _s =	0.9	
f _y =	275	MPa	Tab 14.6.3.3, p651	f _y =	400	MPa
$\phi_c =$	0.75			φ _c =	0.75	
b =	1000	mm		b =	1000	mm
#5 Rebar Diameter =	15.875	mm		#5 Rebar Diameter =	15.875	mm
A _{s-15M} =	197.9	mm²		A _{s-15M} =	200	mm ²
Slab thickness, t _{slab} =	7.5	in		Depth of Cap =	7.5	in
	190.5	mm			190.5	mm
Clear Cover =	1.0	in, bot	dwg. 14	Clear Cover =	1.0	in, top
	25.4	mm			25.4	mm
d =	157.1625	mm				
Spacing =	9	in, bot		Spacing =	9	in, top
	228.6	mm			228.6	mm
# of 15M bars =	4.374	per metre		# of 15M bars =	4.374	per metre
A _{long.} =	866	mm ²		A _{long.} =	875	mm ²
$T_s = \phi_s A_s f_y =$	214.3	kN		$T_s = \phi_s A_s f_y =$	315.0	kN

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		Tower Span and Approach Span Old Slab Capacity				PAGE	2	of	3
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$a = T_s/(\phi_c \alpha_1 f_c b) =$	17.42	mm	$a = T_s/(\phi_c \alpha_1 f_c b) =$	25.61	mm	
Lever arm =	148.5	mm	Lever arm =	144	mm	
M _r = T _s (Lever arm) =	31.8	kNm/m	$M_r = T_s$ (Lever arm) =	45.5	kNm	

Empirical Design Method - cl 8.18.4

(b) Ratio of the spacing of the supporting beams to the thickness of the slab <=18 $S_{beams} = 1.8795 \text{ m}$

S_{beams}/t_{slab} = 9.9 ratio<=18, OK (c) the spacing of the supporting beams does not exceed 4.0 m spacing < 4.0 m, OK

Cast-in-Place Deck Slabs

(a) Calculate p

$$\label{eq:ptransverse} \begin{split} \rho_{transverse} &= A_{s.transverse}/A = & 0.008 \\ rho, trans.>0.003, OK \\ \rho_{long.} &= A_{s.long.}/A = & 0.006 \\ rho, long.>0.003, OK \\ (b) OK \\ (f) spacing < 300 mm, OK \end{split}$$

Concrete Deck Slabs	14.13.1.2,	p665	
t =	7.5 190.5 t>175mm	in mm	
$\mathbf{d}_{\mathbf{i}} = \mathbf{d}_{\mathbf{t}} = \mathbf{d} =$	157.1625	mm	
Transverse reinforcement			
spacing =	6	in	
	152.4	mm	
# of bars/m =	6.56		
A _{si} =	1299	mm ²	
Longitudinal reinforcement			
spacing =	9	in	
	228.6	mm	
# of bars/m =	4.37		
A _{si} =	866	mm ²	
$q = 50[A_{sl}/(bd_{l})+A_{st}/(bd_{t})] =$	0.689		
Read from Figure14.13.1.2.2(b)	non-compo	osite slab	
R _d =	800	kN	deck=190 mm, span=1.9 m, Figure 14.13.1.2.2(b), p666
F _a =	1.08		approximate, using q, read from figure 14.13.1.2.2(b), p666
F _c =	0.87		f' _c = 20 MPa
$R_n = R_d F_q F_c =$	750	kN	

DELCAN	SUBJECT:	Burlington Ca	nal Lift Bridge	JOB NO.	BT3252BTJ00			
		Tower Span and Approach Span Old Slab Capacity				PAGE	3 of	3
	MADE BY:	KL	DATE:	Jun. 18, 07	CHECKED BY:		DATE:	

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$$\phi_{md} = 0.5$$

R_f = ϕ_{md} R_n = 375 kN

5.7.1.7 Transverse Bending Moments in DecksCl. 5.7.1.7.1, 186Treat it as simple span deck using maximum wheel load of CL-625 TruckM = (S+0.6)P/10

S = P = M = (S+0.6)P/10 = M _f = 80%M = Live Load Factor = DLA =	1.9431 87.5 22.3 17.8 1.7 1.4	m kN kNm kNm	
F. M _f =	42.37	kNm	
UF. M _{f.sw} = Load factor = F. M _{f.sw} =	1.32 1.2 1.584	kNm kNm	LUSAS model-"BCLB-Wheel load transverse on deck.mdl"
UF. M _{f.asphalt} = Load factor = F. M _{f.asphalt} =	0.704 1.5 1.056	kNm kNm	LUSAS model-"BCLB-Wheel load transverse on deck.mdl"
Total F. M _f =	45.01	kNm	
Conclusioin	Mr>Mf, Oł	(