FOR:	JOB NO:	SHEET NO:
MADE BY:	CHECKED BY:	BACKCHECKED BY:
DATE:	DATE:	DATE:

HNTB

$$\boxed{\text{Calculations for RFI 406}}$$

- Haunch & Shear Stud Checks
- Girder design checks @ G5

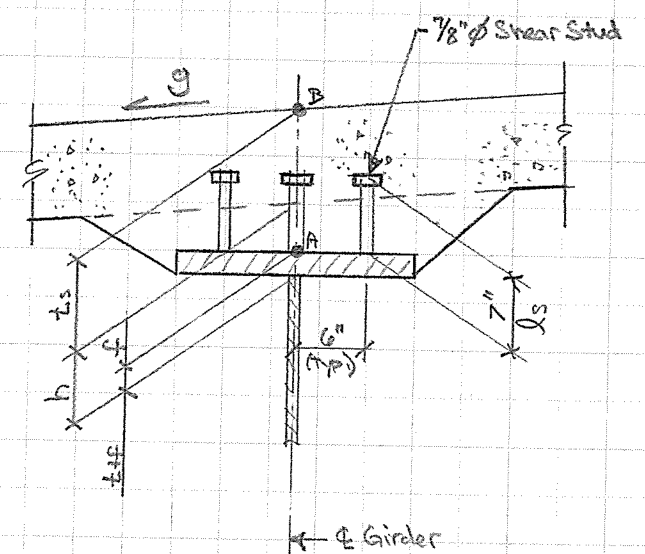
ME-101-1204

FOR: Ramp A5	JOB NO: 49633	SHEET NO:
MADE BY: LER	CHECKED BY:	BACKCHECKED BY:
DATE: 6/26/12	DATE:	DATE:

HNTB

Haunch Variation (Spans 1 & 2)

Evaluate variation of "sag" observed at girders 4 & 5 in span 1 and corresponding implications to concrete dead load and shear stud height along girders.



t_s = slab thickness
= 9.25"

h = haunch thickness
= 4.75" (constant), except at span 1; see slab haunching tables on Sheet 54a/62 in RFC plans

t_{tf} = thickness of top flange

t = fillet thickness; 2" (min) and 5" (max) per ODOT BDM 405.2.
= $h - t_{tf}$

Shear Studs - per AASHTO 6.10.10.1.4:
min. pen. into deck = 2"
min. cover over stud = 2"

Elev. A — elev. at top of girder prior to deck placement (steel only)

Elev. B - elev. at top of deck over ℄ girder in final position

$\Delta_{slab+DC}$ = girder deflection due to dead loads other than steel dead load and FWS.

Δh = variation in haunch thickness from measured value to plan value
$= h_{measured} - h_{plan}$

$\Delta h_{measured} = [\text{Elev. B} - (\text{Elev. A} - \Delta_{slab+DC})] - t_s + t_{tf}$

Δw_h = change in haunch weight
$= b_h * \Delta h$
b_h = 33" for BDGS Model

g = cross slope of deck; 5.3% (max)

l_s = stud height

ME-101-1204

For	Cleveland - Ramp A5	Job No.	49633	Sheet No.	
Made by	LER	Checked by		Backchecked by	
Date	10/3/12	Date		Date	

HNTB

GRDER 4 HAUNCH VARIATION (SPANS 1 AND 2)

Point	t_{tf} (in)	h_{plan} (in)	Top Girder Elev.	Top Slab Elev.	$\Delta_{slab+DC}$ (in)	$h_{measured}$ (in)	$t_{measured}$ (in)	Δh (in)	Δw_h (kip/ft)	Shear Studs Cover$_{min}$ (in)	Shear Studs Embed$_{min}$ (in)	
1.0000	1.25	4.75	671.17	672.23	0.0000	4.73	3.48	-0.02	0.00	5.41	3.20	OK
1.0500	1.25	4.75	671.65	672.65	-0.8492	4.79	3.54	0.04	0.00	5.47	3.14	OK
1.1000	1.25	4.75	NA	673.08	-1.6873							
1.1500	1.25	4.75	672.60	673.50	-2.4761	5.25	4.00	0.50	0.02	5.93	2.68	OK
1.2000	1.25	4.75	673.04	673.91	-3.1813	5.56	4.31	0.81	0.03	6.24	2.38	OK
1.2109	1.375	4.75	NA	674.00	-3.3209							
1.2500	1.375	4.75	673.50	674.32	-3.7751	5.70	4.32	0.95	0.03	6.26	2.36	OK
1.3000	1.375	4.625	673.92	674.70	-4.2395	5.66	4.29	1.04	0.04	6.22	2.39	OK
1.3500	1.375	4.625	674.34	675.08	-4.5594	5.59	4.21	0.96	0.03	6.15	2.47	OK
1.4000	1.375	4.5625	674.73	675.45	-4.7257	5.49	4.12	0.93	0.03	6.05	2.57	OK
1.4500	1.375	4.5	675.12	675.83	-4.7369	5.41	4.03	0.91	0.03	5.96	2.65	OK
1.5000	1.375	4.4375	675.49	676.21	-4.5979	5.34	3.96	0.90	0.03	5.90	2.72	OK
1.5500	1.375	4.375	675.87	676.59	-4.3201	5.01	3.63	0.63	0.02	5.56	3.05	OK
1.6000	1.375	4.3125	676.22	676.96	-3.9212	4.92	3.55	0.61	0.02	5.48	3.14	OK
1.6500	1.375	4.5	676.60	677.40	-3.4329	5.12	3.75	0.62	0.02	5.68	2.94	OK
1.6986	1.75	4.75	NA	677.83	-2.9119							
1.7000	1.75	4.75	677.01	677.84	-2.8964	5.34	3.59	0.59	0.02	5.53	3.09	OK
1.7500	1.75	4.75	677.39	678.26	-2.3395	5.26	3.51	0.51	0.02	5.44	3.17	OK
1.8000	1.75	4.75	677.78	678.68	-1.7871	5.16	3.41	0.41	0.01	5.34	3.27	OK
1.8500	1.75	4.75	678.16	679.10	-1.2617	5.08	3.33	0.33	0.01	5.26	3.35	OK
1.9000	2.75	4.75	678.63	679.53	-0.7818	5.05	2.30	0.30	0.01	4.23	4.38	OK
1.9500	2.75	4.75	679.02	679.95	-0.3549	5.01	2.26	0.26	0.01	4.19	4.42	OK
2.0000	2.75	4.75	679.42	680.37	0.0000	4.90	2.15	0.15	0.01	4.08	4.54	OK
2.0500	2.75	4.75	679.82	680.78	0.2161	4.74	1.99	-0.01	0.00	3.92	4.69	OK
2.1000	2.75	4.75	680.23	681.19	0.3592	4.56	1.81	-0.19	-0.01	3.75	4.87	OK
2.1500	1.75	4.75	680.57	681.60	0.4428	4.34	2.59	-0.41	-0.01	4.52	4.09	OK
2.2000	1.75	4.75	680.99	682.00	0.4659	4.21	2.46	-0.54	-0.02	4.39	4.22	OK
2.2500	1.75	4.75	681.41	682.41	0.4367	4.12	2.37	-0.63	-0.02	4.30	4.31	OK
2.3000	1.75	4.75	681.83	682.82	0.3708	3.99	2.24	-0.76	-0.03	4.17	4.44	OK
2.3500	1.75	4.75	682.25	683.23	0.2811	3.96	2.21	-0.79	-0.03	4.15	4.47	OK
2.4000	1.75	4.75	682.67	683.64	0.1791	3.95	2.20	-0.80	-0.03	4.14	4.48	OK
1.4236	1.75	4.75	NA	683.84	0.1295							
2.4500	1.25	4.75	683.05	684.05	0.0744	3.95	2.70	-0.80	-0.03	4.63	3.98	OK
2.5000	1.25	4.75	683.47	684.46	-0.0241	3.86	2.61	-0.89	-0.03	4.55	4.07	OK
2.5500	1.25	4.75	683.89	684.87	-0.1078	3.88	2.63	-0.87	-0.03	4.56	4.05	OK
2.6000	1.25	4.75	684.30	685.28	-0.1696	3.97	2.72	-0.78	-0.03	4.65	3.97	OK
2.6500	1.25	4.75	684.70	685.69	-0.2054	4.08	2.83	-0.67	-0.02	4.76	3.85	OK
2.7000	1.25	4.75	685.10	686.10	-0.2144	4.19	2.94	-0.56	-0.02	4.87	3.74	OK
2.7500	1.25	4.75	685.49	686.51	-0.1984	4.35	3.10	-0.40	-0.01	5.03	3.58	OK
2.8000	1.25	4.75	685.89	686.91	-0.1622	4.42	3.17	-0.33	-0.01	5.10	3.52	OK
2.8500	1.25	4.75	686.29	687.32	-0.1130	4.54	3.29	-0.21	-0.01	5.22	3.40	OK
2.9000	1.25	4.75	686.69	687.73	-0.0608	4.58	3.33	-0.17	-0.01	5.26	3.36	OK
2.9500	1.25	4.75	687.08	688.14	-0.0180	4.81	3.56	0.06	0.00	5.49	3.12	OK
3.0000	1.25	4.75	687.49	688.55	0.0000	4.79	3.54	0.04	0.00	5.48	3.14	OK

Δw_{h_avg} =	0.00	kip/ft
Δw_{h_max} =	0.04	kip/ft
Δw_{h_min} =	-0.03	kip/ft
Δh_{avg} =	0.04	in
Δh_{max} =	1.04	in
Δh_{min} =	-0.89	in
t_{max} =	4.32	in
t_{min} =	1.81	in

For	Cleveland - Ramp A5	Job No.	49633	Sheet No.	
Made by	LER	Checked by		Backchecked by	
Date	10/3/12	Date		Date	

HNTB

GRDER 5 HAUNCH VARIATION (SPANS 1 AND 2)

Δw_{h_avg} =	0.01	kip/ft
Δw_{h_max} =	0.08	kip/ft
Δw_{h_min} =	-0.06	kip/ft
Δh_{avg} =	0.16	in
Δh_{max} =	2.42	in
Δh_{min} =	-1.65	in
t_{max} =	5.40	in
t_{min} =	1.25	in

Point	t_{tf} (in)	h_{plan} (in)	Top Girder Elev.	Top Slab Elev.	$\Delta_{slab+DC}$ (in)	$h_{measured}$ (in)	$t_{measured}$ (in)	Δh (in)	Δw_h (kip/ft)	Shear Studs $Cover_{min}$ (in)	Shear Studs $Embed_{min}$ (in)	
1.0000	1.5	4.75	671.83	672.87	0.0000	4.78	3.28	0.03	0.00	5.21	3.40	OK
1.0500	1.5	4.75	672.31	673.31	-1.0464	5.28	3.78	0.53	0.02	5.72	2.90	OK
1.1000	1.5	4.75	672.77	673.73	-2.0536	5.86	4.36	1.11	0.04	6.29	2.32	OK
1.1500	1.5	4.75	673.19	674.13	-2.9800	6.44	4.94	1.69	0.06	6.87	1.74	NG
1.1999	1.625	4.75	NA	674.52	-3.7915							
1.2000	1.625	4.75	673.71	674.52	-3.7924	5.94	4.32	1.19	0.04	6.25	2.37	OK
1.2500	1.625	4.6875	674.06	674.91	-4.4670	7.03	5.40	2.34	0.08	7.34	1.28	NG
1.3000	1.625	4.5625	674.45	675.25	-4.9872	6.99	5.36	2.42	0.08	7.29	1.32	NG
1.3500	1.625	4.5	674.83	675.59	-5.3397	6.86	5.23	2.36	0.08	7.17	1.45	NG
1.4000	1.625	4.375	675.20	675.93	-5.5169	6.69	5.07	2.32	0.08	7.00	1.61	NG
1.4500	1.625	4.3125	675.55	676.28	-5.5190	6.55	4.93	2.24	0.08	6.86	1.75	NG
1.5000	1.625	4.1875	675.91	676.62	-5.3523	6.19	4.57	2.01	0.07	6.50	2.11	OK
1.5500	1.625	4.125	676.25	676.96	-5.0298	5.86	4.24	1.74	0.06	6.17	2.44	OK
1.6000	1.625	4	676.58	677.30	-4.5707	5.59	3.97	1.59	0.05	5.90	2.72	OK
1.6500	1.625	4.3125	676.94	677.71	-4.0089	5.68	4.06	1.37	0.05	5.99	2.62	OK
1.7000	1.625	4.75	677.39	678.15	-3.3921	4.87	3.24	0.12	0.00	5.18	3.44	OK
1.7028	1.75	4.75	NA	678.18	-3.3566							
1.7500	1.75	4.75	677.68	678.56	-2.7499	5.78	4.03	1.03	0.04	5.96	2.65	OK
1.8000	1.75	4.75	678.04	678.97	-2.1101	5.72	3.97	0.97	0.03	5.90	2.72	OK
1.8500	1.75	4.75	678.42	679.38	-1.4983	5.52	3.77	0.77	0.03	5.70	2.91	OK
1.9000	2.75	4.75	678.86	679.77	-0.9364	5.32	2.57	0.57	0.02	4.50	4.11	OK
1.9500	2.75	4.75	679.21	680.15	-0.4308	5.22	2.47	0.47	0.02	4.40	4.21	OK
2.0000	2.75	4.75	679.57	680.54	0.0000	5.10	2.35	0.35	0.01	4.28	4.33	OK
2.0500	2.75	4.75	679.94	680.90	0.2741	4.76	2.01	0.01	0.00	3.94	4.67	OK
2.1000	2.75	4.75	680.32	681.28	0.4747	4.48	1.73	-0.27	-0.01	3.66	4.95	OK
2.1500	2	4.75	680.68	681.66	0.6138	3.94	1.94	-0.81	-0.03	3.88	4.74	OK
2.2000	2	4.75	681.09	682.06	0.6918	3.67	1.67	-1.08	-0.04	3.60	5.01	OK
2.2500	2	4.75	681.49	682.45	0.7155	3.54	1.54	-1.21	-0.04	3.48	5.14	OK
2.3000	2	4.75	681.90	682.84	0.6974	3.37	1.37	-1.38	-0.05	3.30	5.31	OK
2.3500	2	4.75	682.30	683.23	0.6489	3.30	1.30	-1.45	-0.05	3.23	5.39	OK
2.4000	2	4.75	682.70	683.63	0.5801	3.25	1.25	-1.50	-0.05	3.18	5.44	OK
1.4237	2	4.75	NA	683.81	0.5431							
2.4500	1.25	4.75	683.04	684.02	0.4992	3.24	1.99	-1.51	-0.05	3.93	4.69	OK
2.5000	1.25	4.75	683.45	684.41	0.4092	3.17	1.92	-1.58	-0.05	3.86	4.76	OK
2.5500	1.25	4.75	683.85	684.80	0.3189	3.10	1.85	-1.65	-0.06	3.78	4.83	OK
2.6000	1.25	4.75	684.24	685.20	0.2364	3.24	1.99	-1.51	-0.05	3.92	4.69	OK
2.6500	1.25	4.75	684.63	685.59	0.1672	3.37	2.12	-1.38	-0.05	4.05	4.56	OK
2.7000	1.25	4.75	685.02	685.98	0.1145	3.43	2.18	-1.32	-0.05	4.11	4.50	OK
2.7500	1.25	4.75	685.40	686.37	0.0788	3.60	2.35	-1.15	-0.04	4.28	4.34	OK
2.8000	1.25	4.75	685.78	686.77	0.0584	3.78	2.53	-0.97	-0.03	4.46	4.15	OK
2.8500	1.25	4.75	686.16	687.16	0.0484	3.95	2.70	-0.80	-0.03	4.63	3.99	OK
2.9000	1.25	4.75	686.53	687.55	0.0421	4.23	2.98	-0.52	-0.02	4.91	3.70	OK
2.9500	1.25	4.75	686.90	687.94	0.0299	4.46	3.21	-0.29	-0.01	5.14	3.47	OK
3.0000	1.25	4.75	687.28	688.34	0.0000	4.63	3.38	-0.12	0.00	5.31	3.30	OK

use 8" stud

GIRDER 4 / Span1

Ramp A5						Girder 4
Screed Point	**Top of Flange (Surveyed)**	**Top of Haunch**	**Concrete Haunch**	**Top Flange**	**Surveyed Haunch**	**Theo. Haunch**
CL Brg [Rr]	671.17	671.46	0.30	0.10	0.40	0.40
0.05	671.65	671.95	0.30	0.10	0.40	0.40
0.10	#DIV/0!	672.45	#DIV/0!	0.10	#DIV/0!	0.40
0.15	672.60	672.94	0.34	0.10	0.45	0.40
0.20	673.04	673.40	0.36	0.10	0.46	0.40
0.25	673.50	673.86	0.36	0.11	0.47	0.40
0.30	673.92	674.28	0.36	0.11	0.47	0.39
0.35	674.34	674.69	0.36	0.11	0.47	0.39
0.40	674.73	675.08	0.35	0.11	0.46	0.38
0.45	675.12	675.46	0.34	0.11	0.45	0.38
0.50	675.49	675.82	0.33	0.11	0.44	0.37
0.55	675.87	676.18	0.31	0.11	0.42	0.36
0.60	676.22	676.52	0.30	0.11	0.41	0.36
0.65	676.60	676.91	0.31	0.11	0.42	0.38
0.70	677.01	677.31	0.30	0.15	0.45	0.40
0.75	677.39	677.68	0.29	0.15	0.44	0.40
0.80	677.78	678.06	0.28	0.15	0.43	0.40
0.85	678.16	678.43	0.27	0.15	0.42	0.40
0.90	678.63	678.81	0.18	0.23	0.41	0.40
0.95	679.02	679.21	0.19	0.23	0.42	0.40
CL Brg [P1]	679.42	679.60	0.18	0.23	0.41	0.40

GIRDER 4 /Span 2

Ramp A5						Girder 4
Screed Point	Top of Flange (Surveyed)	Top of Haunch	Concrete Haunch	Top Flange	Surveyed Haunch	Theo. Haunch
CL Brg [P1]	679.42	679.60	0.18	0.23	0.41	0.40
0.05	679.82	679.99	0.17	0.23	0.40	0.40
0.10	680.23	680.39	0.16	0.23	0.39	0.40
0.15	680.57	680.79	0.22	0.15	0.37	0.40
0.20	680.99	681.19	0.20	0.15	0.35	0.40
0.25	681.41	681.60	0.19	0.15	0.34	0.40
0.30	681.83	682.02	0.19	0.15	0.34	0.40
0.35	682.25	682.44	0.19	0.15	0.34	0.40
0.40	682.67	682.85	0.18	0.15	0.33	0.40
0.45	683.05	683.27	0.22	0.10	0.32	0.40
0.50	683.47	683.69	0.22	0.10	0.32	0.40
0.55	683.89	684.11	0.22	0.10	0.32	0.40
0.60	684.30	684.52	0.22	0.10	0.32	0.40
0.65	684.70	684.94	0.24	0.10	0.34	0.40
0.70	685.10	685.35	0.25	0.10	0.35	0.40
0.75	685.49	685.76	0.27	0.10	0.37	0.40
0.80	685.89	686.15	0.26	0.10	0.36	0.40
0.85	686.29	686.56	0.27	0.10	0.37	0.40
0.90	686.69	686.96	0.27	0.10	0.37	0.40
0.95	687.08	687.37	0.29	0.10	0.39	0.40
CL Brg [P2]	687.49	687.78	0.29	0.10	0.39	0.40

GIRDER 5 / Span 1

Ramp A5						Girder 5
Screed Point	Top of Flange (Surveyed)	Top of Haunch	Concrete Haunch	Top Flange	Surveyed Haunch	Theo. Haunch
CL Brg [Rr]	671.83	672.10	0.27	0.13	0.40	0.40
0.05	672.31	672.63	0.32	0.13	0.45	0.40
0.10	672.77	673.13	0.36	0.13	0.49	0.40
0.15	673.19	673.61	0.42	0.13	0.54	0.40
0.20	673.71	674.07	0.36	0.14	0.50	0.40
0.25	674.06	674.51	0.45	0.14	0.58	0.39
0.30	674.45	674.90	0.45	0.14	0.59	0.38
0.35	674.83	675.27	0.44	0.14	0.58	0.38
0.40	675.20	675.62	0.42	0.14	0.55	0.36
0.45	675.55	675.96	0.41	0.14	0.54	0.36
0.50	675.91	676.29	0.38	0.14	0.51	0.35
0.55	676.25	676.61	0.36	0.14	0.49	0.34
0.60	676.58	676.91	0.33	0.14	0.47	0.33
0.65	676.94	677.28	0.34	0.14	0.48	0.36
0.70	677.39	677.66	0.27	0.21	0.47	0.40
0.75	677.68	678.02	0.34	0.15	0.48	0.40
0.80	678.04	678.38	0.34	0.15	0.48	0.40
0.85	678.42	678.72	0.31	0.15	0.45	0.40
0.90	678.86	679.08	0.22	0.23	0.45	0.40
0.95	679.21	679.42	0.21	0.23	0.44	0.40
CL Brg [P1]	679.57	679.77	0.20	0.23	0.43	0.40

Check Stud Embed

$h = 0.59 \times 12 = 7.08''$

$t_{tf} = 1.625''$

$X_{slope} = 5.3\%$

Stud Spa. = 6"

$l_{std} = 7''$

$7'' - (7.08 - 1.625 + 6 \times 0.053)$

$= 1.23'' < 2''$ NG.

$\therefore$ use 8" stud

GIRDER 5 /Span 2

Ramp A5						Girder 5
Screed Point	Top of Flange (Surveyed)	Top of Haunch	Concrete Haunch	Top Flange	Surveyed Haunch	Theo. Haunch
CL Brg [P1]	679.57	679.77	0.20	0.23	0.43	0.40
0.05	679.94	680.11	0.17	0.23	0.40	0.40
0.10	680.32	680.47	0.15	0.23	0.38	0.40
0.15	680.68	680.84	0.16	0.17	0.33	0.40
0.20	681.09	681.23	0.14	0.17	0.31	0.40
0.25	681.49	681.62	0.13	0.17	0.30	0.40
0.30	681.90	682.01	0.11	0.17	0.28	0.40
0.35	682.30	682.41	0.11	0.17	0.28	0.40
0.40	682.70	682.81	0.11	0.17	0.28	0.40
0.45	683.04	683.21	0.17	0.10	0.27	0.40
0.50	683.45	683.61	0.16	0.10	0.26	0.40
0.55	683.85	684.00	0.15	0.10	0.25	0.40
0.60	684.24	684.41	0.17	0.10	0.27	0.40
0.65	684.63	684.81	0.18	0.10	0.28	0.40
0.70	685.02	685.20	0.18	0.10	0.28	0.40
0.75	685.40	685.59	0.19	0.10	0.29	0.40
0.80	685.78	685.99	0.21	0.10	0.31	0.40
0.85	686.16	686.39	0.23	0.10	0.33	0.40
0.90	686.53	686.78	0.25	0.10	0.35	0.40
0.95	686.90	687.17	0.27	0.10	0.37	0.40
CL Brg [P2]	687.28	687.57	0.29	0.10	0.39	0.40

FOR: Ramp A5	JOB NO: 49633	SHEET NO:
MADE BY: LER	CHECKED BY:	BACKCHECKED BY:
DATE: 10/1/12	DATE:	DATE:

HNTB

Span 1 Erection / Steel DL Stresses Disposition Post Jacking

Walsh completed the corrective jacking procedures at span 1 of Ramp A5 as detailed by Genesis Structures in their August 23, 2012 submittal.

Survey of the 0.55L pts. indicate that the magnituded of correction to top of girder elevations is consistant with that predicted by Genisis.

Using the flange stresses provided by Genesis in their Aug. submittal, and assuming their justification by the good correspondace between measured and predicted correction magnitudes, girder 5 was checked at critical pts. 0.355L & 1.0L. Refer to the attached calculations. The results in the format of design ratios at top & bot. flanges are summarized below.

@ 0.355L

Case	TF	BF
Cost.	0.88	0.60
Final	0.86	0.96
Orig. Design	0.96	0.97

@ 1.00 L

Case	TF	BF
Cost.	0.54	0.51
Final	0.73	0.85
Orig. Design	0.80	0.81

All design ratios are <1.0.

Conclusion

The girders are capable of sustaining the estimated steel dead load stress after the corrective jacking procedures without overstresses durring construction or in the final condition of the structure based on the design material strength of 50 ksi.

Est. rotation after slab pour is about 1/2" to 3/4" at G3-G5 @ 0.55L (over 8' web depth).

ME-101-1204

----- GIRDER 5 FLANGE PLATE AREA REQUIRED FOR STRENGTH/CONSTRUCTIBILITY (* = DIFFERENT THAN INPUT) -------------

SPAN.LOC	TOP FLANGE						BOTTOM FLANGE					
	INP AREA	REQ AREA	NG	WIDTH	THICK	STRESS	INP AREA	REQ AREA	NG	WIDTH	THICK	STRESS
FRAC	(in²)	(in²)		(in)	(in)	RATIO	(in²)	(in²)		(in)	(in)	RATIO
1.226	45.5	45.5		28.0000	1.6250	0.83	67.5	67.5		36.0000	1.8750	0.84
1.250	45.5	45.5		28.0000	1.6250	0.87	67.5	67.5		36.0000	1.8750	0.87
1.258	45.5	45.5		28.0000	1.6250	0.88	67.5	67.5		36.0000	1.8750	0.89
1.290	45.5	45.5		28.0000	1.6250	0.93	67.5	67.5		36.0000	1.8750	0.93
1.300	45.5	45.5		28.0000	1.6250	0.93	67.5	67.5		36.0000	1.8750	0.94
1.323	45.5	45.5		28.0000	1.6250	0.95	67.5	67.5		36.0000	1.8750	0.96
1.350	45.5	45.5		28.0000	1.6250	0.96	67.5	67.5		36.0000	1.8750	0.97
1.355	45.5	45.5		28.0000	1.6250	0.96	67.5	67.5		36.0000	1.8750	0.97
1.387	45.5	45.5		28.0000	1.6250	0.96	67.5	67.5		36.0000	1.8750	0.97
1.400	45.5	45.5		28.0000	1.6250	0.95	67.5	67.5		36.0000	1.8750	0.97
1.419	45.5	45.5		28.0000	1.6250	0.94	67.5	67.5		36.0000	1.8750	0.96
1.450	45.5	45.5		28.0000	1.6250	0.91	67.5	67.5		36.0000	1.8750	0.93
1.452	45.5	45.5		28.0000	1.6250	0.90	67.5	67.5		36.0000	1.8750	0.93
1.484	45.5	45.5		28.0000	1.6250	0.86	67.5	67.5		36.0000	1.8750	0.89
1.500	45.5	45.5		28.0000	1.6250	0.82	67.5	67.5		36.0000	1.8750	0.86
1.516	45.5	45.5		28.0000	1.6250	0.79	67.5	67.5		36.0000	1.8750	0.82
1.548	45.5	45.5		28.0000	1.6250	0.72	67.5	67.5		36.0000	1.8750	0.76
1.548	45.5	45.5		28.0000	1.6250	0.71	67.5	67.5		36.0000	1.8750	0.76
1.549	45.5	45.5		28.0000	1.6250	0.71	67.5	67.5		36.0000	1.8750	0.75
1.550	45.5	45.5		28.0000	1.6250	0.71	67.5	67.5		36.0000	1.8750	0.75
1.581	45.5	45.5		28.0000	1.6250	0.62	67.5	67.5		36.0000	1.8750	0.67
1.600	45.5	45.5		28.0000	1.6250	0.56	67.5	67.5		36.0000	1.8750	0.61
1.600	45.5	45.5		28.0000	1.6250	0.55	67.5	67.5		36.0000	1.8750	0.61
1.613	45.5	45.5		28.0000	1.6250	0.51	67.5	67.5		36.0000	1.8750	0.57
1.615	45.5	45.5		28.0000	1.6250	0.50	67.5	67.5		36.0000	1.8750	0.56
1.615	45.5	45.5		28.0000	1.6250	0.50	67.5	67.5		36.0000	1.8750	0.53
1.619	45.5	45.5		28.0000	1.6250	0.49	67.5	67.5		36.0000	1.8750	0.52
1.622	45.5	45.5		28.0000	1.6250	0.48	67.5	67.5		36.0000	1.8750	0.51
1.645	45.5	45.5		28.0000	1.6250	0.39	67.5	67.5		36.0000	1.8750	0.44
1.650	45.5	45.5		28.0000	1.6250	0.38	67.5	67.5		36.0000	1.8750	0.42
1.677	45.5	45.5		28.0000	1.6250	0.27	67.5	67.5		36.0000	1.8750	0.33
1.700	45.5	45.5		28.0000	1.6250	0.20	67.5	67.5		36.0000	1.8750	0.25
1.703	45.5	45.5		28.0000	1.6250	0.19	67.5	67.5		36.0000	1.8750	0.24
1.703	63.0	63.0		36.0000	1.7500	0.16	66.5	66.5		38.0000	1.7500	0.24
1.709	63.0	63.0		36.0000	1.7500	0.14	66.5	66.5		38.0000	1.7500	0.22
1.742	63.0	63.0		36.0000	1.7500	0.09	66.5	66.5		38.0000	1.7500	0.10
1.742	63.0	63.0		36.0000	1.7500	0.09	66.5	66.5		38.0000	1.7500	0.11
1.750	63.0	63.0		36.0000	1.7500	0.11	66.5	66.5		38.0000	1.7500	0.13
1.774	63.0	63.0		36.0000	1.7500	0.19	66.5	66.5		38.0000	1.7500	0.21
1.800	63.0	63.0		36.0000	1.7500	0.28	66.5	66.5		38.0000	1.7500	0.31
1.806	63.0	63.0		36.0000	1.7500	0.30	66.5	66.5		38.0000	1.7500	0.34
1.838	63.0	63.0		36.0000	1.7500	0.43	66.5	66.5		38.0000	1.7500	0.47
1.850	63.0	63.0		36.0000	1.7500	0.47	66.5	66.5		38.0000	1.7500	0.52
1.865	63.0	63.0		36.0000	1.7500	0.53	66.5	66.5		38.0000	1.7500	0.59
1.865	99.0	99.0		36.0000	2.7500	0.37	104.5	104.5		38.0000	2.7500	0.37
1.871	99.0	99.0		36.0000	2.7500	0.38	104.5	104.5		38.0000	2.7500	0.39
1.900	99.0	99.0		36.0000	2.7500	0.47	104.5	104.5		38.0000	2.7500	0.47
1.903	99.0	99.0		36.0000	2.7500	0.48	104.5	104.5		38.0000	2.7500	0.48
1.935	99.0	99.0		36.0000	2.7500	0.58	104.5	104.5		38.0000	2.7500	0.58
1.950	99.0	99.0		36.0000	2.7500	0.62	104.5	104.5		38.0000	2.7500	0.63
1.968	99.0	99.0		36.0000	2.7500	0.69	104.5	104.5		38.0000	2.7500	0.69
2.000	99.0	99.0		36.0000	2.7500	0.80	104.5	104.5		38.0000	2.7500	0.81
2.000	99.0	99.0		36.0000	2.7500	0.80	104.5	104.5		38.0000	2.7500	0.80
2.034	99.0	99.0		36.0000	2.7500	0.72	104.5	104.5		38.0000	2.7500	0.72
2.050	99.0	99.0		36.0000	2.7500	0.68	104.5	104.5		38.0000	2.7500	0.68
2.068	99.0	99.0		36.0000	2.7500	0.64	104.5	104.5		38.0000	2.7500	0.64
2.100	99.0	99.0		36.0000	2.7500	0.57	104.5	104.5		38.0000	2.7500	0.57
2.110	99.0	99.0		36.0000	2.7500	0.55	104.5	104.5		38.0000	2.7500	0.55
2.141	99.0	99.0		36.0000	2.7500	0.49	104.5	104.5		38.0000	2.7500	0.49
2.141	72.0	72.0		36.0000	2.0000	0.64	76.0	76.0		38.0000	2.0000	0.66
2.150	72.0	72.0		36.0000	2.0000	0.62	76.0	76.0		38.0000	2.0000	0.64
2.153	72.0	72.0		36.0000	2.0000	0.61	76.0	76.0		38.0000	2.0000	0.63
2.195	72.0	72.0		36.0000	2.0000	0.52	76.0	76.0		38.0000	2.0000	0.54
2.200	72.0	72.0		36.0000	2.0000	0.51	76.0	76.0		38.0000	2.0000	0.53

COMPRESSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced compression flange per AASHTO 6.10.8.2. The flexural resistance will be the minimum of the local buckling resistance and the lateral torsional buckling resistance.

INPUT [G5, Span 1, Section 2, 1.355L, Const.]

Materials:

Steel -	F_y =	50	ksi
	E =	29000	ksi
	$F_{yr} = 0.7\ F_y$ =	35	ksi

Section:

Compression Flange -	b_{fc} =	28	in
	t_{fc} =	1.625	in
Web -	D =	96	in
	t_w =	0.6875	in
Tension Flange -	b_{ft} =	36	in
	t_{ft} =	1.875	in

Bracing:

Unbraced Length -	L_b =	11.93	ft

Factored Flange Stresses:

Compression Flange -	f_{ub_c} =	-33.63	ksi
Tension Flange -	f_{ub_t} =	26.48	ksi
Lateral Flange Stress -	f_{l_c} =	6.68	ksi
	f_{l_t} =	3.43	ksi

*Positve tension, negative compression.

WEB LOAD-SHEDDING FACTOR

Calcualte web load-shedding factor, R_b, per AASHTO 6.10.1.10.2.

$R_b = 1 - [a_w / (1200+300a_w)][2D_c/t_w - \lambda_{rw}] \leq 1.0$

$D_c = D_t\,[(-f_{bu\_c})/(-f_{bu\_c} + f_{bu\_t})] - t_{fc}$

= 54.04 in

$a_w = (2D_c\,t_w) / (b_{fc}\,t_{fc})$

= 1.63

$\lambda_{rw} = 5.7\ \sqrt{(E/Fy)}$

= 137.3

R_b = **0.981**

LOCAL BUCKLING RESISTANCE [6.10.8.2]

Calculate the slenderness parameters:

$\lambda_f = b_{fc} / 2t_{fc}$

= 8.62

$\lambda_{pf} = 0.38\ \sqrt{(E/F_y)}$

= 9.15

$\lambda_{rf} = 0.56\ \sqrt{(E/F_{yr})}$

= 16.12

If $\lambda_f \leq \lambda_{pf}$, then:

$F_{nc} = R_b\,R_h\,F_y$ ($R_h = 1.00$)

= 49.04 ksi <=== Controls

Else:

$F_{nc} = [1 - (1 - F_{yr}/(R_hF_y))((\lambda_f - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]\ R_b\,R_h\,F_y$

= 50.17 ksi

F_{nc_1} = **49.04** ksi

LATERAL TORSIONAL BUCKLING RESISTANCE [6.10.8.3]

Calculate braced length parameters:

$r_t = b_{fc} / \sqrt{(12*(1 + (1/3)((D_ct_w)/(b_{fc})(t_{fc}))))}$

= 7.17

$L_p = 1.0\ r_t\ \sqrt{(E/F_y)}$

= 172.59 in

$L_r = \pi\ r_t\ \sqrt{(E/F_{yr})}$

648.05 in

L_b = 143.16 in

Calculate elastic torsional buckling stress.

$F_{cr} = C_b\,R_b\,\pi^2\,E / (L_b/r_t)^2$ (Assume $C_b = 1.00$)

= 703.37 ksi

If $L_b \leq L_p$, then:

$F_{nc} = R_b\,R_h\,F_y$ ($R_h = 1.00$)

= 49.04 ksi <===Controls

If $L_b > L_r$, then:

$F_{nc} = F_{cr} \leq R_b\,R_h\,R_y$

= 49.04 ksi

Else:

$F_{nc} = C_b\,[1 - (1 - F_{yr}/(R_hF_y))((L_f - L_{pf})/(L_{rf} - L_{pf})]\ R_b\,R_h\,F_y$

= 49.04 ksi

F_{nc_2} = **49.04** ksi

$F_{nc} = \mathrm{MIN}[F_{nc\_1}, F_{nc\_2}]$

= **49.04** ksi

AMPLIFICATION FACTOR [6.10.1.6]

Calculate the amplification factor to account for 2nd order effects (if applicable).

$L_p' = 1.2\ L_p\ \sqrt{((C_b\ R_b)/(f_{bu}/F_y))}$
$= 250.08$

For $L_b \le L_p'$:

$A_F = 1.00$

Else:

$A_F = [0.85/(1-f_{bu}/F_{cr})]$
$= 0.89$

$A_F =$ **1.00**

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.3.2.1. Note that $\phi_f = 1.0$.

$R = [f_{bu} + A_F\ f_l]/R_h F_{yc}$ (6.10.3.2.1-1)
for $R_h =$ 1.0
$R = 0.81$

$R = [f_{bu} + A_F\ f_l/3]/F_{nc}$ (6.10.3.2.1-2)
$= 0.73$

R = **0.81** **OK**

CHECK WEB BEND-BUCKLING RESISTANCE

For slender webs, check web bend bucking resistance per AASHTO 6.10.3.2.1. Note that $\phi_f = 1.0$.

Check web slenderness:

$2D_c/t_w \le 5.7\ \sqrt{(E/F_{yc})}$
$2D_c/t_w = 157$
$5.7\ \sqrt{(E/F_{yc})} = 137$ **Consider Web Bend-Bucking**

$F_{crw} = [0.9\ E\ k] / (D/t_w)^2 \le \min(R_h\ F_{yc}, F_{yw}/0.7)$

$k = 9 / (D_c/D)^2$
$= 28.4$

$F_{crw} = 38.01$

$R = f_{bu}/F_{crw}$
= **0.88** **OK**

TENSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced tension flange per AASHTO 6.10.8.3.

$\phi F_{nt} = R_h F_y \quad (R_h = 1.0)$

$= 50$ ksi

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.3.2.2. Note that $\phi_f = 1.0$.

$R = [f_{bu} + f_l]/F_{nt}$ (6.10.3.2.2-1)

$=$ **0.60** **OK**

COMPRESSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced compression flange per AASHTO 6.10.8.2. The flexural resistance will be the minimum of the local buckling resistance and the lateral torsional buckling resistance.

INPUT [G5, Span 1, Section 2, 1.355L, Final]

Materials:

Steel - $F_y =$ 50 ksi
$E =$ 29000 ksi
$F_{yr} = 0.7\ F_y =$ 35 ksi

Section:

Compression Flange - $b_{fc} =$ 28 in
$t_{fc} =$ 1.625 in

Web - $D =$ 96 in
$t_w =$ 0.6875 in

Tension Flange - $b_{ft} =$ 36 in
$t_{ft} =$ 1.875 in

Bracing:

Unbraced Length - $L_b =$ 11.93 ft

Factored Flange Stresses:

Compression Flange - $f_{ub\_c} =$ -42.96 ksi
Tension Flange - $f_{ub\_t} =$ 46.02 ksi
Lateral Flange Stress - $f_{l\_c} =$ 0.00 ksi
$f_{l\_t} =$ 6.41 ksi

*Positve tension, negative compression.

WEB LOAD-SHEDDING FACTOR

Calcualte web load-shedding factor, R_b, per AASHTO 6.10.1.10.2.

$R_b = 1 - [a_w / (1200+300a_w)][2D_c/t_w - \lambda_{rw}] \leq 1.0$

$D_c = D_t\ [(-f_{bu\_c})/(-f_{bu\_c} + f_{bu\_t})] - t_{fc}$
$=$ 46.41 in

$a_w = (2D_c\ t_w) / (b_{fc}\ t_{fc})$
$=$ 1.40

$\lambda_{rw} = 5.7\ \sqrt{(E/Fy)}$
$=$ 137.3

$R_b =$ **1.000**

LOCAL BUCKLING RESISTANCE [6.10.8.2]

Calculate the slenderness parameters:

$\lambda_f = b_{fc} / 2t_{fc}$
$=$ 8.62
$\lambda_{pf} = 0.38\ \sqrt{(E/F_y)}$
$=$ 9.15
$\lambda_{rf} = 0.56\ \sqrt{(E/F_{yr})}$
$=$ 16.12

If $\lambda_f \leq \lambda_{pf}$, then:

$F_{nc} = R_b\ R_h\ F_y$ ($R_h = 1.00$)
$=$ 50.00 ksi <=== Controls

Else:

$F_{nc} = [1 - (1 - F_{yr}/(R_hF_y))((\lambda_f - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]\ R_b\ R_h\ F_y$
$=$ 51.15 ksi

$F_{nc\_1} =$ **50.00** ksi

LATERAL TORSIONAL BUCKLING RESISTANCE [6.10.8.3]

Calculate braced length parameters:

$r_t = b_{fc} / \sqrt{(12*(1 + (1/3)((D_ct_w)/(b_{fc})(t_{fc}))))}$
$=$ 7.28

$L_p = 1.0\ r_t\ \sqrt{(E/F_y)}$
$=$ 175.25 in

$L_r = \pi\ r_t\ \sqrt{(E/F_{yr})}$
658.06 in

$L_b =$ 143.16 in

Calculate elastic torsional buckling stress.

$F_{cr} = C_b\ R_b\ \pi^2\ E / (L_b/r_t)^2$ (Assume $C_b = 1.00$)
$=$ 739.53 ksi

If $L_b \leq L_p$, then:

$F_{nc} = R_b\ R_h\ F_y$ ($R_h = 1.00$)
$=$ 50.00 ksi <===Controls

If $L_b > L_r$, then:

$F_{nc} = F_{cr} \leq R_b\ R_h\ R_y$
$=$ 50.00 ksi

Else:

$F_{nc} = C_b\ [1 - (1 - F_{yr}/(R_hF_y))((L_f - L_{pf})/(L_{rf} - L_{pf})]\ R_b\ R_h\ F_y$
$=$ 50.00 ksi

$F_{nc\_2} =$ **50.00** ksi

$F_{nc} = MIN[F_{nc\_1}, F_{nc\_2}]$
$=$ **50.00** ksi

AMPLIFICATION FACTOR [6.10.1.6]

Calculate the amplification factor to account for 2nd order effects (if applicable).

$L_p' = 1.2\ L_p\ \sqrt{((C_b\ R_b)/(f_{bu}/F_y))}$
$= 226.88$

For $L_b \leq L_p'$:

$A_F = 1.00$

Else:

$A_F = [0.85/(1-f_{bu}/F_{cr})]$
$= 0.90$

$A_F =$ **1.00**

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.8.1.1. Note that $\phi_f = 1.0$.

$R = [f_{bu} + A_F\ f_l/3]/F_{nc}$ (6.10.8.1.1-1)
$=$ **0.86 OK**

For compression flanges of composite sections in postive bending, the lateral flange bending term in neglected per AASHTO 10.7.2.1.

TENSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced tension flange per AASHTO 6.10.8.3.

$\phi F_{nt} = R_h F_y \quad (R_h = 1.0)$

$= 50$ ksi

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.7.2.1 for composite sections in postive bending or AASHTO 6.10.8.1.2 for non-composite sections.
Note that $\phi_f = 1.0$.

$R = [f_{bu} + f_l/3]/F_{nt}$ (6.10.8.1.2-1)

$=$ **0.96 OK**

STRESS CALCULATIONS - CONSTRUCTION
GIRDER 5 - 1.355L

Vertical Moment Data

Moment data taken from T187 output at point of maximum. moment in the panel segment.

M_{U_STL} = 4000 kip-ft [from Genesis]
M_{U_Other} = 11820 kip-ft [from T187 model]

Lateral Flange Bending Moments Due to Curvature

The lateral flange bending moments due to curvature will be estimated per AASHTO Equ. C4.6.1.2.4b-1.

$$M_l = \frac{M\,l^2}{12\,R\,D}$$

R = Girder radius at segment under consideration
= 180.75 ft
D = Girder web depth
= 8 ft
l = Distance between brace points
= 11.93 ft

M_l = 97 kip-ft

Section Properties

See separate calculations for section properties.

b_{tf} = 28 in t_{tf} = 1.625 in
b_{bf} = 36 in t_{bf} = 1.875 in

Condition	S_{tf} (in^3)	S_{bf} (in^3)	S_{l_tf} (in^3)	S_{l_bf} (in^3)
Non-Composite	5645	7170	212	405

Flange Stresses

Calculate stresses due to vertical bending and lateral flange bending moments.

Load	f_{b_tf} (ksi)	f_{b_bf} (ksi)	f_{l_tf} (ksi)	f_{l_bf} (ksi)
DC_A	-33.63	26.48	5.48	2.87

Lateral flange bending stresses for DC_A moments are only calculated for the slab DL. The lateral flange bending stresses due to steel DL are included under additional stresses.

Additional Lateral Flange Bending Stresses

Include lateral flange bending stressed due to excessive girder tilt and errection, and overhang loading.

(a) Out-of-Plumbness:

The girder is out of plumb by 0.375" over 8' at midspan. Estimate the lateral flange bending due eccentricity of load placed on flange with respec to the center of the web (D/2).

e = 0.1875 in (max)
w = uniform load; estimate based on max. M_{DC_A} within Span 1 (see separate calculations).
= 5.0 kip/ft
m_z = 0.08 kip-in/in

$$f_l = \frac{m_z\,b_f}{490}$$

f_{l_tf} = 0.00 ksi
f_{l_bf} = 0.01 ksi

(b) Erection:

See separate calculations.

f_{l_tf} = 0.65 ksi [from Genesis]
f_{l_bf} = 0.04 ksi [from Genesis]

(c) Overhang Loading

The moment on the exterior girder due to overhang bracket loads is about:

m_{z_OH} = 4.5 kip-ft/ft

$$f_l = \frac{m_z\,b_f}{490}$$
= 490 kip-in

f_{l_tf} = 0.26 ksi
f_{l_bf} = 0.33 ksi

Factored Flange Stresses (Strength I)

f_{ub_tf} = -33.63 ksi f_{l_tf} = 6.68 ksi
f_{ub_bf} = 26.48 ksi f_{l_bf} = 3.43 ksi

STRESS CALCULATIONS - FINAL
GIRDER 5 - 1.355L

Vertical Moment Data

Moment data taken from BDGS output at point of maximum. moment in the panel segment, except as noted.

$M_{DC\_A\_Steel}$ = 3200 kip-ft [from Genesis]
$M_{DC\_A\_Other}$ = 8067 kip-ft [from T187 model]
M_{DC_B} = 789 kip-ft
M_{DW} = 2516 kip-ft
M_{LL+I} = 5747 kip-ft

Lateral Flange Bending Moments Due to Curvature

The lateral flange bending moments due to curvature will be estimated per AASHTO Equ. C4.6.1.2.4b-1.

$$M_l = \frac{M\,l^2}{12\,R\,D}$$

R = Girder radius at segment under consideration
= 180.75 ft
D = Girder web depth
= 8 ft
l = Distance between brace points
= 11.93 ft

$M_{l\_DC\_A}$ = 66 kip-ft
$M_{l\_DC\_B}$ = 6 kip-ft
M_{l_DW} = 21 kip-ft
M_{l_LL+I} = 47 kip-ft

Section Properties

See separate calculations for section properties.

b_{tf} = 28 in t_{tf} = 1.625 in
b_{bf} = 36 in t_{bf} = 1.875 in

Condition	S_{tf} (in^3)	S_{bf} (in^3)	S_{l_tf} (in^3)	S_{l_bf} (in^3)
Non-Composite	5645	7170	212	405
Composite (3n)	10504	8241		
Composite (n)	21820	9058		

Flange Stresses

Calculate stresses due to vertical bending and lateral flange bending moments.

Load	f_{b_tf} (ksi)	f_{b_bf} (ksi)	f_{l_tf} (ksi)	f_{l_bf} (ksi)
DC_A	-23.95	18.86	3.74	1.96
DC_B	-0.90	1.15	0	0.19
DW	-2.87	3.66	0	0.61
LL+I	-3.16	7.61	0	1.40

Lateral flange bending stresses for DC_A moments are only calculated for the slab DL. The lateral flange bending stresses due to steel DL are included under additional stresses.

Additional Lateral Flange Bending Stresses

Include lateral flange bending stressed due to excessive girder tilt and errection.

(a) Out-of-Plumbness:

The girder is out of plumb by 0.375" over 8' at midspan. Estimate the lateral flange bending due eccentricity of load placed on flange with respect to the center of the web (D/2).

e = 0.1875 in (max)
w = uniform load; estimate based on max. M_{DC_A} within Span 1 (see separate calculations).
= 5.0 kip/ft
m_z = 0.08 kip-in/in

$$f_l = \frac{m_z\, b_f}{490}$$

f_{l_tf} = 0.00 ksi
f_{l_bf} = 0.01 ksi

(b) Erection:

See separate calculations.

f_{l_tf} = 0.65 ksi [from Genesis]
f_{l_bf} = 0.04 ksi [from Genesis]

Factored Flange Stresses (Strength I)

f_{ub_tf} = -42.96 ksi f_{l_tf} = 5.77 ksi
f_{ub_bf} = 46.02 ksi f_{l_bf} = 6.41 ksi

For	Cleveland - Ramp A5	Job No.	49633	Sheet No.	
Made by	LER	Checked by		Backchecked by	
Date	10/1/12	Date		Date	

HNTB

COMPRESSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced compression flange per AASHTO 6.10.8.2. The flexural resistance will be the minimum of the local buckling resistance and the lateral torsional buckling resistance.

INPUT [G5, Span 1, Section 4, 2.000L, Const.]

Materials:

Steel -	F_y =	50	ksi
	E =	29000	ksi
	$F_{yr} = 0.7\ F_y$ =	35	ksi

Section:

Compression Flange -	b_{fc} =	38	in
	t_{fc} =	2.750	in
Web -	D =	96	in
	t_w =	0.6875	in
Tension Flange -	b_{ft} =	36	in
	t_{ft} =	2.75	in

Bracing:

Unbraced Length -	L_b =	12.00	ft

Factored Flange Stresses:

Compression Flange -	f_{ub_c} =	-24.77	ksi
Tension Flange -	f_{ub_t} =	25.78	ksi
Lateral Flange Stress -	f_{l_c} =	8.10	ksi
	f_{l_t} =	7.68	ksi

*Positve tension, negative compression.

WEB LOAD-SHEDDING FACTOR

Calcualte web load-shedding factor, R_b, per AASHTO 6.10.1.10.2.

$$R_b = 1 - [a_w / (1200+300a_w)][2D_c/t_w - \lambda_{rw}] \leq 1.0$$

$$D_c = D_t\ [(-f_{bu\_c})/(-f_{bu\_c} + f_{bu\_t})] - t_{fc}$$
$$= 46.99 \text{ in}$$

$$a_w = (2D_c\ t_w) / (b_{fc}\ t_{fc})$$
$$= 0.62$$

$$\lambda_{rw} = 5.7\ \sqrt{(E/Fy)}$$
$$= 137.3$$

R_b = **1.000**

LOCAL BUCKLING RESISTANCE [6.10.8.2]

Calculate the slenderness parameters:

$$\lambda_f = b_{fc} / 2t_{fc}$$
$$= 6.91$$
$$\lambda_{pf} = 0.38\ \sqrt{(E/F_y)}$$
$$= 9.15$$
$$\lambda_{rf} = 0.56\ \sqrt{(E/F_{yr})}$$
$$= 16.12$$

If $\lambda_f \leq \lambda_{pf}$, then:

$F_{nc} = R_b\ R_h\ F_y$ (R_h = 1.00)
= 50.00 ksi <=== Controls

Else:

$F_{nc} = [1 - (1 - F_{yr}/(R_hF_y))((\lambda_f - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]\ R_b\ R_h\ F_y$
= 54.83 ksi

F_{nc_1} = **50.00** ksi

LATERAL TORSIONAL BUCKLING RESISTANCE [6.10.8.3]

Calculate braced length parameters:

$r_t = b_{fc} / \sqrt{(12^*(1 + (1/3)((D_ct_w)/(b_{fc})(t_{fc}))))}$
= 10.44

$L_p = 1.0\ r_t\ \sqrt{(E/F_y)}$
= 251.54 in

$L_r = \pi\ r_t\ \sqrt{(E/F_{yr})}$
944.52 in

L_b = 144.00 in

Calculate elastic torsional buckling stress.

$F_{cr} = C_b\ R_b\ \pi^2\ E / (L_b/r_t)^2$ (Assume C_b = 1.00)
= 1505.80 ksi

If $L_b \leq L_p$, then:

$F_{nc} = R_b\ R_h\ F_y$ (R_h = 1.00)
= 50.00 ksi <===Controls

If $L_b > L_r$, then:

$F_{nc} = F_{cr} \leq R_b\ R_h\ R_y$
= 50.00 ksi

Else:

$F_{nc} = C_b\ [1 - (1 - F_{yr}/(R_hF_y))((L_f - L_{pf})/(L_{rf} - L_{pf})]\ R_b\ R_h\ F_y$
= 50.00 ksi

F_{nc_2} = **50.00** ksi

$F_{nc} = MIN[F_{nc\_1}, F_{nc\_2}]$
= **50.00** ksi

AMPLIFICATION FACTOR [6.10.1.6]

Calculate the amplification factor to account for 2nd order effects (if applicable).

$L_p' = 1.2\, L_p \sqrt{((C_b\, R_b)/(f_{bu}/F_y))}$
$= 428.86$

For $L_b \le L_p'$:

$A_F = 1.00$

Else:

$A_F = [0.85/(1-f_{bu}/F_{cr})]$
$= 0.86$

$A_F =$ **1.00**

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.3.2.1. Note that $\phi_f = 1.0$.

$R = [f_{bu} + A_F\, f_l]/R_h F_{yc}$ (6.10.3.2.1-1)

for $R_h = 1.0$

$R = 0.66$

$R = [f_{bu} + A_F\, f_l/3]/F_{nc}$ (6.10.3.2.1-2)
$= 0.55$

$R =$ **0.66** **OK**

CHECK WEB BEND-BUCKLING RESISTANCE

For slender webs, check web bend bucking resistance per AASHTO 6.10.3.2.1. Note that $\phi_f = 1.0$.

Check web slenderness:

$2D_c/t_w \le 5.7 \sqrt{(E/F_{yc})}$

$2D_c/t_w = 137$

$5.7 \sqrt{(E/F_{yc})} = 137$ **Ignore Web Bend-Bucking**

$F_{crw} = [0.9\, E\, k] / (D/t_w)^2 \le \min(R_h\, F_{yc}, F_{yw}/0.7)$

$k = 9 / (D_c/D)^2$
$= 37.6$

$F_{crw} = 50.00$

$R = f_{bu}/F_{crw}$
$=$ **1.00** **OK**

TENSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced tension flange per AASHTO 6.10.8.3.

$\phi F_{nt} =$ $R_h F_y$ ($R_h = 1.0$)
= 50 ksi

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.3.2.2. Note that $\phi_f = 1.0$.

$R = [f_{bu} + f_l]/F_{nt}$ (6.10.3.2.2-1)
= **0.67** **OK**

COMPRESSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced compression flange per AASHTO 6.10.8.2. The flexural resistance will be the minimum of the local buckling resistance and the lateral torsional buckling resistance.

INPUT **[G5, Span 1, Section 4, 2.000L, Final]**

Materials:

Steel -

F_y = 50 ksi
E = 29000 ksi
$F_{yr} = 0.7\ F_y$ = 35 ksi

Section:

Compression Flange - b_{fc} = 38 in
t_{fc} = 2.750 in
Web - D = 96 in
t_w = 0.6875 in
Tension Flange - b_{ft} = 36 in
t_{ft} = 2.75 in

Bracing:

Unbraced Length - L_b = 12.00 ft

Factored Flange Stresses:

Compression Flange - f_{ub_c} = -41.99 ksi
Tension Flange - f_{ub_t} = 35.99 ksi
Lateral Flange Stress - f_{l_c} = 8.30 ksi
f_{l_t} = 7.86 ksi

*Positve tension, negative compression.

WEB LOAD-SHEDDING FACTOR

Calcualte web load-shedding factor, R_b, per AASHTO 6.10.1.10.2.

$R_b = 1 - [a_w / (1200+300a_w)][2D_c/t_w - \lambda_{rw}] \leq 1.0$

$D_c = D_t\ [(-f_{bu\_c})/(-f_{bu\_c} + f_{bu\_t})] - t_{fc}$
= 51.90 in

$a_w = (2D_c\ t_w) / (b_{fc}\ t_{fc})$
= 0.68

$\lambda_{rw} = 5.7\ \sqrt{(E/Fy)}$
= 137.3

R_b = **0.993**

LOCAL BUCKLING RESISTANCE [6.10.8.2]

Calculate the slenderness parameters:

$\lambda_f = b_{fc} / 2t_{fc}$
= 6.91
$\lambda_{pf} = 0.38\ \sqrt{(E/F_y)}$
= 9.15
$\lambda_{rf} = 0.56\ \sqrt{(E/F_{yr})}$
= 16.12

If $\lambda_f \leq \lambda_{pf}$, then:

$F_{nc} = R_b\ R_h\ F_y$ (R_h = 1.00)
= 49.67 ksi <=== Controls

Else:

$F_{nc} = [1 - (1 - F_{yr}/(R_hF_y))((\lambda_f - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]\ R_b\ R_h\ F_y$
= 54.46 ksi

F_{nc_1} = **49.67** ksi

LATERAL TORSIONAL BUCKLING RESISTANCE [6.10.8.3]

Calculate braced length parameters:

$r_t = b_{fc} / \sqrt{(12*(1 + (1/3)((D_ct_w)/(b_{fc})(t_{fc}))))}$
= 10.39

$L_p = 1.0\ r_t\ \sqrt{(E/F_y)}$
= 250.32 in

$L_r = \pi\ r_t\ \sqrt{(E/F_{yr})}$
939.94 in

L_b = 144.00 in

Calculate elastic torsional buckling stress.

$F_{cr} = C_b\ R_b\ \pi^2\ E / (L_b/r_t)^2$ (Assume C_b = 1.00)
= 1481.27 ksi

If $L_b \leq L_p$, then:

$F_{nc} = R_b\ R_h\ F_y$ (R_h = 1.00)
= 49.67 ksi <===Controls

If $L_b > L_r$, then:

$F_{nc} = F_{cr} \leq R_b\ R_h\ R_y$
= 49.67 ksi

Else:

$F_{nc} = C_b\,[1 - (1 - F_{yr}/(R_hF_y))((L_f - L_{pf})/(L_{rf} - L_{pf})]\ R_b\ R_h\ F_y$
= 49.67 ksi

F_{nc_2} = **49.67** ksi

$F_{nc} = MIN[F_{nc\_1}, F_{nc\_2}]$
= **49.67** ksi

AMPLIFICATION FACTOR [6.10.1.6]

Calculate the amplification factor to account for 2nd order effects (if applicable).

$L_p' = 1.2\ L_p \sqrt{((C_b\ R_b)/(f_{bu}/F_y))}$
$= 326.69$

For $L_b \leq L_p'$:

$A_F = 1.00$

Else:

$A_F = [0.85/(1-f_{bu}/F_{cr})]$
$= 0.87$

$A_F =$ **1.00**

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.8.1.1. Note that $\phi_f = 1.0$.

$R = [f_{bu} + A_F\ f_l/3]/F_{nc}$ (6.10.8.1.1-1)
$=$ **0.90** **OK**

For compression flanges of composite sections in postive bending, the lateral flange bending term in neglected per AASHTO 10.7.2.1.

TENSION FLANGE FLEXURAL RESISTANCE

Calculate the flexural resistance of a discretely braced tension flange per AASHTO 6.10.8.3.

$\phi F_{nt} = R_h F_y \quad (R_h = 1.0)$

$= 50$ ksi

CHECK FLANGE BENDING STRESS

Check combined flange bending stresses per AASHTO 6.10.7.2.1 for composite sections in postive bending or AASHTO 6.10.8.1.2 for non-composite sections.
Note that $\phi_f = 1.0$.

$R = [f_{bu} + f_l/3]/F_{nt}$ (6.10.8.1.2-1)

$=$ **0.77** **OK**

For	Ramp A5	Job No.	49633	Sheet No.
Made by	LER	Checked by		Backchecked by
Date	10/1/12	Date		Date

HNTB

STRESS CALCULATIONS - CONSTRUCTION
GIRDER 5 - 2.000L

Vertical Moment Data

Moment data taken from T187 output at point of maximum. moment in the panel segment.

$M_{U\_STL} =$ -6883 kip-ft [from Genesis]
$M_{U\_Other} =$ -15805 kip-ft [from T187 model]

Lateral Flange Bending Moments Due to Curvature

The lateral flange bending moments due to curvature will be estimated per AASHTO Equ. C4.6.1.2.4b-1.

$$M_l = \frac{M\, l^2}{12\, R\, D}$$

R = Girder radius at segment under consideration
= 180.75 ft
D = Girder web depth
= 8 ft
l = Distance between brace points
= 0 ft

THIS SEGMENT IS NOT CURVED.

$M_l =$ 0 kip-ft

Section Properties

See separate calculations for section properties.

$b_{tf} =$ 36 in $t_{tf} =$ 2.75 in
$b_{bf} =$ 38 in $t_{bf} =$ 2.75 in

Condition	S_{tf} (in^3)	S_{bf} (in^3)	S_{l_tf} (in^3)	S_{l_bf} (in^3)
Non-Composite	10562	10990	594	662

Flange Stresses

Calculate stresses due to vertical bending and lateral flange bending moments.

Load	f_{b_tf} (ksi)	f_{b_bf} (ksi)	f_{l_tf} (ksi)	f_{l_bf} (ksi)
DC_A	25.78	-24.77	0.00	0.00

Lateral flange bending stresses for DC_A moments are only calculated for the slab DL. The lateral flange bending stresses due to steel DL are included under additional stresses.

Additional Lateral Flange Bending Stresses

Include lateral flange bending stressed due to excessive girder tilt and errection, and overhang loading.

(a) Out-of-Plumbness:

The girder is out of plumb by 0.375" over 8' at midspan. Estimate the lateral flange bending due eccentricity of load placed on flange with respec to the center of the web (D/2).

e = 0.1875 in (max)
w = uniform load; estimate based on max. M_{DC_A} within Span 1 (see separate calculations).
= 5.0 kip/ft
$m_z =$ 0.08 kip-in/in

$$f_l = \frac{m_z\, b_f}{1301}$$

$f_{l\_tf} =$ 0.00 ksi
$f_{l\_bf} =$ 0.00 ksi

(b) Erection:

See separate calculations.

$f_{l\_tf} =$ 0.77 ksi [from Genesis]
$f_{l\_bf} =$ 0.55 ksi [from Genesis]

(c) Overhang Loading

The moment on the exterior girder due to overhang bracket loads is about:

$m_{z\_OH} =$ 4.5 kip-ft/ft

$$f_l = \frac{m_z\, b_f}{= 1301 \text{ kip-in}}$$

$f_{l\_tf} =$ 0.12 ksi
$f_{l\_bf} =$ 0.13 ksi

Factored Flange Stresses (Strength I)

$f_{ub\_tf} =$ 25.78 ksi $f_{l\_tf} =$ 1.15 ksi
$f_{ub\_bf} =$ -24.77 ksi $f_{l\_bf} =$ 0.89 ksi

STRESS CALCULATIONS - FINAL
GIRDER 5 - 2.000L

Vertical Moment Data

Moment data taken from BDGS output at point of maximum. moment in the panel segment, except as noted.

$M_{DC\_A\_Steel}$ = -5507 kip-ft [from Genesis]
$M_{DC\_A\_Other}$ = -11188 kip-ft [from T187 model]
M_{DC_B} = -1096 kip-ft
M_{DW} = -3291 kip-ft
M_{LL+I} = -6217 kip-ft

Lateral Flange Bending Moments Due to Curvature

The lateral flange bending moments due to curvature will be estimated per AASHTO Equ. C4.6.1.2.4b-1.

$$M_l = \frac{M\, l^2}{12\, R\, D}$$

R = Girder radius at segment under consideration
= 180.75 ft
D = Girder web depth
= 8 ft
l = Distance between brace points
= 0 ft

THIS SEGMENT IS NOT CURVED.

$M_{l\_DC\_A}$ = 0 kip-ft
$M_{l\_DC\_B}$ = 0 kip-ft
M_{l_DW} = 0 kip-ft
M_{l_LL+I} = 0 kip-ft

Section Properties

See separate calculations for section properties.

b_{tf} = 36 in t_{tf} = 2.75 in
b_{bf} = 38 in t_{bf} = 2.75 in

Condition	S_{tf} (in^3)	S_{bf} (in^3)	S_{l_tf} (in^3)	S_{l_bf} (in^3)
Non-Composite	10562	10990	594	662
Composite (3n)	14839	11595		
Composite (n)	23886	12227		

Flange Stresses

Calculate stresses due to vertical bending and lateral flange bending moments.

Load	f_{b_tf} (ksi)	f_{b_bf} (ksi)	f_{l_tf} (ksi)	f_{l_bf} (ksi)
DC_A	18.97	-18.23	0.00	0.00
DC_B	0.89	-1.13	0	0.00
DW	2.66	-3.41	0	0.00
LL+I	3.12	-6.10	0	0.00

Lateral flange bending stresses for DC_A moments are only calculated for the slab DL. The lateral flange bending stresses due to steel DL are included under additional stresses.

Additional Lateral Flange Bending Stresses

Include lateral flange bending stressed due to excessive girder tilt and errection.

(a) Out-of-Plumbness:

The girder is out of plumb by 0.375" over 8' at midspan. Estimate the lateral flange bending due eccentricity of load placed on flange with respect to the center of the web (D/2).

e = 0.1875 in (max)
w = uniform load; estimate based on max. M_{DC_A} within Span 1 (see separate calculations).
= 5.0 kip/ft
m_z = 0.08 kip-in/in

$$f_l = \frac{m_z\, b_f}{1301}$$

f_{l_tf} = 0.00 ksi
f_{l_bf} = 0.00 ksi

(b) Erection:

See separate calculations.

f_{l_tf} = 0.77 ksi [from Genesis]
f_{l_bf} = 0.55 ksi [from Genesis]

Factored Flange Stresses (Strength I)

f_{ub_tf} = 35.99 ksi f_{l_tf} = 1.01 ksi
f_{ub_bf} = -41.99 ksi f_{l_bf} = 0.72 ksi

FOR: Ramp A5	JOB NO: 49633	SHEET NO:
MADE BY: LER	CHECKED BY:	BACKCHECKED BY:
DATE: 10/1/12	DATE:	DATE:

HNTB

Rotations @ 0.55L

Estimate rotation of girder about its long. axis at 0.55L. The following data is taken from T187 file rampa5_rfi_full_const.out.

Girder	Pt.	Steel DL Θ_x	Steel DL Θ_z	Slab DL Θ_x	Slab DL Θ_z
3	457	0.002	-0.004	0.003	-0.007
4	724	0.001	-0.004	0.002	-0.006
5	983	0.001	-0.004	0.001	-0.007

Rotations are given w/ respect to global coordinate system. See seperate calc. for conv. of rot. to local system at pt. of interest.

Est. Girder Tilt (per 8' web depth)

Girder	Steel DL	Slab
5	3/8"	5/8"
4	3/8"	1/2"
3	3/8"	3/4"

* Est. rot. after slab pour ≈ 1/2" to 3/4" on G3-G5.

ESTIMATED GIRDER ROTATION - G5_0.55L - STEEL DL

Point	x	z	θ_x	θ_z
978	-4.31944	113.5892		
979	-4.35361	113.6274	0.001	-0.004

$\Delta x =$ -0.03418

$\Delta z =$ 0.03822

l = 0.051272

phi = 0.841185 rad

θ_x_L = -0.00365 rad

θ_z_L = 0.001921 rad

Web Tilt = 0.35024 in

ESTIMATED GIRDER ROTATION - G5_0.55L - SLAB WEIGHT

Point	x	z	θ_x	θ_z
978	-4.31944	113.5892		
979	-4.35361	113.6274	0.001	-0.007

$\Delta x =$ -0.03418

$\Delta z =$ 0.03822

l = 0.051272

phi = 0.841185 rad

θ_x_L = -0.00588 rad

θ_z_L = 0.003921 rad

Web Tilt = 0.56493 in

ESTIMATED GIRDER ROTATION - G4_0.55L - STEEL DL

Point	x	z	θ_x	θ_z
978	-11.6509	107.036		
979	-12.0348	107.4641	0.001	-0.004

Δx = -0.38399
Δz = 0.42813
l = 0.575102
phi = 0.839698 rad

θ_x_L = -0.00365 rad   θ_z_L = 0.001926 rad

Web Tilt = 0.349965 in

ESTIMATED GIRDER ROTATION - G4_0.55L - SLAB WEIGHT

Point	x	z	θ_x	θ_z
978	-11.6509	107.036		
979	-12.0348	107.4641	0.002	-0.006

$\Delta x =$ -0.38399

$\Delta z =$ 0.42813

l = 0.575102

phi = 0.839698 rad

θ_x_L = -0.0058 rad   θ_z_L = 0.002517 rad

Web Tilt = 0.557001 in

ESTIMATED GIRDER ROTATION - G3_0.55L - STEEL DL

Point	x	z	θ_x	θ_z
978	-12.0142	92.13705		
979	-13.8591	94.4604	0.002	-0.004

$\Delta x =$ -1.8449

$\Delta z =$ 2.323348

l = 2.966751

phi = 0.899681 rad

θ_x_L = -0.00438 rad   θ_z_L = 0.000921 rad

Web Tilt = 0.420121 in

ESTIMATED GIRDER ROTATION - G3_0.55L - SLAB WEIGHT

Point	x	z	θ_x	θ_z
978	-12.0142	92.13705		
979	-13.8591	94.4604	0.003	-0.007

Δx = -1.8449

Δz = 2.323348

l = 2.966751

phi = 0.899681 rad

θ_x_L = -0.00735 rad

θ_z_L = 0.002004 rad

Web Tilt = 0.705371 in

Larry Rolwes

From: Halterman, Joel <jhalterman@walshgroup.com>
Sent: Thursday, September 27, 2012 3:45 PM
To: Kirk Gegick (Kirk.Gegick@dot.state.oh.us)
Cc: Smaron, Timothy; David Rogowski; Larry Rolwes; Febus, Scott; Tracy, John; 'Tom Hyland (thomas.hyland@dot.state.oh.us)'
Subject: FW: A5 Jacking Results

Kirk –

A5 jacking looks like a success. Tim and I have had discussions with both Genesis and HNTB, and we all think this is a good result.

In summary (see table below):

- Girder 5 was raised 2"; this is what Genesis expected we would raise it.
- Compared to plan elevations: G5 is 2" low, G4 is 1", and G3 is at plan. This was the anticipated result.
- Web plumb looks good; we were +2" out of plumb on G5 and are now only 3/8" out of plumb.

The plan moving forward:

- Complete screed sheets for Span 1 and send to Genesis. Will have this done by end of the day.
- Genesis will review and provide a summary of the results and confirm how the results match the submittal.
- Walsh will provide a formal submittal to HNTB for review and approval. At this time, we will also send it to the Department.
- Hopefully, HNTB should approve and, with ODOT's concurrence, we can close the book on A5 span 1.

We intend to move forward re-grading Span 1 and re-starting SIP formwork tomorrow.

Regards,

Joel Halterman | Project Manager
Walsh Construction Company
Cleveland Innerbelt | 2301 Scranton Road | Cleveland, Ohio 44113
Tel: (216) 452.5907 | Fax: (216) 566.9975 | Cell: (219) 608.6097

From: Halterman, Joel
Sent: Thursday, September 27, 2012 2:17 PM
To: Larry Rolwes
Cc: Smaron, Tim (tsmaron@walshgroup.com); 'David Rogowski'
Subject: A5 Jacking Results

Larry – Just lowered A5; results are as follows:

	Plan	Before Jacking	Delta from Plan before Jacking	ELV after Jacking	Jacking Change	Genesis Planned Correction	Delta from Plan after Jacking	Web Tilt Angle	Web Plumb (8' tall)
Girder 3	675.04	675.02	0.02	675.028	0.008	0.002	-0.012	89.9	-0.01
Girder 4	675.56	675.43	0.13	675.483	0.053	0.041	-0.077	89.85	-0.02
Girder 5	676.08	675.74	0.34	675.908	0.168	0.163	-0.172	89.75	-0.03

GENESIS
STRUCTURES

Genesis Structures, Inc.
104 West 9th Street, Suite 200
Kansas City, Missouri 64105
(P) 816-421-1520
(F) 816-421-1528

Cleveland Innerbelt
Ramp A5 Geometry Corrections
Supporting Calculations

STATE OF OHIO
DAVID D.
BYERS
E-75506
REGISTERED
PROFESSIONAL ENGINEER

8-23-12

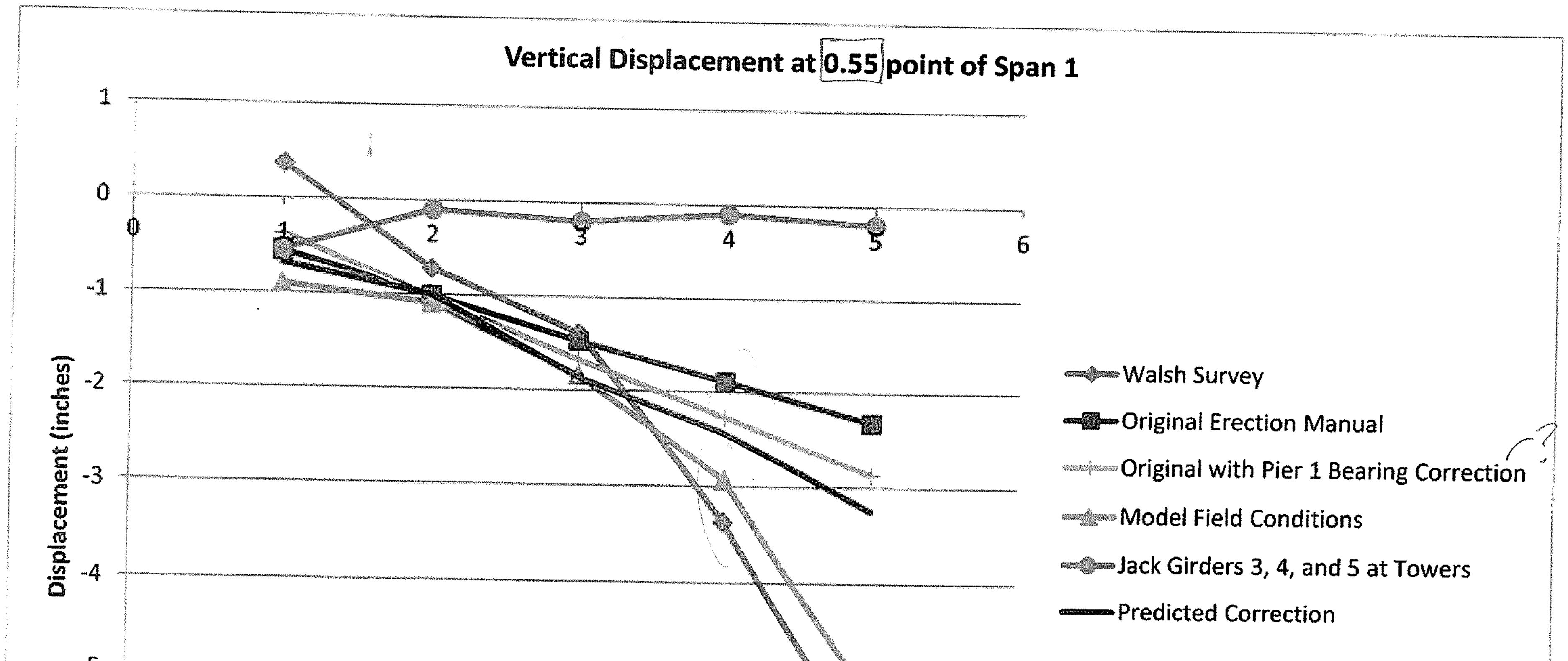
August 23, 2012

Prepared for:

Walsh Construction

STATE OF OHIO
DAVID M.
ROGOWSKI
E-60699
REGISTERED
PROFESSIONAL ENGINEER

8/23/12



– @ G5, "corrected" position ~1" from plan

@0.55L $\delta_{SL} \cong 2.25''$ (plan)

est. after corr. ≈ 3.25"

≈ ½" seems to be due to the "bearing correction"

∴ $\Delta\delta \cong$ ½" (not bad)

$\Delta_{\substack{cor \\ model}} = 5.19 - 3.24 \cong 2'' \pm$

$\Delta\delta_{STL} = (676.08 - 675.74)(12) = 4.08''$

∴ plan removes ≈ ½ of $\Delta\,\delta_{STL}$

Stress Comparison

Girder 5

Distance	Location	Splice	Predicted Correction							
			Vertical Bending		Lateral/Torsional Bending		Total Stress			
			Top Flange	Bot. Flange	Top Flange	Bot. Flange	Top Flange		Bot. Flange	
(in)			(ksi)	(ksi)	(ksi) +/-	(ksi) +/-	Max	Min	Max	Min
0	0.000		-0.96	0.86	0.70	0.07	-0.26	-1.66	0.94	0.79
72	0.032		-2.38	1.81	3.67	1.75	1.29	-6.06	3.56	0.06
215.2	0.097		-3.94	2.83	0.41	0.65	-3.53	-4.35	3.48	2.18
358.4	0.161	FS1	-5.31	3.95	0.44	0.25	-4.86	-5.75	4.20	3.69
501.6	0.226		-5.78	4.39	0.36	0.15	-5.42	-6.15	4.54	4.24
644.8	0.290		-6.49	4.99	0.84	0.20	-5.66	-7.33	5.18	4.79
788	0.355		-6.86	5.31	0.65	0.04	-6.22	+2% -7.51	5.35 -2%	5.26
931.2	0.419		-6.91	5.36	0.50	0.12	-6.41	-7.41	5.48	5.24
1074.4	0.484		-6.55	5.07	0.36	0.34	-6.20	-6.91	5.41	4.73
1217.6	0.548		-5.73	4.35	0.16	0.10	-5.57	-5.89	4.45	4.24
1360.8	0.613		-4.30	3.28	0.43	0.47	-3.87	-4.73	3.75	2.80
1504	0.677	FS2	-2.43	1.79	0.24	0.13	-2.18	-2.67	1.92	1.66
1647.2	0.742	Shop Splice	-0.18	0.07	0.14	0.14	-0.04	-0.32	0.21	-0.07
1790.4	0.806		1.70	-1.75	0.17	0.06	1.87	1.54	-1.69	-1.82
1933.6	0.871		2.68	-2.64	0.05	0.26	2.73	2.62	-2.37	-2.90
2076.8	0.935		4.16	-4.04	0.17	0.51	4.33	3.99	-3.53	-4.55
2220.8	1.000		6.28	-5.99	0.77	0.55	7.05 +25%	5.50	-5.45	-6.54 +10%

Note: Negative stress values indicate compression
Distance = Length Along Girder to Node from CL Abutment
Location = Distance ratio = Distance/Total Length

October 02, 2012

GENESIS
STRUCTURES

Mr. Joel Halterman
Walsh Construction
2301 Scranton Road
Cleveland, Ohio 44113

RE: Ramp A5 Field Geometry Corrections

Mr. Halterman;

We have reviewed the survey results provided on 9/27/12 and are satisfied that the Ramp A5 structure geometry has been corrected as predicted following the procedures set forth in our plans dated 8/23/12 and as modified in the field as summarized in our e-mail of 9/24/12 (attached).

Below are the survey results provided on 9/27/12 at the 50% Span Length:

	Plan	Before Jacking	Delta from Plan before Jacking	ELV after Jacking	Jacking Change	Genesis Planned Correction	Delta from Plan after Jacking	Web Tilt Angle	Web Plumb (8' tall)
Girder 3	675.04	675.02	0.02	675.028	0.008	0.002	-0.012	89.9	-0.01
Girder 4	675.56	675.43	0.13	675.483	0.053	0.041	-0.077	89.85	-0.02
Girder 5	676.08	675.74	0.34	675.908	0.168	0.163	-0.172	89.75	-0.03

The values provided above indicate the predicted vertical corrections were achieved within satisfactory tolerances for the type of work performed (within 1/16" at G5, within 1/8" at G4 and within 1/16" at G3). In addition, the webs now appear to be almost vertical as predicted, again well within acceptable tolerances.

We have also included a "before" and "after" survey comparison of the projected haunches. Based on the corrections seen, it appears that the girders are currently positioned so that the maximum haunch depth at Girder 5 is 2 ½" (down from 4 3/8") and the maximum haunch depth at Girder 4 is effectively 1" (down from 1 ¾").

Most importantly, with the field corrections matching the predicted theoretical corrections, we are satisfied that the girder flange stress reductions as reported in our correction calculations dated 8/23/12 have been met.

If you have any questions related to our review, please contact me at (816) 421-1520.

Sincerely,

David Rogowski P.E.

STATE OF OHIO
DAVID M. ROGOWSKI
E-60699
REGISTERED
PROFESSIONAL ENGINEER

10/2/12

Geometry Corrections for Critical Girders (G4 & G5)

Ramp A5 - Girder5 - Span 1 (in)			
	Before Haunch	After Haunch	Correction
CL Brg [Rr]	-0.14	0.00	-0.14
0.05	0.82	0.60	0.22
0.10	1.74	1.09	0.65
0.15	2.77	1.75	1.02
0.20	2.38	1.21	1.17
0.25	3.78	2.33	1.46
0.30	4.21	2.47	1.73
0.35	4.34	2.40	1.94
0.40	4.36	2.28	2.08
0.45	4.24	2.19	2.05
0.50	4.03	1.99	2.03
0.55	3.75	1.80	1.95
0.60	3.43	1.61	1.82
0.65	2.93	1.42	1.51
0.70	2.18	0.94	1.24
0.75	2.05	1.05	1.00
0.80	1.70	1.05	0.65
0.85	1.22	0.66	0.56
0.90	1.04	0.63	0.41
0.95	0.77	0.52	0.25
CL Brg [P1]	0.53	0.42	0.11

"Before Haunch" = before geometry corrections

"After Haunch" = after geometry corrections

Ramp A5 - Girder4 - Span 1 (in)			
	Before Haunch	After Haunch	Correction
CL Brg [Rr]	-0.13	0.04	-0.17
0.05	0.00	0.09	-0.09
0.10	0.12	NA	NA
0.15	0.93	0.62	0.31
0.20	1.04	0.78	0.26
0.25	1.35	0.89	0.46
0.30	1.59	1.02	0.56
0.35	1.70	1.01	0.69
0.40	1.76	0.96	0.80
0.45	1.73	0.96	0.77
0.50	1.58	0.89	0.69
0.55	1.54	0.68	0.86
0.60	1.19	0.61	0.58
0.65	1.27	0.59	0.68
0.70	1.24	0.62	0.61
0.75	0.96	0.47	0.49
0.80	0.94	0.42	0.52
0.85	0.61	0.24	0.37
0.90	0.46	0.19	0.27
0.95	0.49	0.32	0.17
CL Brg [P1]	0.32	0.42	-0.10

"Before Haunch" = before geometry corrections

"After Haunch" = after geometry corrections

David Rogowski

From: David Rogowski
Sent: Monday, September 24, 2012 7:38 AM
To: 'Halterman, Joel'
Cc: 'Fischer, Jason'; Cooper, Scott; lmatchulat@genesisstructures.com
Subject: Ramp A5

Tracking:

Recipient	Delivery
'Halterman, Joel'	
'Fischer, Jason'	
Cooper, Scott	
lmatchulat@genesisstructures.com	Delivered: 9/24/2012 7:38 AM

Joel,

Just wanted to give you an update on what we authorized over the weekend.

On Saturday, the guys were jacking the girders for the final position before removing bolts between Girder G4 and G5.

1) Initial Survey shots before jacking
   a. G3 = 605.834
   b. G4 = 606.224
   c. G5 = 606.547
2) Survey when jacks reached noted loads in our erection correction procedure
   a. G3 = 605.897 (+3/4") ..... jack load at 80 kips
   b. G4 = 606.327 (+1 ¼") ..... jack load at 70 kips
   c. G5 = 606.682 (+1 5/8") ..... jack load at 115 kips
   d. Note that we experienced some settlement in the mats and had to reset the jacks to allow for more stroke
3) Survey when we locked down jacks and started removing bolts in cross-frames between G4 & G5
   a. G3 = 605.952 (+1.3/8").....jack load at 80 kips
   b. G4 = 606.446 (+2 5/8") .....jack load at 110 kips
   c. G5 = 606.882 (+4") ..... jack load at 195 kips
   d. Note that we did not opt to lower G4 and G3 because this would have put too much load on G5 and we were getting close to max'ing those towers out

GENESIS STRUCTURES, INC.
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Kansas City, Missouri 64105
www.genesisstructures.com

NOTE: ELEVATIONS BASED ON A REFERENCE ELEVATION OF 600.00. USE ONLY FOR COMPARISON OF TOWER JACKING HEIGHTS

DMR