ATTACHMENT 1
EQUIPMENT LOADING CALCULATIONS

ATTACHMENT 1-1

SIMPLIFIED EQUIPMENT LOADING CALCULATION

Table 1 Estimated Stress on Liner vs. Type of Operating Equipment

Table 1a Wheel Equipment

No.	Type of Wheel Equipment	Brand Name	Operating Weight (lbs)	Estimated Tire Type	Estimated Max. Tire Pressure (psi)	Wheelbase (ft)	Estimated Centerline Front Tire Width	Contact Area Width	Contact Area Length
1	Rubber tire dozer	CAT 834H	106,844	35/65R33	62	14.93	12.47	35	13.54
2	Front loader	CAT 988	112,092	35/65R33	87	14.93	11.94	35	10.12
3	Front loader	CAT 992	221,073	45/65R45	91	19.32	15.46	45	14.85
6	Side dump trailer	SmithCo S1-2317	25,000	11R22.5	100	17.30	6.67	22	7.39
7	Side dump trailer	SmithCo S2-4034	50,000	11R22.5	100	33.38	6.67	44	7.39
8	Side dump trailer	SmithCo S3-4234	75,000	11R22.5	100	33.38	6.67	66	7.39
9	Side dump trailer	SmithCo S5-4636	100,000	11R22.5	100	36.00	6.67	88	7.39

Table 1b Track Equipment

No.	Type of Track Equipment	Brand Name	Operating Weight (lbs)	Shoe Width (inch)	Ground Pressure (psi)	Length of Track on Ground (ft)	Track Gauge (O.C. Distance between Tracks) (ft)	Contact Area Width (inch)	Contact Area Length (inch)
1	Bulldozer	CAT D10	148,277	24	22.36	12.67	8.33	24	152
2	Bulldozer	CAT D11	248,600	28	27.90	14.58	9.50	28	175

Table 1c Approximate Vertical Pressure on Liner

Depth to Liner (ft)	Equipment								
	CAT 834H	CAT 988	SmithCo S1-2317	SmithCo S2-4034	SmithCo S3-4234	SmithCo S5-4636	CAT 992	CAT D10	CAT D11
0	62.0	87.0	100.0	100.0	100.0	100.0	91.0	22.4	27.9
1	35.3	40.0	31.5	36.1	36.7	36.8	56.6	18.3	24.1
2	16.4	17.7	11.3	16.6	18.3	18.9	29.1	12.2	17.1
3	8.9	9.4	5.5	9.2	11.1	12.0	16.7	8.7	12.5
3.5	6.8	7.2	4.1	7.2	9.0	10.0	13.1	7.5	10.9
4	5.4	5.7	3.2	5.7	7.4	8.4	10.5	6.6	9.6
6	2.6	2.7	1.5	2.8	3.8	4.6	5.1	4.2	6.2
7	1.9	2.0	1.1	2.1	2.9	3.6	3.9	3.4	5.2
8	1.5	1.6	0.8	1.6	2.3	2.9	3.0	2.9	4.4
9	1.2	1.2	0.7	1.3	1.9	2.3	2.4	2.4	3.7
10	1.0	1.0	0.5	1.0	1.5	1.9	2.0	2.1	3.2

Note: Stress imposed by critical equipment to be confirmed with detailed stress analysis (see Tables 2.1 to 2.5)

ATTACHMENT 1-2

DETAILED EQUIPMENT LOADING WORKSHEETS

Table 2.1 Detailed Overliner Depth Calculation

Equipment type:	Cat 992 Front End Loader
Job No:	073-81694
Made By:	GG
Checked By:	SAO
Reviewed By:	FKM
Date:	9/8/2010

Input parameters:

Overliner material density, γ'	120	pcf
Interface friction angle, ϕ	30	degrees
Lateral reaction coef., K	0.25	
Equipment:	CAT 992G	
Standard tire:	45/65R45	
Tire width:	45.00	inch
Gross machine operating weight	221,073	lbs
Minimum factor of safety	1.3	

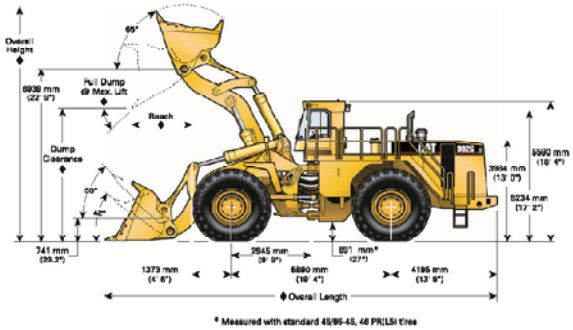

Figure 1. Dimensions

Use integration of the Boussinesq solution (1885)

1. Define pressure exerted by single tire

Load per tire	60,795	lbs
Tire pressure, q	91	psi
Contact area	668.08	inch^2
Length, a	14.85	inch
Width, b	45.00	inch

2. Define geometry

Wheelbase (3)	19.32	ft
Centerline front tire width (est.)	15.50	ft
Centerline rear tire width (est.)	15.5	ft
Overall tire width (est.)	19.25	ft

Location	Point ID	x (ft)	y(ft)	Surface Load (psi)	a (inch)	b (inch)
Origin (wheelbase center)	A	0.00	0.00	0	0.00	0.00
Mid front axle	B	9.66	0.00	0	0.00	0.00
Front right tire	C	9.66	7.75	91	14.85	45.00
Front left tire	D	9.66	-7.75	91	14.85	45.00
Mid rear axle	E	-9.66	0.00	0	0.00	0.00
Rear rigth tire	F	-9.66	7.75	91	14.85	45.00
Rear left tire	G	-9.66	-7.75	91	14.85	45.00

3. Calculate additional vertical stresses (psi)

Depth \ Point ID	A	B	C	D	E	F	G
1	0.00	0.02	56.65	56.65	0.02	56.65	56.65
2	0.02	0.13	29.06	29.06	0.13	29.06	29.06
3	0.07	0.34	16.69	16.69	0.34	16.69	16.69
3.5	0.10	0.47	13.12	13.12	0.47	13.12	13.12
4	0.14	0.61	10.54	10.54	0.61	10.54	10.54
6	0.36	1.08	5.19	5.19	1.08	5.19	5.19
7	0.48	1.22	3.94	3.94	1.22	3.94	3.94
8	0.60	1.31	3.10	3.10	1.31	3.10	3.10
9	0.71	1.34	2.52	2.52	1.34	2.52	2.52
10	0.80	1.34	2.11	2.11	1.34	2.11	2.11

4. Calculate activated friction angle

Depth \ Point ID	A	B	C	D	E	F	G
1	0.07	0.47	35.89	35.89	0.47	35.89	35.89
2	0.28	1.56	33.34	33.34	1.56	33.34	33.34
3	0.57	2.71	28.95	28.95	2.71	28.95	28.95
3.5	0.73	3.17	26.27	26.27	3.17	26.27	26.27
4	0.89	3.54	23.48	23.48	3.54	23.48	23.48
6	1.48	4.09	13.66	13.66	4.09	13.66	13.66
7	1.69	3.99	10.25	10.25	3.99	10.25	10.25
8	1.84	3.75	7.76	7.76	3.75	7.76	7.76
9	1.91	3.46	5.98	5.98	3.46	5.98	5.98
10	1.94	3.14	4.70	4.70	3.14	4.70	4.70

5. Calculate factor of safety

Depth \ Point ID	A	B	C	D	E	F	G
1	454.11	70.62	0.80	0.80	70.62	0.80	0.80
2	120.06	21.16	0.88	0.88	21.16	0.88	0.88
3	58.36	12.22	1.04	1.04	12.22	1.04	1.04
3.5	45.35	10.42	1.17	1.17	10.42	1.17	1.17
4	36.97	9.34	1.33	1.33	9.34	1.33	1.33
6	22.28	8.07	2.37	2.37	8.07	2.37	2.37
7	19.52	8.29	3.19	3.19	8.29	3.19	3.19
8	18.01	8.80	4.23	4.23	8.80	4.23	4.23
9	17.27	9.56	5.51	5.51	9.56	5.51	5.51
10	17.06	10.53	7.03	7.03	10.53	7.03	7.03

Table 2.2 Detailed Overliner Depth Calculation

Equipment type:	Cat 988H Front End Loader
Job No:	073-81694
Made By:	GG
Checked By:	SAO
Reviewed By:	KFM
Date:	9/8/2010

Input parameters:

Overliner material density, γ'	120	pcf	(use structural fill data from Golder, 2008, Appendix C)
Interface friction angle, ϕ	30	degrees	
Lateral reaction coef., K	0.25		(assume Poisson's coefficient of 0.2)
Equipment:	CAT 988H		
Standard tire:	35/65R33		
Tire width:	35.00	inch	
Gross machine operating weight	112,092	lbs	(4.25 meter linkage and wide spade rock bucket)
Minimum factor of safety	1.3		

1	Height to Top of Cab	4128 mm	13.54 ft
2	Height to Top of Exhaust Stacks	4112 mm	13.49 ft
3	Height to Top of Air Cleaner	3382 mm	11.1 ft
4	Height to Top of Hood	3156 mm	10.35 ft
5	Center Line of Rear Axle to Edge of Rear Bumper	3132 mm	10.28 ft
6	Center Line of Front Axle to Hitch	2275 mm	7.46 ft
7	Wheel Base Length	4550 mm	14.93 ft
8	Length with Bucket on Ground	◆	◆
9	Ground Clearance	549 mm	1.8 ft
10	Height to Center of Wheel	978 mm	3.21 ft
11	C-Pin Height	1009 mm 899 mm*	3.31 ft 2.95 ft*
12	Dig Depth	226 mm 195 mm*	0.74 ft 0.64 ft*

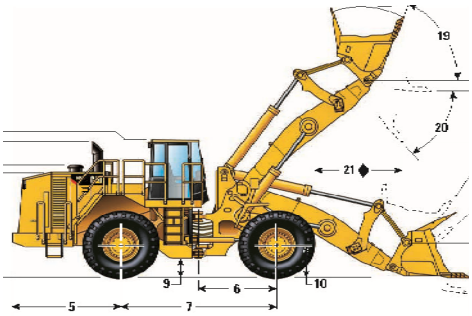

Figure 1. Dimensions

Use integration of the Boussinesq solution (1885)

1. Define pressure exerted by single tire

Load per tire	30,825	lbs
Tire pressure, q	87	psi
Contact area	354.31	inch^2
Length, a	10.12	inch
Width, b	35.00	inch

2. Define geometry

Wheelbase (7)	14.93	ft
Centerline front tire width (est.)	11.94	ft
Centerline rear tire width (est.)	11.94	ft
Overall tire width (est.)	14.86	ft

Location	Point ID	x (ft)	y(ft)	Surface Load (psi)	a (inch)	b (inch)
Origin (wheelbase center)	A	0.00	0.00	0	0.00	0.00
Mid front axle	B	7.47	0.00	0	0.00	0.00
Front right tire	C	7.47	5.97	87	10.12	35.00
Front left tire	D	7.47	-5.97	87	10.12	35.00
Mid rear axle	E	-7.47	0.00	0	0.00	0.00
Rear rigth tire	F	-7.47	5.97	87	10.12	35.00
Rear left tire	G	-7.47	-5.97	87	10.12	35.00

3. Calculate additional vertical stresses (psi)

Depth \ Point ID	A	B	C	D	E	F	G
1	0.01	0.03	39.98	39.98	0.03	39.98	39.98
2	0.04	0.21	17.68	17.68	0.21	17.68	17.68
3	0.11	0.50	9.43	9.43	0.50	9.43	9.43
3.5	0.16	0.65	7.26	7.26	0.65	7.26	7.26
4	0.22	0.78	5.75	5.75	0.78	5.75	5.75
6	0.49	1.11	2.78	2.78	1.11	2.78	2.78
7	0.61	1.15	2.12	2.12	1.15	2.12	2.12
8	0.70	1.14	1.69	1.69	1.14	1.69	1.69
9	0.77	1.10	1.40	1.40	1.10	1.40	1.40
10	0.81	1.05	1.19	1.19	1.05	1.19	1.19

4. Calculate activated friction angle

Depth \ Point ID	A	B	C	D	E	F	G
1	0.13	0.84	35.50	35.50	0.84	35.50	35.50
2	0.48	2.51	31.42	31.42	2.51	31.42	31.42
3	0.94	3.81	24.92	24.92	3.81	24.92	24.92
3.5	1.17	4.20	21.42	21.42	4.20	21.42	21.42
4	1.39	4.41	18.13	18.13	4.41	18.13	18.13
6	1.98	4.18	8.90	8.90	4.18	8.90	8.90
7	2.10	3.76	6.37	6.37	3.76	6.37	6.37
8	2.12	3.31	4.71	4.71	3.31	4.71	4.71
9	2.07	2.89	3.59	3.59	2.89	3.59	3.59
10	1.97	2.50	2.82	2.82	2.50	2.82	2.82

5. Calculate factor of safety

Depth \ Point ID	A	B	C	D	E	F	G
1	249.02	39.36	0.81	0.81	39.36	0.81	0.81
2	68.33	13.18	0.94	0.94	13.18	0.94	0.94
3	35.13	8.66	1.24	1.24	8.66	1.24	1.24
3.5	28.21	7.87	1.47	1.47	7.87	1.47	1.47
4	23.82	7.49	1.76	1.76	7.49	1.76	1.76
6	16.67	7.91	3.69	3.69	7.91	3.69	3.69
7	15.74	8.78	5.17	5.17	8.78	5.17	5.17
8	15.59	9.97	7.01	7.01	9.97	7.01	7.01
9	15.99	11.45	9.20	9.20	11.45	9.20	9.20
10	16.80	13.21	11.70	11.70	13.21	11.70	11.70

Table 2.3 Detailed Overliner Depth Calculation

Equipment type:	SmithCo S1-2317 Side Dump Trailer
Job No:	073-81694
Made By:	GG
Checked By:	SAO
Reviewed By:	KFM
Date:	9/8/2010

Input parameters:

Overliner material density, γ'	120 pcf	(use structural fill data from Golder, 2008, Appendix C)	
Interface friction angle, ϕ	30 degrees		
Lateral reaction coef., K	0.25	(assume Poisson's coefficient of 0.2)	
Equipment:	SmithCo S1-2317		
Standard tire:	11R22.5	Side factor:	77% (max. percentage of load carried by wheels
Tire width:	11.00 inch		on the dump side per SmithCo. recommendations)
Gross oper.weight (rear axle)	25,000 lbs	(acting on rear axles w/ 25,000 lbs capacity)	
Minimum factor of safety	1.3		

Ref: http://www.sidedump.com

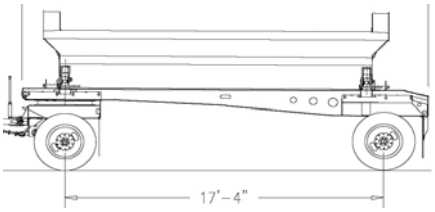

Figure 1. Dimensions

Frame Length:	22' 2"	**Hinges:**	Self-Aligning, Spherical Bearing
Tub Length:	17'	**Suspension:**	Air Ride Suspension
Width:	102"	**Axles:**	(2) 25,000# capacity
Height:	8' 2" at Tub side, 9' 4" at Center	**Hubs:**	10 Hole, Hub Piloted
Tub Capacity:	Round Bottom Tub, 11.5 Cubic Yard Waterfall Round Bottom Tub, 15.5 Cubic Yard, Full Capacity	**ABS:**	2S1M Anti-Lock Brake System
		Drums:	Outboard Mount, Cast Steel
Tub Construction:	1/4" Thick, AR400 Steel (or equivalent) 3/16" Thick, AR400 Steel (or equivalent) is Optional	**Wheels:**	Steel Disc, 8.25 x 22.5 (8)
		Tires:	11R 22.5 G Radial Tires (8)

Use integration of the Boussinesq solution (1885)

1. Define pressure exerted by single tire

Load per tire (centric load)	6,250	lbs	(dump side)	9,625	lbs	(back side)	2,875	lbs
Tire pressure, q	100	psi		100	psi		100	psi
Contact area	62.50	inch^2		96.25	inch^2		28.75	inch^2
Length, a	5.68	inch		8.75	inch		2.61	inch
Width, b	11.00	inch		11.00	inch		11.00	inch

2. Define geometry

Wheelbase	17.33	ft
Centerline tire width (est)	6.50	ft
Inside tire width (est)	4.5	ft
Overall tire width (trailer width)	8.50	ft

Location	Point ID	x (ft)	y(ft)	Surface Load (psi)	a (inch)	b (inch)	
Origin (trailer center)	A	0.00	0.00	0	0.00	0.00	
Back tire (dump side)	B	6.50	8.67	100	22.00	8.75	(2 tires)
Mid point (dump side)	C	6.50	0.00	0	0.00	0.00	
Front tire (dump side)	D	6.50	-8.67	100	22.00	8.75	(2 tires)
Mid back axle	E	0.00	8.67	0	0.00	0.00	
Mid front axle	F	0.00	-8.67	0	0.00	0.00	
Back tire (back/off-dump side)	G	-6.50	8.67	100	22.00	2.61	(2 tires)
Mid point (back/off-dump side)	H	-6.50	0.00	0	0.00	0.00	
Front tire (back/off-dump side)	I	-6.50	-8.67	100	22.00	2.61	(2 tires)

3. Calculate additional vertical stresses (psi)

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.00	36.47	0.00	36.47	0.01	0.01	11.81	0.00	11.81
2	0.01	13.32	0.02	13.32	0.05	0.05	4.07	0.01	4.07
3	0.03	6.51	0.05	6.51	0.13	0.13	1.97	0.02	1.97
3.5	0.04	4.89	0.08	4.89	0.17	0.17	1.48	0.03	1.48
4	0.05	3.80	0.11	3.80	0.21	0.21	1.15	0.04	1.15
6	0.12	1.75	0.22	1.75	0.34	0.34	0.55	0.08	0.55
7	0.16	1.30	0.26	1.30	0.37	0.37	0.42	0.11	0.42
8	0.19	1.01	0.30	1.01	0.38	0.38	0.35	0.12	0.35
9	0.22	0.81	0.32	0.81	0.38	0.38	0.29	0.14	0.29
10	0.24	0.67	0.33	0.67	0.36	0.36	0.26	0.15	0.26

4. Calculate activated friction angle

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.03	35.37	0.07	35.37	0.19	0.19	32.63	0.02	32.63
2	0.11	29.99	0.24	29.99	0.63	0.63	21.26	0.08	21.26
3	0.21	21.82	0.46	21.82	1.05	1.05	11.42	0.16	11.42
3.5	0.27	17.88	0.57	17.88	1.21	1.21	8.30	0.21	8.30
4	0.33	14.46	0.66	14.46	1.33	1.33	6.12	0.25	6.12
6	0.52	6.18	0.91	6.18	1.41	1.41	2.20	0.36	2.20
7	0.58	4.21	0.94	4.21	1.32	1.32	1.48	0.39	1.48
8	0.61	2.98	0.93	2.98	1.18	1.18	1.08	0.40	1.08
9	0.61	2.18	0.89	2.18	1.05	1.05	0.82	0.40	0.82
10	0.60	1.65	0.84	1.65	0.92	0.92	0.65	0.39	0.65

5. Calculate factor of safety

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	1169.25	0.81	500.98	0.81	173.61	173.61	0.90	1441.70	0.90
2	312.08	1.00	138.55	1.00	52.62	52.62	1.48	393.60	1.48
3	154.06	1.44	72.14	1.44	31.52	31.52	2.86	200.86	2.86
3.5	120.87	1.79	58.40	1.79	27.28	27.28	3.96	160.61	3.96
4	99.61	2.24	49.75	2.24	24.87	24.87	5.39	134.97	5.39
6	63.27	5.33	36.32	5.33	23.40	23.40	15.03	92.27	15.03
7	57.12	7.84	35.05	7.84	25.15	25.15	22.28	85.68	22.28
8	54.51	11.10	35.48	11.10	27.94	27.94	30.61	83.22	30.61
9	53.90	15.16	37.11	15.16	31.62	31.62	40.25	83.36	40.25
10	54.86	20.06	39.60	20.06	36.13	36.13	50.57	85.31	50.57

Table 2.4 Detailed Overliner Depth Calculation

Equipment type:	SmithCo S2-4034 Side Dump Trailer
Job No:	073-81694
Made By:	GG
Checked By:	SAO
Reviewed By:	KFM
Date:	9/8/2010

Input parameters:

Overliner material density, γ'	120 pcf	(use structural fill data from Golder, 2008, Appendix C)	
Interface friction angle, ϕ	30 degrees		
Lateral reaction coef., K	0.25	(assume Poisson's coefficient of 0.2)	
Equipment:	SmithCo S2-4034		
Standard tire:	11R22.5	Side factor:	77% (max. percentage of load carried by wheels
Tire width:	11.00 inch		on the dump side per SmithCo. recommendations)
Gross oper.weight (rear axles)	50,000 lbs	(acting on 2 axles w/ 25,000 lbs per axle)	
Minimum factor of safety	1.3		

Ref: http://www.sidedump.com

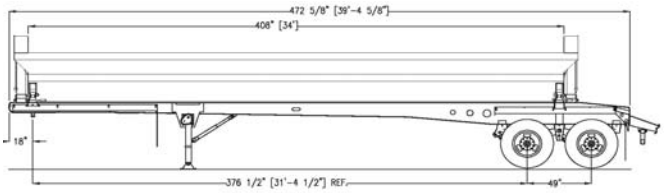

Figure 1. Dimensions

Frame Length:	39' 5"	**Hinges:**	Self-Aligning, Spherical Bearing Type (greasable)
Tub Length:	34'	**Suspension:**	Holland Binkley Four Spring, 3 Leaf Springs
Width:	102"	**Axles:**	(2) 25,000# capacity
Height:	8' 2" @ Tub Side, 9' 4" @ Center	**Hubs:**	10 Hole, Hub Piloted
Tub Capacity:	Round Bottom Tub, 23 Cubic Yard, Waterfull	**ABS:**	2S1M Anti-Lock Brake System
	Round Bottom Tub, 31 Cubic Yard, Full Capacity	**Drums:**	Outboard Mount, Cast Steel
	V-Shaped Tub, 24 Cubic Yard, Waterfull	**Wheels:**	Steel Disc, 8.25 x 22.5 (8)
	V-Shaped Tub, 32 Cubic Yard, Full Capacity	**Tires:**	11 R 22.5 G Radial Tires (8)

Use integration of the Boussinesq solution (1885)

1. Define pressure exerted by single tire

Load per tire (centric load)	6,250	lbs	(dump side)	9,625	lbs	(back side)	2,875	lbs
Tire pressure, q	100	psi		100	psi		100	psi
Contact area	62.50	inch^2		96.25	inch^2		28.75	inch^2
Length, a	5.68	inch		8.75	inch		2.61	inch
Width, b	11.00	inch		11.00	inch		11.00	inch

2. Define geometry

Wheelbase (est.)	33.42	ft
Centerline tire width (est)	6.50	ft
Inside tire width (est)	4.5	ft
Overall tire width (trailer width)	8.50	ft

Location	Point ID	x (ft)	y(ft)	Surface Load (psi)	a (inch)	b (inch)	
Origin (rear axles center)	A	0.00	0.00	0	0.00	0.00	
Outside tire (dump side)	B	6.50	4.08	100	22.00	8.75	(2 tires)
Rear axles center (dump side)	C	6.50	0.00	0	0.00	0.00	
Inside tire (dump side)	D	6.50	-4.08	100	22.00	8.75	(2 tires)
Mid outside/rear-back axle	E	0.00	4.08	0	0.00	0.00	
Mid inside/rear-front axle	F	0.00	-4.08	0	0.00	0.00	
Outside tire (back/off-dump side)	G	-6.50	4.08	100	22.00	2.61	(2 tires)
Rear axles center (back side)	H	-6.50	0.00	0	0.00	0.00	
Inside tire (back side)	I	-6.50	-4.08	100	22.00	2.61	(2 tires)

3. Calculate additional vertical stresses (psi)

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.01	36.47	0.10	36.47	0.01	0.01	11.81	0.03	11.81
2	0.04	13.33	0.52	13.33	0.05	0.05	4.08	0.15	4.08
3	0.12	6.55	1.02	6.55	0.14	0.14	1.98	0.31	1.98
3.5	0.17	4.94	1.20	4.94	0.19	0.19	1.50	0.37	1.50
4	0.22	3.87	1.33	3.87	0.24	0.24	1.17	0.41	1.17
6	0.41	1.87	1.37	1.87	0.41	0.41	0.59	0.45	0.59
7	0.47	1.45	1.26	1.45	0.45	0.45	0.48	0.43	0.48
8	0.51	1.17	1.13	1.17	0.48	0.48	0.41	0.40	0.41
9	0.52	0.98	1.00	0.98	0.48	0.48	0.36	0.37	0.36
10	0.52	0.84	0.89	0.84	0.48	0.48	0.33	0.35	0.33

4. Calculate activated friction angle

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.16	35.37	2.33	35.37	0.21	0.21	32.63	0.71	32.63
2	0.55	30.00	5.63	30.00	0.69	0.69	21.27	1.88	21.27
3	1.01	21.87	7.01	21.87	1.16	1.16	11.47	2.45	11.47
3.5	1.21	17.97	7.07	17.97	1.35	1.35	8.37	2.50	8.37
4	1.38	14.61	6.86	14.61	1.50	1.50	6.21	2.43	6.21
6	1.69	6.54	5.02	6.54	1.67	1.67	2.37	1.82	2.37
7	1.66	4.62	4.08	4.62	1.59	1.59	1.67	1.50	1.67
8	1.57	3.40	3.29	3.40	1.47	1.47	1.27	1.24	1.27
9	1.44	2.59	2.66	2.59	1.33	1.33	1.00	1.04	1.00
10	1.30	2.03	2.15	2.03	1.19	1.19	0.83	0.88	0.83

5. Calculate factor of safety

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	208.24	0.81	14.19	0.81	160.24	160.24	0.90	46.29	0.90
2	59.75	1.00	5.85	1.00	48.20	48.20	1.48	17.58	1.48
3	32.76	1.44	4.69	1.44	28.47	28.47	2.85	13.48	2.85
3.5	27.29	1.78	4.65	1.78	24.44	24.44	3.92	13.25	3.92
4	23.95	2.22	4.80	2.22	22.07	22.07	5.30	13.59	5.30
6	19.60	5.04	6.57	5.04	19.83	19.83	13.95	18.18	13.95
7	19.90	7.14	8.09	7.14	20.78	20.78	19.81	22.03	19.81
8	21.09	9.72	10.04	9.72	22.53	22.53	26.09	26.59	26.09
9	22.99	12.77	12.45	12.77	24.92	24.92	32.95	31.75	32.95
10	25.53	16.30	15.36	16.30	27.91	27.91	40.01	37.42	40.01

Table 2.5 Detailed Overliner Depth Calculation

Equipment type:	SmithCo S3-4234 Side Dump Trailer
Job No:	073-81694
Made By:	GG
Checked By:	SAO
Reviewed By:	KFM
Date:	9/8/2010

Input parameters:

Overliner material density, γ'	120 pcf	(use structural fill data from Golder, 2008, Appendix C)	
Interface friction angle, ϕ	30 degrees		
Lateral reaction coef., K	0.25	(assume Poisson's coefficient of 0.2)	
Equipment:	SmithCo S3-4234		
Standard tire:	11R22.5	Side factor:	77% (max. percentage of load carried by wheels
Tire width:	11.00 inch		on the dump side per SmithCo. recommendations)
Gross oper.weight (rear axles)	75,000 lbs	(acting on 3 axles w/ 25,000 lbs per axle)	
Minimum factor of safety	1.3		

Ref: http://www.sidedump.com

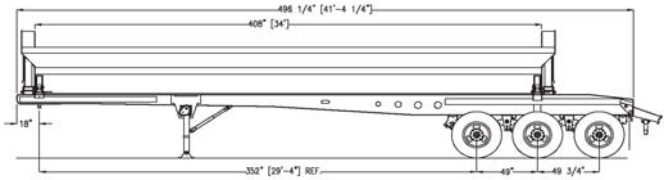

Figure 1. Dimensions

Frame Length:	41' 4"	**Hinges:**	Self-Aligning, Spherical Bearing Type (grea
Tub Length:	34'	**Suspension:**	Holland Binkley Six Spring, 3 Leaf Springs
Width:	102"	**Axles:**	(3) 25,000# capacity
Height:	8' 2" @ Tub Side, 9' 4" @ Center	**Hubs:**	10 Hole, Hub Piloted
Tub Capacity:	Round Bottom Tub, 23 Cubic Yard, Waterfull	**ABS:**	2S1M Anti-Lock Brake System
	Round Bottom Tub, 31 Cubic Yard, Full Capacity	**Drums:**	Outboard Mount, Cast Steel
	V-Shaped Tub, 24 Cubic Yard, Waterfull	**Wheels:**	Steel Disc, 8.25 x 22.5 (12)
	V-Shaped Tub, 32 Cubic Yard, Full Capacity	**Tires:**	11 R 22.5 G Radial Tires (12)

Use integration of the Boussinesq solution (1885)

1. Define pressure exerted by single tire

Load per tire (centric load)	6,250	lbs	(dump side)	9,625	lbs	(back side)	2,875	lbs
Tire pressure, q	100	psi		100	psi		100	psi
Contact area	62.50	inch^2		96.25	inch^2		28.75	inch^2
Length, a	5.68	inch		8.75	inch		2.61	inch
Width, b	11.00	inch		11.00	inch		11.00	inch

2. Define geometry

Wheelbase (est.)	33.38	ft
Centerline tire width (est)	6.50	ft
Inside tire width (est)	4.5	ft
Overall tire width (trailer width)	8.50	ft

Location	Point ID	x (ft)	y(ft)	Surface Load (psi)	a (inch)	b (inch)	
Origin (rear axles center)	A	0.00	0.00	0	0.00	0.00	
Outside tire (dump side)	B	6.50	4.15	100	22.00	8.75	(2 tires)
Mid tire (dump side)	C	6.50	0.00	100	22.00	8.75	(2 tires)
Inside tire (dump side)	D	6.50	-4.08	100	22.00	8.75	(2 tires)
Mid outside axle	E	0.00	4.15	0	0.00	0.00	
Mid inside axle	F	0.00	-4.08	0	0.00	0.00	
Outside tire (back/off-dump side)	G	-6.50	4.15	100	22.00	2.61	(2 tires)
Mid tire (back side)	H	-6.50	0.00	100	22.00	2.61	(2 tires)
Inside tire (back side)	I	-6.50	-4.08	100	22.00	2.61	(2 tires)

3. Calculate additional vertical stresses (psi)

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.01	36.52	36.56	36.52	0.01	0.01	11.83	11.84	11.83
2	0.09	13.58	13.83	13.59	0.08	0.08	4.15	4.22	4.16
3	0.24	7.03	7.51	7.06	0.20	0.20	2.13	2.27	2.14
3.5	0.34	5.52	6.07	5.54	0.27	0.28	1.67	1.84	1.68
4	0.43	4.50	5.10	4.53	0.35	0.35	1.37	1.55	1.38
6	0.75	2.54	3.09	2.55	0.61	0.61	0.81	0.98	0.81
7	0.83	2.06	2.54	2.07	0.69	0.69	0.68	0.84	0.69
8	0.87	1.72	2.12	1.73	0.73	0.73	0.60	0.73	0.61
9	0.88	1.47	1.79	1.48	0.74	0.74	0.55	0.66	0.55
10	0.86	1.27	1.54	1.28	0.73	0.74	0.50	0.59	0.50

4. Calculate activated friction angle

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	0.34	35.37	35.37	35.37	0.28	0.28	32.63	32.63	32.63
2	1.15	30.10	30.20	30.11	0.95	0.95	21.43	21.58	21.44
3	1.98	22.49	23.05	22.52	1.63	1.64	12.03	12.55	12.05
3.5	2.32	18.97	19.83	19.01	1.91	1.92	9.10	9.75	9.13
4	2.59	15.94	17.06	15.99	2.13	2.14	7.04	7.76	7.07
6	2.94	8.31	9.63	8.35	2.44	2.45	3.16	3.77	3.18
7	2.82	6.23	7.36	6.26	2.35	2.36	2.35	2.83	2.36
8	2.61	4.78	5.70	4.81	2.19	2.20	1.84	2.22	1.85
9	2.35	3.75	4.47	3.77	2.00	2.00	1.49	1.78	1.50
10	2.09	3.00	3.55	3.01	1.79	1.80	1.25	1.47	1.25

5. Calculate factor of safety

Depth \ Point ID	A	B	C	D	E	F	G	H	I
1	95.89	0.81	0.81	0.81	116.90	116.19	0.90	0.90	0.90
2	28.68	1.00	0.99	1.00	34.91	34.71	1.47	1.46	1.47
3	16.67	1.39	1.36	1.39	20.30	20.19	2.71	2.59	2.70
3.5	14.24	1.68	1.60	1.68	17.31	17.22	3.60	3.36	3.59
4	12.78	2.02	1.88	2.01	15.53	15.45	4.68	4.24	4.66
6	11.26	3.96	3.40	3.94	13.57	13.51	10.46	8.77	10.40
7	11.73	5.29	4.47	5.26	14.05	14.00	14.07	11.68	14.00
8	12.68	6.90	5.78	6.87	15.08	15.03	17.93	14.92	17.85
9	14.04	8.80	7.38	8.77	16.56	16.51	22.13	18.57	22.05
10	15.79	11.02	9.30	10.98	18.45	18.40	26.53	22.53	26.44