

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

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1. INTRODUCTION

The Getrich project includes construction and operation of new grassroots heavy oil production and upgrading facility to be located on the Gorse Lake lease, located about 140 km East of Fort McMurray, Alberta. The site is undeveloped other than those associated with testing and exploration.

A 135,000 BPD production facility is planned using steam assisted gravity drainage (SAGD) technology. The produced heavy oil will feed the proposed Upgrader. Additional feedstock will come from offsite sources. The upgrader will receive heavy feedstock and produce synthetic crude oil, capable of being refined into finished products by others. Sulphur will be the main by-product.

This document covers the engineering design and computation for the Man Deluge Building located in 1500 area of the project.

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1.1. REFERENCE

All design calculations for structural steel and reinforced concrete shall be done by the Limit States Design method in SI units.

The calculations themselves are the basis for the minimum design criteria, all information on the drawing shall take precedence. Where there is a conflict between codes, standards and/or specifications, the most onerous shall apply.

CODES

National Building Code of Canada (NBCC), 1995 & Structural Commentaries
 Alberta Building Code 1997

STANDARDS

CAN/CSA-A5-98	Portland cement
CSA-A23.4-00	Precast Concrete Materials and Construction
CAN/CSA-A23.5-M86 (R1992)	Supplementary Cementing Materials
CAN/CSA-S6-00	Design of Highway Bridges
CSA-A23.3-94	Design of Concrete Structures
CSA-S304.1-94	Masonry Design for Buildings
CSA-A23.1-00	Concrete Materials and Methods of Concrete Construction
CSA-A23.2-00	Methods of Test for Concrete
CSA-S16-01	Limit States Design of Steel Structures
CAN/CSA-G40.20/G40.21-98	General Requirements for Rolled or Welded Structural Quality Steel
CAN/CSA-S136-01	Cold Formed Steel Structural Members

SPECIFICATIONS

ASTM A307-02	Specification for Carbon Steel Bolts and Studs
ASTM A320-02	Specification for Alloy Steel Bolting Materials for Low Temperature Service
ASTM A325-02	Specification for Structural Bolts, Steel and Heat Treated joints
ASTM A563-00	Specification for Carbon and Alloy Steel Nuts
F436-02	Specification for Hardened Steel Washers.

PROJECT SPECIFICATIONS

045.215.00001 rev 0A	Structural and Civil Design Criteria and applicable Fluor Practices
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PROJECT DESIGN BULLETINS

These are to be observed. They are available electronically in the project directory.

OTHERS

CISC Handbook of Steel Construction
 Geotechnical Report – ECA Engineering Consultants Ltd. Phase F and G(0505-5500344 March 2004)

COMPUTER SOFTWARE

For Structural Analysis and Unity code checks to Canadian codes performed using RISA-3D Version 5c

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1.2. MATERIALS

Structural steel	CAN/CSA G40.21M, grade 350W for WF and HSS. Grade 300W for angles, channels and plates.
Connection bolts	ASTM A325 ¾" minimum high strength bolts. (in ¼" increments)
Anchor bolts	ASTM A-307 or ASTM A-320 grade L7.
Welding electrodes	CSA W59
Structural Concrete	The specified compressive strength 30 MPa at 28 days
Lean concrete	The specified compressive strength 10 MPa at 28 days
Reinforcing steel	Minimum specified yield strength of 400 MPa.

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1.3. DESIGN LOADS

Refer also to the Civil and Structural Design Criteria for details.

Dead load (D)

Total dead weight of empty equipment and/or structures, including fireproofing, insulation, piping and cable trays. Add 15% for connections (in operation) Weight of backfill to be included in foundation design as appropriate. For empty pipes, assume 1.15 kN/m².

Operating Load (D)

This shall be the weight of fluids in equipment and pipes under normal conditions at maximum operating level. For pipes assume 2.0 kN/m². This shall be treated as dead load for the load factors in Limit State Design

Test Load (D)

This is the dead load and weight of liquid necessary to pressure test equipment, vessels and piping. This shall be treated as dead load for the load factors in Limit State Design

Live Load (L)

This consists of movable loads, including personnel, snow, equipment, portable machinery, permanently stored materials during maintenance and may be applied at grade or on platforms.

Wind load (W)

Wind Pressures are derived from reference velocity pressure of q = 0.32 kPa. This corresponds to 1/30 year wind. No shielding to be considered. Wind pressures shall be calculated as per NBCC 4.1.8.1:

$$p = q C_e C_g C_p$$

where

- q reference velocity pressure
- C_e Exposure factor
- C_g Gust effect factor
- C_p External pressure coefficient

Maintenance load (L)

This also includes Tube bundle removal. This shall be considered live load in load combinations.

Slug/Thermal forces (T)

This is applied as per Fluor Practice. Not only those due to temperature effects but also anchorage of piping and equipment, sliding and rolling frictional forces and any slug flow conditions must be identified as early as possible.

Thermally, unless provided by piping assume 10% of operating loads.

Friction, unless provided by piping, assume longitudinal friction as 10% of operation loads and for transverse friction stress, assume 5kN at each beam supporting pipes.

For anchor loads, unless provided by piping stress, assume 5 kN at each joint shown on piping stress memo.

Snow load (SL)

Need only apply to the following:

- A) electrical cable trays. 50% applied to the top level and the rest distributed equally to the other levels. For single level tray apply 100 % snow load.
- B) Platforms constructed with solid floor plate.

Earthquake Load (EQ)

Not applicable

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1.4. LOAD COMBINATIONS

For load combinations, operating loads shall be considered as a dead load. In the case of overturning, uplift and stress reversals only 85% of dead load shall be considered (without the weight of fluid).

For Limit State Design of Strength and Stability

The load combinations shall be taken as

$$\alpha_D D + \gamma \psi [\alpha_L L + \alpha_W W + \alpha_T T]$$

For Limit State Design of Serviceability

The load combinations shall be taken as

$$D + \psi [L + W + T]$$

where $\alpha_D = 1.25$ or 0.85

$\alpha_L = 1.5$

$\alpha_W = 1.5$ and

$\alpha_T = 1.25$

Load combination factor

$\psi = 1.0$ when only one of the loads L, W, or T is included

$\psi = 0.70$ with two

$\psi = 0.60$ with all three

Importance factor

$\gamma = 1.0$

		Erection	Operating			Test
		D+W	D+L	D+L+W	D+L+W+T	D+L+W
Parameter		Cat. 1	Cat. 2	Cat.3	Cat. 4	Cat. 5
Strength & Stability	α_D	0.85	1.25	1.25	1.25	1.25
	α_L	-	1.5	1.5	1.5	1.50
	α_W	1.5	-	1.5	1.5	0.375
	α_T	-	-	-	1.25	-
	ψ	1.0	1.0	0.7	0.6	0.7
	γ	1.0	1.0	1.0	1.0	1.0
Serviceability	ψ	1.0	1.0	0.7	0.6	0.7

Refer to Structural Job Data book for relevant Load designations and combinations.

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CHECKLIST

	List of Contents	Yes	No	Remarks/References
1.0	Preliminary Engineering			
	Calculations	Yes		
	Sketches	Yes		
	RISA model		No	
2.0	Conceptual Philosophy			
	Fireproofing		No	
	Modules		No	
	Stick built	Yes		
	Other	Yes		Blast-resistant to 3 psi at 100 ms
3.0	Datasheets			
	Process		No	
	Vendor data		No	
	Piping Stress		No	
4.0	Correspondence			
	Client		No	
	Project		No	
	Piping		No	
	Electrical		No	
5.0	Any go-bys	Yes		ASCE method of design
6.0	Status of PDS model			
	Inclusions		N/A	
	Exclusions		N/A	
	Forecasts		N/A	
	Instructions		N/A	

Calculations

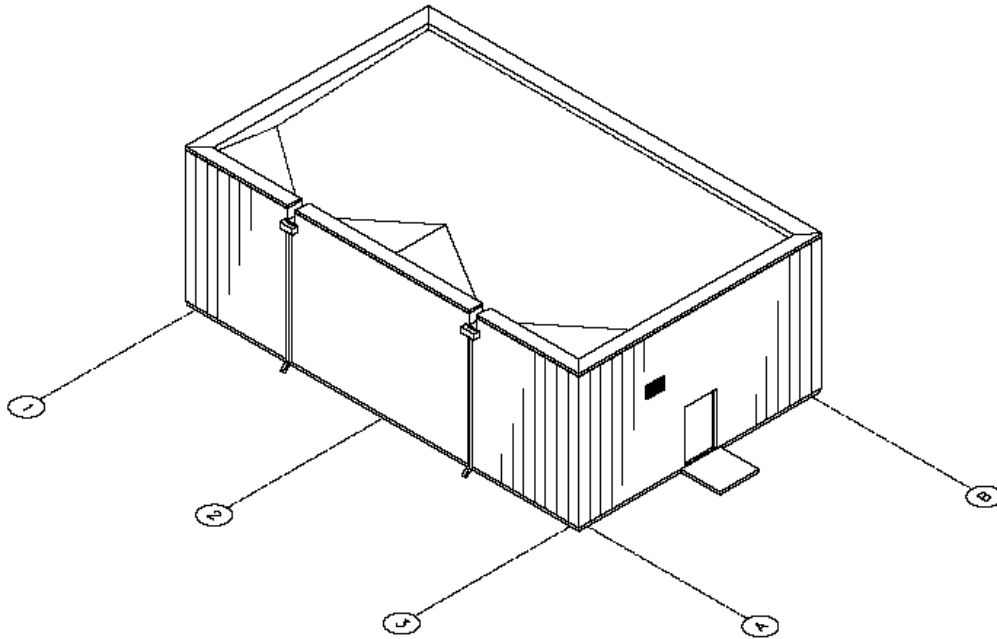
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2. DESCRIPTION OF CONSTRUCTION

Steel framed building supporting in-situ concrete walls and roof designed to protect the equipment module housed inside the building from a blast load of 3 psi at 0.1 s.

Walls connected directly to steel frames with Nelson studs. Steel frames all bolted to piled foundations, assumed dynamically to be pinned. Roof cast in place with Q-decking.

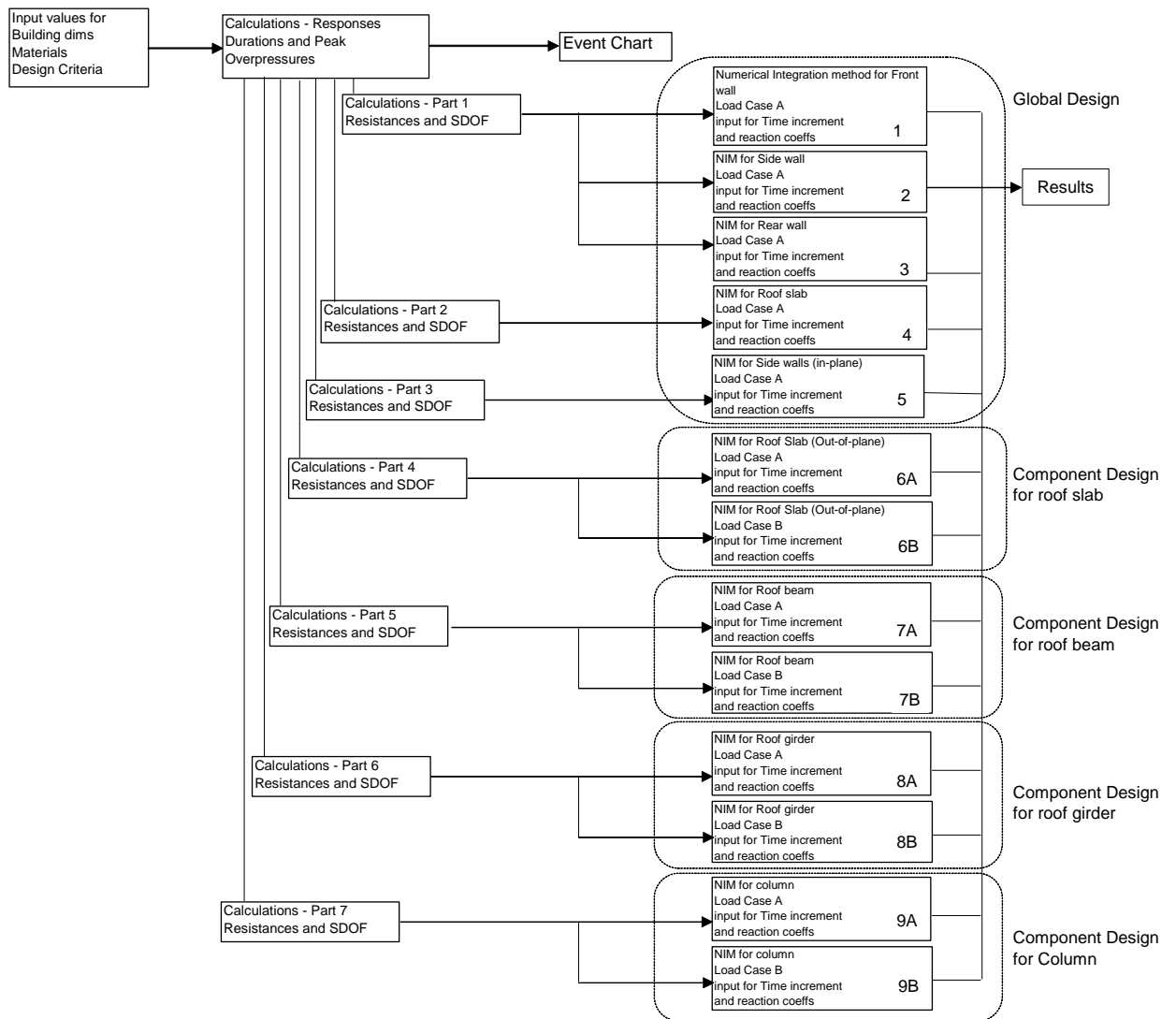
Low response is assumed thus the building elements will be allowed to yield in the presence of the blast. Analysis is based on the ASCE 1997 Blast resistant design for petrochemical facilities.



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2.1. INPUT PARAMETERS



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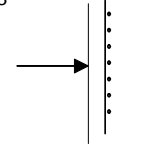
Materials

		Imperial	Metric			
Structural Steel	A36	36 ksi	248 MPa	B	45.93 ft	14.000 m
Reinforcing Steel	Grade 60	58 ksi	400 MPa	L	29.53 ft	9.001 m
Steel Modulus	E_s	29007400 psi	200000 MPa	H	18.05 ft	5.502 m
Concrete Modulus	E_c	3605000 psi	24856 MPa			
Concrete	f'_c	4000 psi	27.6 MPa			
Transformed modulus	$n = E_s/E_c$	8.05				
Soil density	\square	115 pcf	18.1 kN/m ³			
Acceleration of gravity	g	32.2 ft/sec ²	9.81 m/sec ²			
Roof dead loads	w	25 psf	1.2 kPa	LL disregarded		

Check for Case A Design on Long side of the building
 Check for Case B Design on short side of the building

Overpressure	P_{so}	3 psi	20.7 kPa
Duration	t_d	0.1 sec	0.1
Building Performance Response		Low	Low

Ref
Figure 3.3



Wall spans

Span	H_i	17 ft	5.182 m
Design width	b	1 ft	0.305 m

Trial size

Wall thickness	h	10 in	254 mm	Vertical bars outside of horiz bars
Reinf. Arrangement		#5 @ 6 in	15M @ 150	
	A_s	0.31 in ²	200 mm ²	

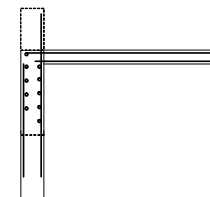
Roof spans

Span	L	45.1 ft	c/c (For Load Case A)
depth		29.5 ft	outside dims.

Determine width of composite (wall) flange condition

a	$= (45.931 \text{ ft span})/2$	22.97 ft
b	$= 6 (10 \text{ in})/12$	5.00 ft
c	$= (17 \text{ ft wall span})/2$	8.50 ft
Effective width	b_f	5.00 ft

ACI 318, Section 8.10.3



Trial size

Concrete slab 5 in thickness plus 2 in steel decking, for an average of 6 in (150 mm)

slab thickness	slab depth	5 in	150 mm
Average thickness		6 in	150 mm
Roof reinforcing		#3 @ 7 in	#3@180
A_s		0.11 in ²	71 mm ²
Chord reinforcing		10 in	254 mm
		10#8 per chord	
A_s		7.9 in ²	5100 mm ²

(as per wall details)

Roof beam

Roof beam span	W14 x 38	38 lb/ft
Loading span		15 ft
beam depth	d	5.75 ft
flange width	b_f	14.1 in
flange thickness	t_f	6.77 in
web depth	h_c	0.515 in
web thickness	t_w	11.625 in
		0.31 n
	$b_f / 2t_f =$	6.6
	$h_c / t_w =$	37.5
Radius of gyration	r_y	1.55 in
moment of inertia	I	385 in ⁴
Plastic modulus	Z_x	61.5 in ³

Calculations

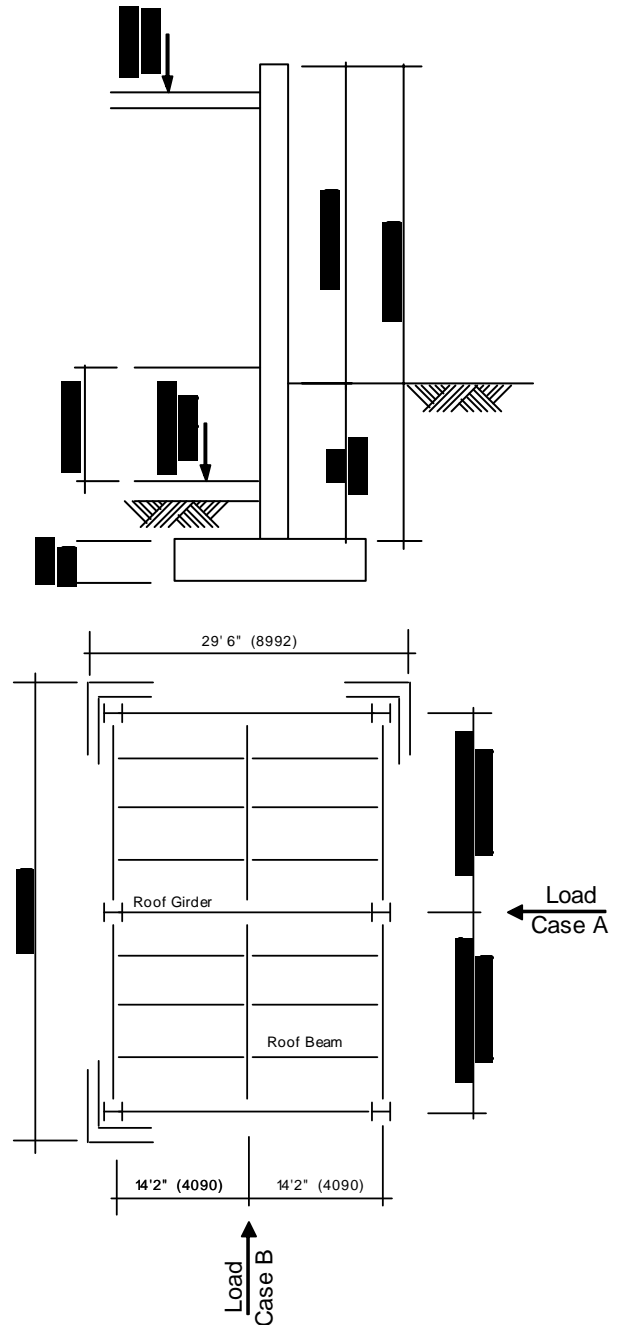
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Roof girder

trial size	W21 x 111		111 lb/ft
Roof Girder span			30 ft
Loading span			23 ft
beam depth	d		21.5 in
flange width	b _f		12.3 in
flange thickness	t _f		0.875 in
web depth	h _c		18 in
web thickness	t _w		0.55 in
		b _f / 2t _f =	7.03
		h _c / t _w =	32.73
Radius of gyration	r _y		2.9 in
moment of inertia	I		2670 in ⁴
Plastic modulus	Z _x		279 in ³

Column

trial size	W10 x 45		45 lb/ft
Column height			13.8 ft
Loading span			23 ft
Area	A		13.3 in ²
flange width	b _f		12.3 in
flange thickness	t _f		0.875 in
web depth	h _c		18 in
web thickness	t _w		0.55 in
		b _f / 2t _f =	7.03
		h _c / t _w =	32.73
Radius of gyration	r _y		2.01 in
moment of inertia	I		2670 in ⁴
Plastic modulus	Z _x		279 in ³



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Exterior Walls (out of plane loads)

Front Wall Load (for maximum wall response)

Shock front velocity	$U = 1130 (1 + 0.058 P_{so})^{0.5}$		1224 ft/sec	373 m/s	Eqn 3.5
Length of Pressure wave	$L_w = U t_d$		122 ft	37.31 m	Eqn 3.6
Peak dynamic Wind Pressure	$q_o = 0.022 (P_{so})^2$		0.198 psi	1.4 kPa	Eqn 3.4
Magnitude of reflected pressure	$P_r = C_r P_{so}$	where $C_r = (2 + 0.05 P_{so})$	6.45 psi	44.5 kPa	Eqs 3.2 & 3.3
rise time	t_r		0 sec	0 sec	
Clearing distance	$S = \text{minimum of } H \text{ or } B/2$		18.05 ft	5.50164 m	Section 3.5.1
Reflected overpressure clearing time	$t_c = 3 (S / U) < t_d$	$= 3 (18.05) / (1224)$	0.044 sec	0.044 sec	Eqn 3.8
Drag Coefficient	C_d		1.00	1.00	Section 3.3.3
Stagnation Pressure	$P_s = P_{so} + C_d (q_o)$	$= (3) + (1) (0.198)$	3.2 psi	22.0 kPa	Eqn 3.7
Front Wall Impulse	$I_w = 0.5 (P_r - P_o) t_c + 0.5 P_{st} t_d$	$= 0.5 [(6.45) - (3.198)] (0.044) + 0.5 (3.198)(0.1)$	0.231 psi-sec	1.6 kPa	Eqn 3.9
Effective Duration	$t_o = 2 I_w / P_r$	$= 2 (0.231) / (6.45)$	0.072 sec	0.072 sec	Eqn 3.10
Peak load	$P_o =$	$= (216.6)(12)(6.45) / (1000)$	15.8 kips	70.3 kN	

Side Wall Load (for maximum wall response)

Drag Coefficient	C_d		-0.40	-0.40	Section 3.3.3
Equivalent load coeff	L_w/L_1	$= (29.53) / (1)$	29.53	29.53	figure 3.9
			Therefore $C_e =$	1.0	1.0
Equivalent peak overpressure	$Pa = C_e P_{so} + C_d q_o$	$= (1)(3) + (-0.4)(0.198)$	2.9 psi	20.0 kPa	Eqn 3.11
rise time	$t_r = L_1 / U$	$= (1) / (1224)$	0.001 sec	0.001 sec	fig 3.8
duration	t_d		0.1 sec	0.1 sec	
Peak load	P_o	$= (17 \times 12)(12)(2.9) / (1000)$	7.1 kips	31.6 kN	

Roof Loading

Load Case A, parallel to 5.75 ft span of slab

Spans assumed	L_1		5.75 ft	1.753 m	
Drag Coefficient	C_d		-0.40	-0.40	Section 3.3.3
Equivalent load coeff	L_w/L_1	$= (29.53) / (5.75)$	5.14	5.14	figure 3.9
			Therefore $C_e =$	0.9	0.9
Equivalent peak overpressure	$Pa = C_e P_{so} + C_d q_o$	$= (0.9)(3) + (-0.4)(0.198)$	2.6 psi	18.1 kPa	Eqn 3.11
rise time	$t_r = L_1 / U$	$= (5.75) / (1224)$	0.005 sec	0.005 sec	fig 3.8
duration	t_d		0.100 sec	0.100 sec	
Total positive phase duration	$t_o = t_r + t_d$	$= (0.005) + (0.1)$	0.105 sec	0.105 sec	
Peak load	P_o	$= 69 \times 12 \times 2.6208 / 1000$	2.2 kips	9.7 kN	

Load Case B, perpendicular to span

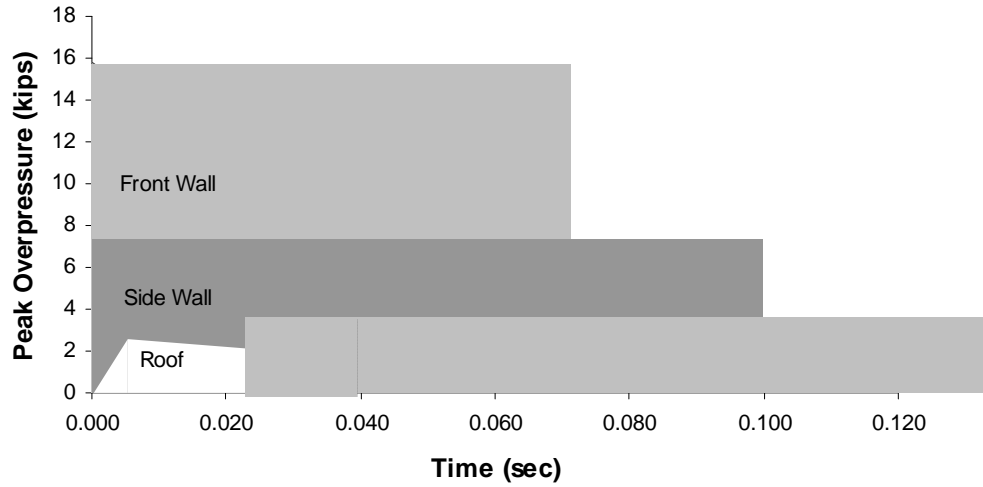
Span assumed	L_1		1 ft	305 mm	
	L_w/L_1		29.53	29.53	Section 3.3.3
			Therefore $C_e =$	1.0	1.0
rise time	$t_r = L_1 / U$		0.001 sec	0.001 sec	
Equivalent peak overpressure	$Pa = C_e P_{so} + C_d q_o$	$= (1)(3) + (-0.4)(0.198)$	2.9 psi	20.1 kPa	Eqn 3.11
Peak load	P_o	$= 69 \times 12 \times 2.92 / 1000$	2.4 kips	10.8 kN	

Rear Wall Loading

Spans assumed	L_1		17.7 ft	5.395 m	
Drag Coefficient	C_d		-0.40	-0.40	Section 3.3.3
Equivalent load coeff	L_w/S	$= (29.53) / (18.05)$	1.64	1.64	figure 3.9
			Therefore $C_e =$	0.50	0.50
Equivalent peak overpressure	$Pa = C_e P_{so} + C_d q_o$	$= (0.5)(3) + (-0.4)(0.198)$	1.4 psi	9.7 kPa	Eqn 3.11
Time of arrival	$t_a = L / U$	$= (29.53) / (1224)$	0.024 sec	0.024 sec	
Rise time	$t_r = S / U$	$= (18.05) / (1224)$	0.015 sec	0.015 sec	TM5-1300 criteria
Duration	t_d		0.100 sec	0.100 sec	
	$t_1 = t_a =$		0.024 sec		Figure 3.8
	$t_2 = t_1 + t_r =$		0.039 sec		
	$t_3 = t_2 + t_d =$		0.139 sec		
Peak load	P_o	$= (204)(12)(1.4)/(1000)$	3.43 kips	15.3 kN	

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EXTERIOR WALLS OUT OF PLANE

Bending Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.17) 58$	74.6 ksi	514 MPa	
	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.19) 4$	4.76 ksi	33 MPa	
Effective depth	d	$= (10) - (1.5 \text{ in}) - (0.314)$	8.19 in	208.0 mm	
Steel layer per face	$A_s \text{ (in}^2\text{/ft)}$	$= (0.31 \times 12) / (6 \text{ in bar spacing})$	0.62 in ²	400.0 mm ²	
Reinf percentages	$\rho = A_s / bd$	$= (0.62) / (12)(8.19)$	0.0063 > 200/ f_{dy}		ACI 318, Eqn 10-3
	$a = A_s (f_y) / (0.85 f_{dc})(b)$	$= 0.62 \times 74.6 / (0.85 \times 4.76 \times 12)$	0.95 in	24.1 mm	
	$M_p = M_n = A_s (f_{dy}) [d - a/2]$	$= 0.62 \times 74.6 [8.19 - 0.95 / 2]$	356.8 in-k	40.3 kNm	
Bending resistance	$R_b = 8M_p/L$	$= 8 \times 356.8 / (17 \times 12)$	13.99 kips	62.3 kN	Table 6.1

Shear Resistance

for dynamic shear	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.0) 4$	4 ksi	27.6 MPa	Appendix 5.A
	$V_n = 2 (f_c)^{0.5} bd$	$= 2 \times \text{sqrt}(4000) \times 1 \times 12 \times 8.19$	12.43 kips	55.3 kN	ACI 318, Eqn 11-3
At critical section	$R_s = V_n / L / (0.5L - d)$	$= 12.43 \times 204 / (0.5 \times 17 \times 12 - 8.19)$	27.03 kips	120.3 kN	

SDOF Equivalent System

because $R_b < R_s$ bending governs

	R_{min}	minimum of R_s and R_b	13.99 kips	62.3 kN	
Allowable response	θ_a	2.0°			Table 5.B.1
Gross moment of inertia	$I_g = b (h)^3 / 12$	$= 12 \times 10^3 / 12$	1000 in ⁴	41623 cm ⁴	
	nA_s	$= 8.05 \times 0.62$	4.99 in ²	3219 mm ²	
Depth of uncracked section	$C_n = [(-nA_s) + (nA_s(nA_s + 2bd)0.5)]/b$	$= [-4.99 + \text{sqrt}(4.99(4.99 + 2 \times 12 \times 8.19))]/12$	2.23 in	56.6 mm	
Cracked moment of inertia	$I_{cr} = b C_n^3 / 3 + nA_s (d - C_n)^2$	$= 12 \times 2.23^3 / 3 + 4.99(8.19 - 2.23)^2$	221.6 in ⁴	9224 cm ⁴	
Averaged moment of inertia	$I_a = (I_g + I_{cr}) / 2$	$= (1000 + 221.6) / 2$	611 in ⁴	25432 cm ⁴	
Effective stiffness	$K = 384EI / 5L^3$	$= (384 \times 3605 \times 611) / (5 \times 204^3)$	19.93 k/in	3491.5 kN/m	
Yield deflection	$y_e = R_u / K$	$= 13.99 / 19.93$	0.7 in	17.8 mm	
Beam mass	$m = (\text{wall weight}) / (\text{gravity})$	$= (0.15 \times 0.83 \times 1 \times 17) / (386.4)$	0.0055 k-sec ² /in	0.963530 kNsec ² /m	
Elastic Load Factor	K_{LM}	$= 0.5 / 0.64$	0.78	0.78	Table 6.1
Plastic Load Factor	K_{LM}	$= 0.33 / 0.5$	0.66	0.66	
Averaged Load Factor	K_{LM}	$= (0.78 + 0.66) / 2$	0.72	0.72	
Equivalent mass	$m_e = (K_{LM}) (\text{beam mass})$	$= 0.72 \times 0.0055$	0.00396 k-sec ² /in	0.694 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.00396 / 19.93)$	0.089 sec	0.089 sec	Eqn 6.8
For Support reactions	$V = 0.385R + 0.115F$				Table 6.1

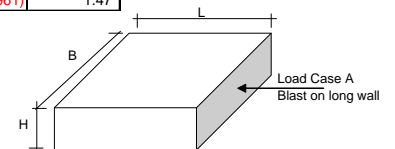
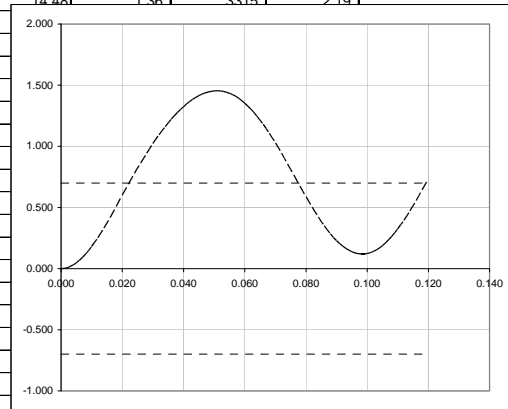
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

FRONT WALL

Equivalent Mass	m_e	0.00396 k-sec ² /in	Summary			
Effective Stiffness	K	19.93 k/in	Maximum deflection	ΔD	1.453 in at time	0.050 sec
Peak Overpressure	Fo	15.8 kips	Plastic deformation	$y_p = y_m - y_e$	0.753 in	
Effective duration	t_e	0.072 sec	ductility ratio		2.08	
Time Increment	Δt	0.002 sec	Rebound peak deflection	y_m	0.119 in at time	0.098 sec
Positive Yield Deflection	+ Δy	0.70 in	Rebound elastic deformation	$y_e = y_m - y_p$	-0.634 in	
Negative Yield Deflection	- Δy	-0.70 in	The peak reaction	R_o	-6.58 kips at time	0.024 sec
Resistance Coefficient	R_{cc}	0.385	Peak rebound reaction	R_o	-1.82 kips at time	0.000 sec
Force Coefficient	F_{cc}	0.115	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.82 °	< 2° OK

Time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	15.80	0.00	3990	1.82
0.002	0.008	0.008	0.000	0.000	15.36	0.16	3839	1.83
0.004	0.031	0.031	0.000	0.000	14.92	0.62	3612	1.95
0.006	0.068	0.068	0.000	0.000	14.48	1.36	3315	2.19
0.008	0.118	0.118	0.000	0.000				
0.010	0.180	0.180	0.000	0.000				
0.012	0.252	0.252	0.000	0.000				
0.014	0.332	0.332	0.000	0.000				
0.016	0.418	0.418	0.000	0.000				
0.018	0.508	0.508	0.000	0.000				
0.020	0.600	0.600	0.000	0.000				
0.022	0.691	0.691	0.000	0.000				
0.024	0.779	0.700	0.079	0.000				
0.026	0.864	0.700	0.164	0.000				
0.028	0.945	0.700	0.245	0.000				
0.030	1.022	0.700	0.322	0.000				
0.032	1.094	0.700	0.394	0.000				
0.034	1.161	0.700	0.461	0.000				
0.036	1.222	0.700	0.522	0.000				
0.038	1.277	0.700	0.577	0.000				
0.040	1.325	0.700	0.625	0.000				
0.042	1.366	0.700	0.666	0.000				
0.044	1.400	0.700	0.700	0.000	6.14	13.95	(1971)	6.08
0.046	1.426	0.700	0.726	0.000	5.71	13.95	(2082)	6.03
0.048	1.444	0.700	0.744	0.000	5.27	13.95	(2193)	5.98
0.050	1.453	0.700	0.753	0.000	4.83	13.95	(2304)	5.93
0.052	1.453	0.700	0.753	0.000	4.39	13.95	(2415)	5.88
0.054	1.443	0.690	0.753	0.000	3.95	13.75	(2475)	5.75
0.056	1.423	0.670	0.753	0.000	3.51	13.35	(2485)	5.54
0.058	1.393	0.640	0.753	0.000	3.07	12.76	(2445)	5.26
0.060	1.353	0.600	0.753	0.000	2.63	11.96	(2355)	4.91
0.062	1.304	0.551	0.753	0.000	2.19	10.98	(2219)	4.48
0.064	1.246	0.493	0.753	0.000	1.76	9.83	(2038)	3.98
0.066	1.180	0.427	0.753	0.000	1.32	8.51	(1817)	3.43
0.068	1.107	0.354	0.753	0.000	0.88	7.06	(1560)	2.82
0.070	1.028	0.275	0.753	0.000	0.44	5.48	(1273)	2.16
0.072	0.944	0.191	0.753	0.000	0.00	3.81	(961)	1.47



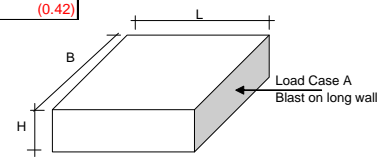
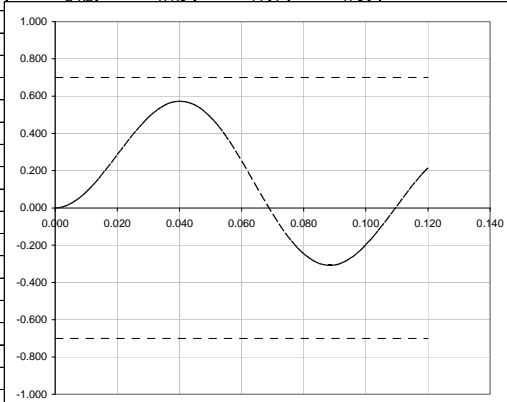
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

SIDE WALL

Equivalent Mass	m_e	0.00396 k-sec ² /in	Summary			
Effective Stiffness	K	19.93 k/in	Maximum deflection	ΔD	0.572 in at time	0.040 sec
Peak Overpressure	F_o	7.1 kips	No plastic deformation			
Effective duration	t_e	0.1 sec				
Time Increment	Δt	0.002 sec	Rebound peak deflection	y_m	-0.308 in at time	0.088 sec
Positive Yield Deflection	$+\Delta y$	0.7 in				
Negative Yield Deflection	$-\Delta y$	-0.7 in	The peak reaction	R_o	-4.88 kips at time	0.040 sec
Resistance Coefficient	R_{cc}	0.385	Peak rebound reaction	R_o	0.01 kips at time	0.070 sec
Force Coefficient	F_{cc}	0.115	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.32 °	< 2° OK

Time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	7.10	0.00	1793	0.82
0.002	0.004	0.004	0.000	0.000	6.96	0.00	1727	0.82
0.004	0.015	0.015	0.000	0.000				
0.006	0.033	0.033	0.000	0.000				
0.008	0.057	0.057	0.000	0.000				
0.010	0.086	0.086	0.000	0.000				
0.012	0.120	0.120	0.000	0.000				
0.014	0.158	0.158	0.000	0.000				
0.016	0.199	0.199	0.000	0.000				
0.018	0.242	0.242	0.000	0.000				
0.020	0.286	0.286	0.000	0.000				
0.022	0.330	0.330	0.000	0.000				
0.024	0.373	0.373	0.000	0.000				
0.026	0.414	0.414	0.000	0.000				
0.028	0.452	0.452	0.000	0.000				
0.030	0.486	0.486	0.000	0.000				
0.032	0.515	0.515	0.000	0.000				
0.034	0.539	0.539	0.000	0.000				
0.036	0.557	0.557	0.000	0.000				
0.038	0.568	0.568	0.000	0.000				
0.040	0.572	0.572	0.000	0.000	4.26	11.40	(1803)	4.88
0.042	0.569	0.569	0.000	0.000	4.12	11.34	(1824)	4.84
0.044	0.559	0.559	0.000	0.000	3.98	11.14	(1809)	4.75
0.046	0.542	0.542	0.000	0.000	3.83	10.80	(1760)	4.60
0.048	0.518	0.518	0.000	0.000	3.69	10.32	(1675)	4.40
0.050	0.487	0.487	0.000	0.000	3.55	9.71	(1555)	4.15
0.052	0.450	0.450	0.000	0.000	3.41	8.97	(1404)	3.84
0.054	0.407	0.407	0.000	0.000	3.27	8.11	(1224)	3.50
0.056	0.359	0.359	0.000	0.000	3.12	7.15	(1018)	3.11
0.058	0.307	0.307	0.000	0.000	2.98	6.12	(792)	2.70
0.060	0.252	0.252	0.000	0.000	2.84	5.02	(551)	2.26
0.062	0.195	0.195	0.000	0.000	2.70	3.89	(300)	1.81
0.064	0.137	0.137	0.000	0.000	2.56	2.73	(44)	1.35
0.066	0.079	0.079	0.000	0.000	2.41	1.57	212	0.88
0.068	0.022	0.022	0.000	0.000	2.27	0.44	463	0.43
0.070	-0.033	-0.033	0.000	0.000	2.13	(0.66)	704	(0.01)
0.072	-0.085	-0.085	0.000	0.000	1.99	(1.69)	930	(0.42)



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

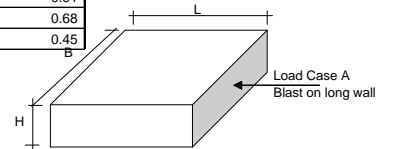
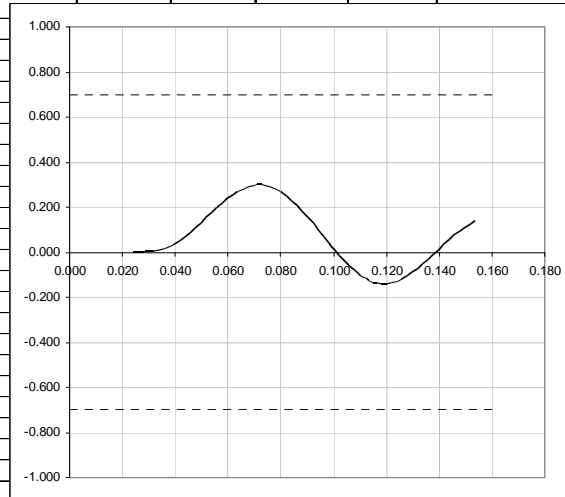
REAR WALL

Equivalent Mass	m_e	0.00396 k-sec ² /in
Effective Stiffness	K	19.93 k/in
Peak Overpressure	F _o	3.43 kips
Effective duration	t _e	0.1 sec
Arrival time	t _a	0.024 sec
Rise time	t _r	0.015 sec
Time Increment	Δt	0.002 sec
Positive Yield Deflection	+ Δy	0.7 in
Negative Yield Deflection	- Δy	-0.7 in
Resistance Coefficient	R _{cc}	0.385
Force Coefficient	F _{cc}	0.115

Summary

Maximum deflection	ΔD	0.297 in at time	0.048
No Plastic Deformation			
Rebound Peak Deflection	y _m	-0.143 in at time	0.094
The peak reaction	R _o	-2.54 kips at time	0.042
Peak Rebound reaction	R _o	0.00 kips at time	#N/A
Support rotation	θ _s = tan ⁻¹ (y _m /0.5L)		0.17 °

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.024	0.000	0.000	0.000	0.000	0.00	0.00	0	0.00
0.002	0.026	0.000	0.000	0.000	0.000	0.46	0.00	115	0.05
0.004	0.028	0.000	0.000	0.000					
0.006	0.030	0.001	0.001	0.000					
0.008	0.032	0.003	0.003	0.000					
0.010	0.034	0.007	0.007	0.000					
0.012	0.036	0.013	0.013	0.000					
0.014	0.038	0.022	0.022	0.000					
0.016	0.040	0.034	0.034	0.000					
0.018	0.042	0.049	0.049	0.000					
0.020	0.044	0.066	0.066	0.000					
0.022	0.046	0.085	0.085	0.000					
0.024	0.048	0.106	0.106	0.000					
0.026	0.050	0.128	0.128	0.000					
0.028	0.052	0.151	0.151	0.000					
0.030	0.054	0.174	0.174	0.000					
0.032	0.056	0.196	0.196	0.000					
0.034	0.058	0.217	0.217	0.000					
0.036	0.060	0.236	0.236	0.000					
0.038	0.062	0.253	0.253	0.000					
0.040	0.064	0.268	0.268	0.000					
0.042	0.066	0.280	0.280	0.000					
0.044	0.068	0.289	0.289	0.000					
0.046	0.070	0.295	0.295	0.000					
0.048	0.072	0.297	0.297	0.000					
0.050	0.074	0.295	0.295	0.000					
0.052	0.076	0.289	0.289	0.000	0.000	2.16	5.76	(909)	2.47
0.054	0.078	0.279	0.279	0.000	0.000	2.09	5.56	(876)	2.38
0.056	0.080	0.265	0.265	0.000	0.000	2.02	5.28	(823)	2.27
0.058	0.082	0.248	0.248	0.000	0.000	1.96	4.94	(754)	2.13
0.060	0.084	0.228	0.228	0.000	0.000	1.89	4.54	(671)	1.97
0.062	0.086	0.205	0.205	0.000	0.000	1.82	4.09	(573)	1.78
0.064	0.088	0.180	0.180	0.000	0.000	1.75	3.59	(464)	1.58
0.066	0.090	0.153	0.153	0.000	0.000	1.68	3.05	(346)	1.37
0.068	0.092	0.125	0.125	0.000	0.000	1.61	2.49	(222)	1.14
0.070	0.094	0.096	0.096	0.000	0.000	1.54	1.91	(93)	0.91
0.072	0.096	0.067	0.067	0.000	0.000	1.47	1.34	35	0.68
0.074	0.098	0.038	0.038	0.000	0.000	1.41	0.76	164	0.45



Calculations

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ROOF SLAB DESIGN

Bending Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.17) 58$	74.6 ksi	514 MPa	
	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.19) 4$	4.76 ksi	33 MPa	
Effective depth	d	$= (354) - (10 \text{ in wall} / 2)$	349 in	8864.6 mm	
Reinf percentages	$\rho = A_s / bd$	$= (7.9) / (60)(349)$	0.0004 < 200 / f_{dy}		ACI 318, Eqn 10-3

$a = A_s (f_y) / (0.85 f'_{dc})(b)$	$= 7.9 \times 74.6 / (0.85 \times 4.76 \times 60)$	2.43 in	61.7 mm
$M_p = A_s (f_y) [d - a/2]$	$= 7.9 \times 74.6 [349 - 2.43 / 2]$	204964 in-k	23165.7 kNm
$R_b = 8(M_{pr}/L + M_{pc}/L)$	$= 16 \times 204963.6 / (45.1 \times 12)$	6060 kips	26965.4 kN

Shear Resistance

for dynamic diagonal shear	$f'_{dc} = (SIF)(DIF) f'_c$	$= (1.0)(1.0) 4$	4 ksi	27.6 MPa	Appendix 5.A
	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.0) 58$	63.8 ksi	439.9 MPa	
Shear resistance from ACI deep beam criteria, only 50% of slab thickness used for resisting in-plane shear	$V_c = 2 (f'_c)^{0.5} bd$	$= 2 \times \text{sqrt} (4000) \times 5 \times 349 / 1000$	221 kips	983 kN	ACI 318, Eqn 11-29
	$A_v = A_{vh}$		0.11 in ²	71 mm ²	
	$s = S_2$		7 in	178 mm	
	l_n / d	$= 541 / 349$	1.55	1.55	
Nominal Shear capacity	$V_n = [(A_v(1+l_n/d)/(12s)+A_{vh}(1-l_n/d)/(12s_2))] f_{dy} d$	$= [(0.11(1+1.55)/(12 \times 7) + 0.11(1 - 1.55)/(12 \times 7))] 63.8 \times 349$	350 kips	1557 kN	ACI 318, Eqn 11-31
	$V_n = V_c + V_s$	$221 + 350$	571 kips	2541 kN	
At critical section (0.15L)	$R_{s1} = 2 V_n / (0.7)$	$= 2 \times 571 / 0.7$	1631 kips	7258 kN	
Shear resistance from shear friction criteria					
for shear friction	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.1) 58$	70.18 ksi	484 MPa	Appendix 5.A
Friction coefficient	$\mu = 1.0 (\lambda) = 1.0$	intentionally roughened surface	1.0	1.0	ACI 318, 11.7.4.3
	A_{vf}	$= (0.11)(12 / 7) \times 2 \times 29.53$	11.14 in ²	7187 mm ²	
	$V_n = A_{vf} f_{dy} \mu$	$= 11.14 \times 70.18 \times 1$	782 kips	3480 kN	
	$R_{s2} = 2V_n$		1564 kips	6959 kN	

SDOF Equivalent System

because $R_{s2} < R_{s1} < R_b$ shear friction governs	R_{min}	minimum of R_{s2} , R_{s1} and R_b	1564 kips	6959 kN	
as minimum reinforcement is not provided, μ_a			1.0	1.0	Table 5.B.1
Stiffness must include shear deformations. Compute midspan deflection for arbitrary load of 1000 lb/in					
Use 50% of roof slab thickness to allow for out-of-plane cracking					
chord height	$d_{ch} = 4b + t$	$= 4 \times 10 + 5$	45 in	1143 mm	
Including chord reinforcing	nA_s	$= 8.05 \times 7.9$	64 in ²	41032 mm ²	
Amplified moment of inertia	$I_a = \Sigma b (h)^3 / 12 + \Sigma A d^2$	$= 2 \times 45 \times 10^3 / 12 + 2.5 \times 334^3 / 12 \dots$			
		$\dots + 2 (45 \times 10 + 63.6) \times 177^2$	40,041,701 in ⁴	17 m ⁴	
Flexural deflection	$\delta_f = wL^4 / 384E_c I_a$	$= 1000 \times 541^4 / (384 \times 40041701 \times 3605000)$	0.0015 in	0.038 mm	AISC LRFD, beam tables
Shear modulus	$G = E_c / 2(1 + \nu)$	$= 3605000 / 2(1 + 0.2)$	1502083 psi	10357 MPa	
Shear deflection	$\delta_s = 0.125 F w L^2 / A G$	$= 0.125 \times (6 / 5) \times 1000541^2 / (5 \times 349 \times 1502083)$	0.0167 in	0.424 mm	Roark p 185
Effective stiffness	$K = w L / (\delta_f + \delta_s)$	$= 1000 \times 541 / (0.0015 + 0.0167)$	29725 k/in	5207423 kN/m	
Yield deflection	$y_e = R_u / K$	$= 1564 / 29725$	0.053 in	1.35 mm	
Include 20% of tributary wall weight with the beam mass					Section 6.4.2
Beam mass	$m = (\text{diaphragm wt} + 0.2 \text{ tributary wall wt}) / \text{gravity}$	$= 0.15 \times [(45.098 \times 0.5 \times 29.53) + 0.2 (0.833 \times 8.5 \times 2)] / 386$	0.308 k-sec ² /in	54.0 kNsec ² /m	
Elastic Load Factor	K_{LM}	$= 0.78$	0.78	0.78	Table 6.1
Equivalent mass	$m_e = (K_{LM}) (\text{beam mass})$	$= 0.78 \times 0.308$	0.24 k-sec ² /in	42.0 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.24 / 29725)$	0.018 sec	0.018 sec	Eqn 6.8
For Support reactions	$V = 0.36R + 0.14F$				Table 6.1

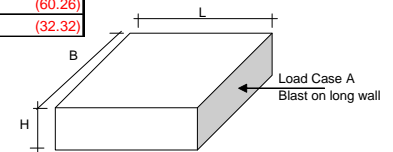
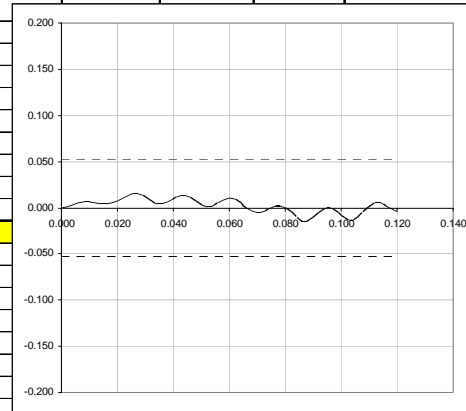
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
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Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF SLAB

Equivalent Mass	m_e	0.24 k-sec ² /in	Summary			
Effective Stiffness	K	29725 k/in	Maximum deflection	ΔD	0.015 in at time	0.026 sec
Use front wall reactions -Rear wall reactions			No plastic deformation			
Period of vibration	t_e	0.072 sec				
Time Increment	Δt	0.002 sec	Rebound peak deflection	y_m	0.004 in at time	0.014 sec
Positive Yield Deflection	+ Δy	0.053 in				
Negative Yield Deflection	- Δy	-0.053 in	The peak reaction	R_o	-201.43 kips at time	0.024 sec
Resistance Coefficient	R_{cc}	0.360	Peak rebound reaction	R_o	66.61 kips at time	0.068 sec
Force Coefficient	F_{cc}	0.140	Support rotation	$\theta_g = \tan^{-1}(y_m/0.5L)$	0.01°	< 2° OK

Time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	82.1	0.00	342	11.49
0.002	0.001	0.001	0.000	0.000	82.5	29.73	220	22.26
0.004	0.003	0.003	0.000	0.000				
0.006	0.005	0.005	0.000	0.000				
0.008	0.006	0.006	0.000	0.000				
0.010	0.006	0.006	0.000	0.000				
0.012	0.005	0.005	0.000	0.000				
0.014	0.004	0.004	0.000	0.000				
0.016	0.004	0.004	0.000	0.000				
0.018	0.005	0.005	0.000	0.000				
0.020	0.007	0.007	0.000	0.000				
0.022	0.010	0.010	0.000	0.000				
0.024	0.013	0.013	0.000	0.000				
0.026	0.015	0.015	0.000	0.000				
0.028	0.014	0.014	0.000	0.000				
0.030	0.011	0.011	0.000	0.000				
0.032	0.007	0.007	0.000	0.000				
0.034	0.004	0.004	0.000	0.000				
0.036	0.004	0.004	0.000	0.000				
0.038	0.006	0.006	0.000	0.000				
0.040	0.009	0.009	0.000	0.000				
0.042	0.012	0.012	0.000	0.000	242.2	356.70	(477)	162.32
0.044	0.013	0.013	0.000	0.000	234.5	386.43	(633)	171.94
0.046	0.011	0.011	0.000	0.000	225.9	326.98	(421)	149.34
0.048	0.007	0.007	0.000	0.000	216.9	208.08	37	105.28
0.050	0.003	0.003	0.000	0.000	207.5	89.18	493	61.15
0.052	0.001	0.001	0.000	0.000	197.5	29.72	699	38.36
0.054	0.002	0.002	0.000	0.000	184.0	59.45	519	47.16
0.056	0.005	0.005	0.000	0.000	167.3	148.63	78	76.93
0.058	0.008	0.008	0.000	0.000	147.9	237.80	(374)	106.32
0.060	0.010	0.010	0.000	0.000	125.8	297.25	(714)	124.63
0.062	0.009	0.009	0.000	0.000	100.6	267.53	(696)	110.39
0.064	0.005	0.005	0.000	0.000	73.5	148.63	(313)	63.80
0.066	0.000	0.000	0.000	0.000	44.6	(0.00)	186	6.25
0.068	-0.004	-0.004	0.000	0.000	14.4	(118.90)	556	(40.78)
0.070	-0.006	-0.006	0.000	0.000	-17.1	(178.35)	672	(66.61)
0.072	-0.005	-0.005	0.000	0.000	-48.3	(148.63)	418	(60.26)
0.074	-0.002	-0.002	0.000	0.000	-78.0	(59.45)	(77)	(32.32)



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

SIDE WALLS, IN-PLANE

Bending Resistance

	Height	depth to foundation	25.5 ft		
	Length		29.53 ft		
for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.17) 58$	74.6 ksi	514 MPa	
	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.19) 4$	4.76 ksi	33 MPa	
For bending assume 12 no bars at the corner provide the tension component for resisting in-plane moment					
	A_s	$= 12 \times 0.31$	3.72 in ²	2400 mm ²	
	b_w		10 in	254.0 mm	
Effective depth	d	$= (354) - (10 \text{ in wall}) + (1.5 \text{ in}) + (0.625 \text{ in bar})/2$	346 in	8788.4 mm	
Reinf percentages	$\rho = A_s / bd$	$= (3.72) / (10)(346)$	0.0011 < 200/ f_{dy}		ACI 318, Eqn 10-3
beam flange	b_f		24.0 in	609.6 mm	
	$a = A_s (f_y) / (0.85 f'_{cd})(b)$	$= 3.72 \times 74.6 / (0.85 \times 4.76 \times 24)$	2.86 in	72.6 mm	WITHIN THICKNESS OF INTERSECTING WALL
	$M_p = A_s (f_y) [d - a/2]$	$= 3.72 \times 74.6 [346 - 2.86 / 2]$	95622 in-k	10808 kNm	
Bending resistance	$R_b = M_p / L$	$= 95622.3 / 306$	312 kips	1388.3 kN	Table 6.1

Shear Resistance

for shear friction	$f_{df} = (SIF)(DIF) f_y$	$= (1.1)(1.1) 58$	70.18 ksi	484 MPa	Appendix 5.A
Friction coefficient	$\mu = 0.6 (\lambda) = 0.6$	not intentionally roughened	0.6	0.6	ACI 318, 11.7.4.3
	A_{vf}	$= (0.31)(12 / 6) \times 2 \times 354$	36.62 in ²	23626 mm ²	
	$R_s = V_n = A_{vf} f_{df} \mu$	$= 36.62 \times 70.18 \times 0.6$	1542 kips	6862 kN	

SDOF Equivalent System

because $R_b < R_s$ bending governs

	R_{min}	minimum of R_s and R_b	312 kips	1388 kN	
as minimum reinforcement is not provided, μ_a			1.5	1.5	Table 5.B.1
Stiffness must include shear deformations. Compute midspan deflection for arbitrary load of 1000 lb/in					
Use 50% of roof slab thickness to allow for out-of-plane cracking					
chord height	$d_{ch} = 4b + t$	$= 4 \times 10 + 10$	50 in	1270 mm	
Including chord reinforcing	nA_s	$= 8.05 \times 3.72$	29.95 in ²	19323 mm ²	
Amplified moment of inertia	$I_a = \Sigma b (h)^3 / 12 + \Sigma A d^2$	$= 2 \times 50 \times 10^3 / 12 + 5 \times 334^3 / 12 \dots$ $\dots + 2 (50 \times 10 + 29.95) \times 177^2$	48,856,643 in ⁴	20 m ⁴	
Flexural deflection	$\delta_f = P H^3 / 3E_c I_a$	$= 1000 \times 306^3 / (3 \times 48856643 \times 3605000)$	0.0542 in	1.377 mm	AISC LRFD, beam tables
Shear modulus	$G = E_c / 2(1 + \nu)$	$= 3605000 / 2(1 + 0.2)$	1502083 psi	10357 MPa	
Shear deflection	$\delta_s = 1.2 H P / A G$	$= 1.2 \times 306 \times 1000 / (5 \times 346 \times 1502083)$	0.0690 in	1.753 mm	Roark p 185
Effective stiffness	$K = w L / (\delta_f + \delta_s)$	$= 1000 / (0.0542 + 0.069)$	8117 k/in	1421990 kN/m	
Yield deflection	$y_e = R_y / K$	$= 312 / 8117$	0.038 in	0.97 mm	
Tributary front & rear wall wt	w_1	$= 0.15 \times 0.83 \times 22.97 \times 8.5 \times 2$	48.6 kips	216 kN	Section 6.4.2
Tributary roof wt	w_2	$= 0.15 \times 0.5 \times 29.53 \times 45.931 / 2$	50.9 kips	226 kN	
Tributary shear wall wt	w_3	$= 0.15 \times 0.83 \times 29.53 \times 25.5 / 2$	46.9 kips	209 kN	
Beam mass	$m = (w_3 + 0.2 (w_2 + w_1)) / \text{gravity}$	$= (46.9 + 0.2 \times (50.9 + 48.6)) / 386$	0.173 k-sec ² /in	30.3 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.173 / 8117)$	0.029 sec	0.029 sec	Eqn 6.8
For Support reactions	$V=R$				Table 6.1

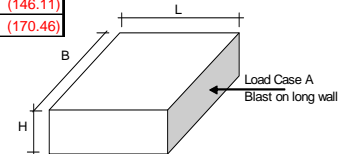
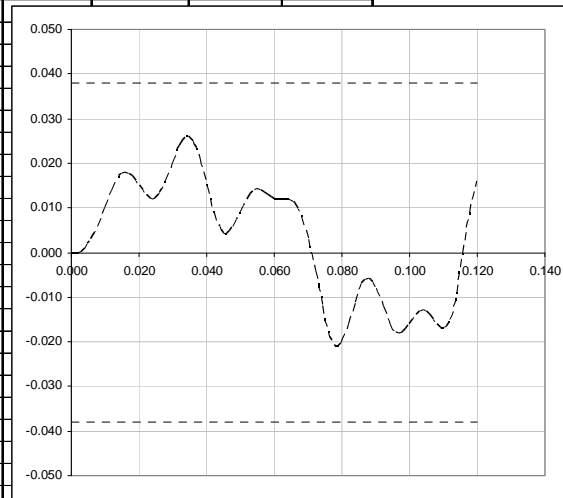
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

SIDE WALL (In-Plane)

Equivalent Mass	m_e	0.173 k-sec ² /in	Summary			
Effective Stiffness	K	8117 k/in	Maximum deflection	ΔD	0.026 in at time	0.034 sec
Use front wall reactions -Rear wall reactions			No plastic deformation			
Period of vibration	t_e	0.029 sec				
Time Increment	Δt	0.002 sec	Rebound peak deflection	y_m	-0.026 in at time	#N/A sec
Positive Yield Deflection	+ Δy	0.038 in				
Negative Yield Deflection	- Δy	-0.038 in	The peak reaction	R_o	-211.04 kips at time	0.034 sec
Resistance Coefficient	R_{cc}	1.000	Peak rebound reaction	R_o	0.00 kips at time	0.000 sec
Force Coefficient	F_{cc}	0.000	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.01 °	< 2° OK

Time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	11.49	0.00	66	0.00
0.002	0.000	0.000	0.000	0.000	22.26	0.00	129	0.00
0.004	0.001	0.001	0.000	0.000	44.41	8.12	210	8.12
0.006	0.003	0.003	0.000	0.000	67.33	24.35	248	24.35
0.008	0.006	0.006	0.000	0.000	80.12	48.70	182	48.70
0.010	0.010	0.010	0.000	0.000	82.83	81.17	10	81.17
0.012	0.014	0.014	0.000	0.000	75.29	113.64	(222)	113.64
0.014	0.017	0.017	0.000	0.000	68.12	137.99	(404)	137.99
0.016	0.018	0.018	0.000	0.000				
0.018	0.017	0.017	0.000	0.000				
0.020	0.015	0.015	0.000	0.000				
0.022	0.013	0.013	0.000	0.000				
0.024	0.012	0.012	0.000	0.000				
0.026	0.013	0.013	0.000	0.000				
0.028	0.016	0.016	0.000	0.000				
0.030	0.020	0.020	0.000	0.000				
0.032	0.024	0.024	0.000	0.000				
0.034	0.026	0.026	0.000	0.000				
0.036	0.025	0.025	0.000	0.000				
0.038	0.021	0.021	0.000	0.000				
0.040	0.015	0.015	0.000	0.000				
0.042	0.009	0.009	0.000	0.000				
0.044	0.005	0.005	0.000	0.000				
0.046	0.004	0.004	0.000	0.000				
0.048	0.006	0.006	0.000	0.000				
0.050	0.009	0.009	0.000	0.000				
0.052	0.012	0.012	0.000	0.000				
0.054	0.014	0.014	0.000	0.000				
0.056	0.014	0.014	0.000	0.000				
0.058	0.013	0.013	0.000	0.000				
0.060	0.012	0.012	0.000	0.000				
0.062	0.012	0.012	0.000	0.000	110.39	97.40	75	97.40
0.064	0.012	0.012	0.000	0.000	63.80	97.40	(194)	97.40
0.066	0.011	0.011	0.000	0.000	6.25	89.29	(480)	89.29
0.068	0.008	0.008	0.000	0.000	-40.78	64.94	(611)	64.94
0.070	0.003	0.003	0.000	0.000	-66.61	24.35	(526)	24.35
0.072	-0.004	-0.004	0.000	0.000	-60.26	(32.47)	(161)	(32.47)
0.074	-0.012	-0.012	0.000	0.000	-32.32	(97.40)	376	(97.40)
0.076	-0.018	-0.018	0.000	0.000	-4.26	(146.11)	820	(146.11)
0.078	-0.021	-0.021	0.000	0.000	2.65	(170.46)	1001	(170.46)



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF SLAB, OUT-OF-PLANE

Bending Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.17) 58$	74.6 ksi	514 MPa	
	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.19) 4$	4.76 ksi	33 MPa	
Effective depth	d_c	$= (5) - (0.75 \text{ in clear}) - ((0.375 \text{ in bar})/2)$	4.06 in	103.1 mm	
	d_s	$= (5) - (0.75 \text{ in clear}) - ((0.375 \text{ in bar})/2 + (2 \text{ in deck})/2)$	5.06 in	128.5 mm	
Steel layer per face	$A_s \text{ (in}^2\text{/ft)}$	$= (0.11 \times 12) / (7 \text{ in bar spacing})$	0.189 in ²	121.9 mm ²	
Reinf percentages	$\rho_c = A_s / bd$	$= (0.189) / (12)(4.06)$	0.0039		
	$\rho_s = A_s / bd$	$= (0.189) / (12)(5.06)$	0.0031 > 200 / f_{dy}	OK	
	$a = A_s (f_y) / (0.85 f_{dc})(b)$	$= 0.189 \times 74.6 / (0.85 \times 4.76 \times 12)$	0.29 in	7.4 mm	
	$M_{pc} = M_n = A_s (f_y) [d - a/2]$	$= 0.189 \times 74.6 [4.06 - 0.29 / 2]$	55.2 in-k	6.2 kNm	
	$M_{ps} = M_n = A_s (f_y) [d - a/2]$	$= 0.189 \times 74.6 [5.06 - 0.29 / 2]$	69.3 in-k	7.8 kNm	
Bending resistance	$R_b = 8(M_p + M_s) / L$	$= 8 \times (55.2 + 69.3) / (5.75 \times 12)$	14.43 kips	64.2 kN	Table 6.1
<u>Shear Resistance</u>					
for dynamic shear	$f_{dc} = (SIF)(DIF) f_c$	$= (1.0)(1.0) 4$	4 ksi	27.6 MPa	Appendix 5.A
	$V_n = 2 (f_c)^{0.5} bd$	$= 2 \times \text{sqrt}(4000) \times 1 \times 12 \times 5.06$	7.68 kips	34.2 kN	ACI 318, Eqn 11-3
At critical section	$R_s = V_n / L / (0.5L - d)$	$= 7.68 \times 69 / (0.5 \times 5.75 \times 12 - 5.06)$	18 kips	80.1 kN	

SDOF Equivalent System

because $R_b < R_s$ bending governs

	R_{min}	minimum of R_b and R_s	14.43 kips	64.2 kN	
Allowable response	θ_a	2.0°			Table 5.B.1
slab weight	w	$= 0.15 \times 0.5$	0.075 ksf		
Static load	W	$= 5.75 \times 1 \times (0.075 + 0.025 \text{ DL})$	0.575 kips	2.6 kN	
Positive R_u	$R_u = R_b - W$	$= 14.43 - 0.575$	13.855 kips	61.7 kN	
Negative R_u	$R_u = R_b + W$	$= - (14.43 + 0.575)$	-15.005 kips	-66.8 kN	
Use average	r	$= (0.0039 + 0.0031) / 2$	0.0035		
Gross moment of inertia	$I_g = b (h)^3 / 12$	$= 12 \times 5^3 / 12$	125 in ⁴	5203 cm ⁴	
	nA_s	$= 8.05 \times 0.189$	1.52 in ²	981 mm ²	
Depth of uncracked section	$C_n = [(-nA_s) + (nA_s(nA_s + 2bd)0.5)] / b$	$= [-1.52 + \text{sqrt}(1.52(1.52 + 2 \times 12 \times 4.06))] / 12$	0.90 in	22.9 mm	
Cracked moment of inertia	$I_{cr} = b C^3 / 3 + nA_s (d - C)^2$	$= 12 \times 0.9^3 / 3 + 1.52 (4.06 - 0.9)^2$	18.1 in ⁴	753 cm ⁴	
Averaged moment of inertia	$I_a = (I_g + I_{cr}) / 2$	$= (125 + 18.1) / 2$	71.6 in ⁴	2978 cm ⁴	
Effective stiffness	$K = 307 E I / L^3$	$= (307 \times 3605 \times 71.55) / (69^3)$	241.05 k/in	42229 kN/m	Biggs Table 5.2
Positive yield deflection	$y_e = R_u / K$	$= 13.855 / 241.05$	0.06 in	1.5 mm	
Negative yield deflection	$y_e = R_u / K$	$= -15.005 / 241.05$	-0.06 in	-1.5 mm	
Beam mass	$m = (\text{beam weight}) / (\text{gravity})$	$= (0.15 \times 0.5 \times 1 \times 5.75) / (386.4)$	0.0011 k-sec ² /in	0.193 kNsec ² /m	
Elastic Load Factor	K_{LM}	$= 0.41 / 0.53$	0.77	0.77	Table 6.1
Plastic Load Factor	K_{LM}	$= 0.33 / 0.5$	0.66	0.66	
Averaged Load Factor	K_{LM}	$= (0.77 + 0.66) / 2$	0.715	0.715	
Equivalent mass	$m_e = (K_{LM}) (\text{beam mass})$	$= 0.715 \times 0.0011$	0.0008 k-sec ² /in	0.140 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.0008 / 241.05)$	0.011 sec	0.011 sec	Eqn 6.8
For Support reactions	$V = 0.37R + 0.13F$				Table 6.1
Average of elastic and plastic conditions					

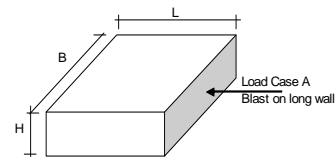
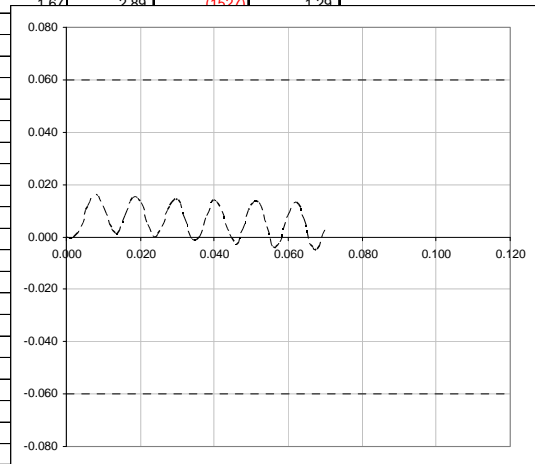
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF SLAB (out of plane)

Equivalent Mass	m_e	0.0008 k-sec ² /in	Summary			
Effective Stiffness	K	241.05 k/in	Maximum deflection	ΔD	0.016 in at time	0.008 sec
Peak Overpressure	F _o	2.17 kips	No Plastic Deformation			
Effective duration	t _e	0.1 sec				
Arrival time	t _a	0 sec				
Rise time	t _r	0.005 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y _m	0.001 in at time	0.014 sec
Positive Yield Deflection	+ Δy	0.06 in				
Negative Yield Deflection	- Δy	-0.06 in	The peak reaction	R _o	-1.70 kips at time	0.008 sec
Resistance Coefficient	R _{cc}	0.370	Peak Rebound reaction	R _o	0.34 kips at time	0.068 sec
Force Coefficient	F _{cc}	0.130	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.03°	< 2° OK

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0	0.00
0.002	0.002	0.000	0.000	0.000	0.000	0.87	0.00	1085	0.11
0.004	0.004	0.004	0.004	0.000	0.000	1.74	0.96	965	0.58
0.006	0.006	0.012	0.012	0.000	0.000	2.15	2.89	(930)	1.35
0.008	0.008	0.016	0.016	0.000	0.000	2.10	3.86	(2190)	1.70
0.010	0.010	0.011	0.011	0.000	0.000	2.06	2.65	(738)	1.25
0.012	0.012	0.003	0.003	0.000	0.000	2.02	0.72	1619	0.53
0.014	0.014	0.001	0.001	0.000	0.000	1.97	0.24	2167	0.35
0.016	0.016	0.008	0.008	0.000	0.000	1.93	1.93	4	0.96
0.018	0.018	0.015	0.015	0.000	0.000	1.89	3.62	(2160)	1.58
0.020	0.020	0.013	0.013	0.000	0.000	1.84	3.13	(1611)	1.40
0.022	0.022	0.005	0.005	0.000	0.000	1.80	1.21	745	0.68
0.024	0.024	0.000	0.000	0.000	0.000	1.76	(0.00)	2197	0.23
0.026	0.026	0.004	0.004	0.000	0.000	1.71	0.96	938	0.58
0.028	0.028	0.012	0.012	0.000	0.000	1.67	2.89	(1527)	1.29
0.030	0.030	0.014	0.014	0.000	0.000				
0.032	0.032	0.007	0.007	0.000	0.000				
0.034	0.034	-0.001	-0.001	0.000	0.000				
0.036	0.036	0.000	0.000	0.000	0.000				
0.038	0.038	0.008	0.008	0.000	0.000				
0.040	0.040	0.014	0.014	0.000	0.000				
0.042	0.042	0.010	0.010	0.000	0.000				
0.044	0.044	0.001	0.001	0.000	0.000				
0.046	0.046	-0.003	-0.003	0.000	0.000				
0.048	0.048	0.003	0.003	0.000	0.000				
0.050	0.050	0.012	0.012	0.000	0.000				
0.052	0.052	0.013	0.013	0.000	0.000				
0.054	0.054	0.004	0.004	0.000	0.000				
0.056	0.056	-0.004	-0.004	0.000	0.000				
0.058	0.058	-0.002	-0.002	0.000	0.000				
0.060	0.060	0.008	0.008	0.000	0.000				
0.062	0.062	0.013	0.013	0.000	0.000				
0.064	0.064	0.007	0.007	0.000	0.000				
0.066	0.066	-0.003	-0.003	0.000	0.000				
0.068	0.068	-0.005	-0.005	0.000	0.000				
0.070	0.070	0.003	0.003	0.000	0.000				



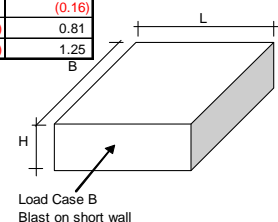
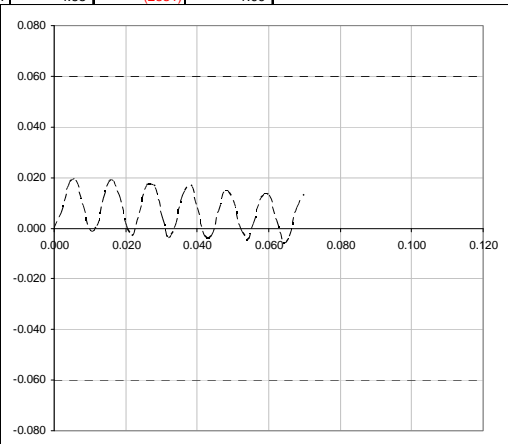
Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF SLAB (out of plane)

Equivalent Mass	m_b	0.0008 k-sec ² /in	Summary			
Effective Stiffness	K	241.05 k/in	Maximum deflection	ΔD	0.019 in at time	0.006 sec
Peak Overpressure	F _o	2.42 kips	No Plastic Deformation			
Effective duration	t _e	0.1 sec				
Arrival time	t _a	0 sec				
Rise time	t _r	0 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y _m	-0.001 in at time	0.010 sec
Positive Yield Deflection	+ Δy	0.06 in				
Negative Yield Deflection	- Δy	-0.06 in	The peak reaction	R _o	-1.99 kips at time	0.006 sec
Resistance Coefficient	R _{cc}	0.370	Peak Rebound reaction	R _o	0.42 kips at time	0.064 sec
Force Coefficient	F _{cc}	0.130	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.03 °	

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	2.42	0.00	3025	0.31
0.002	0.002	0.006	0.006	0.000	0.000	2.37	1.45	1157	0.84
0.004	0.004	0.017	0.017	0.000	0.000	2.32	4.10	(2218)	1.82
0.006	0.006	0.019	0.019	0.000	0.000	2.27	4.58	(2881)	1.99
0.008	0.008	0.009	0.009	0.000	0.000	2.2			
0.010	0.010	-0.001	-0.001	0.000	0.000	2.1			
0.012	0.012	0.001	0.001	0.000	0.000	2.1			
0.014	0.014	0.012	0.012	0.000	0.000	2.0			
0.016	0.016	0.019	0.019	0.000	0.000	2.0			
0.018	0.018	0.013	0.013	0.000	0.000	1.9			
0.020	0.020	0.001	0.001	0.000	0.000	1.9			
0.022	0.022	-0.003	-0.003	0.000	0.000	1.8			
0.024	0.024	0.006	0.006	0.000	0.000	1.8			
0.026	0.026	0.017	0.017	0.000	0.000	1.7			
0.028	0.028	0.016	0.016	0.000	0.000	1.7			
0.030	0.030	0.004	0.004	0.000	0.000	1.6			
0.032	0.032	-0.004	-0.004	0.000	0.000	1.6			
0.034	0.034	0.001	0.001	0.000	0.000	1.6			
0.036	0.036	0.013	0.013	0.000	0.000	1.5			
0.038	0.038	0.017	0.017	0.000	0.000	1.5			
0.040	0.040	0.008	0.008	0.000	0.000	1.4			
0.042	0.042	-0.003	-0.003	0.000	0.000	1.4			
0.044	0.044	-0.003	-0.003	0.000	0.000	1.3			
0.046	0.046	0.007	0.007	0.000	0.000	1.3			
0.048	0.048	0.015	0.015	0.000	0.000	1.2			
0.050	0.050	0.011	0.011	0.000	0.000	1.2	2.89	(1092)	1.14
0.052	0.052	0.000	0.000	0.000	0.000	1.16	0.00	1452	0.15
0.054	0.054	-0.005	-0.005	0.000	0.000	1.11	(1.21)	2898	(0.30)
0.056	0.056	0.002	0.002	0.000	0.000	1.06	0.48	728	0.32
0.058	0.058	0.012	0.012	0.000	0.000	1.02	2.89	(2345)	1.20
0.060	0.060	0.013	0.013	0.000	0.000	0.97	3.13	(2707)	1.29
0.062	0.062	0.003	0.003	0.000	0.000	0.92	0.72	246	0.39
0.064	0.064	-0.006	-0.006	0.000	0.000	0.87	(1.45)	2897	(0.42)
0.066	0.066	-0.003	-0.003	0.000	0.000	0.82	(0.72)	1932	(0.16)
0.068	0.068	0.008	0.008	0.000	0.000	0.77	1.93	(1443)	0.81
0.070	0.070	0.013	0.013	0.000	0.000	0.73	3.13	(3010)	1.25



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF BEAM

Bending Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.29) 36$	51.1 ksi	352 MPa	
check flange	$\lambda_{pf} = 65 / (F_y)^{0.5}$	$= 65 / 7.15$	9.09 > 6.57 OK		AISC LRFD Table B5.1
check web	$\lambda_{pw} = 640 / (F_y)^{0.5}$	$= 640 / 7.15$	89.53 > 37.5 OK		AISC LRFD Table B5.1
Unbraced length for plastic design	$L_{pd} = (3600 + 2200 M_1/M_2) r_y / f_{dy}$	$= (3600 + 0) (1.55) / 51.1$	109.20 in	2773.6 mm	AISC LRFD Eqn F1-1
Plastic moment capacity	$M_p = Z f_{dy}$	$= 61.5 \times 51.1$	3143 in-k	355.2 kNm	
	$R_b = 8 (M_p) / L$	$= (8 \times 3143) / (15 \times 12)$	139.7 kips	621.6 kN	

Shear Resistance

for dynamic shear	$f'_{dc} = (SIF)(DIF) f_y$	$= (1.1)(1.29) 36$	51.1 ksi	352.3 MPa	Appendix 5.A
	$V_n = 0.6 f_{dy} d t_w$	$= 0.6 \times 51.1 \times 14.1 \times 0.31$	134.0 kips	596.3 kN	ACI 318, Eqn 11-3
At critical section	$R_s = 2 V_n$	$= 2 \times 134$	268.0 kips	1192.5 kN	

SDOF Equivalent System

because $R_b < R_s$ bending governs

	R_{min}	minimum of R_s and R_b	139.7 kips	621.6 kN	
Allowable response	θ_a	2.0°			Table 5.B.3
Allowable ductility	μ_a	3.0			LOW RESPONSE
slab weight	w	$= 0.15 \times 0.5$	0.075 ksf		
Static load	W	$= 38 \times 15 + 15 \times 5.75 \times (0.075 + 0.025 DL)$	9.2 kips	40.9 kN	
Positive R_u	$R_u = R_b - W$	$= 139.7 - 9.2$	130.5 kips	580.7 kN	
Negative R_u	$R_u = R_b + W$	$= - (139.7 + 9.2)$	-148.9 kips	-662.6 kN	
Effective stiffness	$K = 384 E I / 5L^3$	$= (384 \times 29007.4 \times 385) / (5 \times 180^3)$	147.1 k/in	25770 kN/m	Biggs Table 5.2
Positive yield deflection	$y_e = R_u / K$	$= 130.5 / 147.1$	0.89 in	22.6 mm	
Negative yield deflection	$y_e = R_u / K$	$= -148.9 / 147.1$	-1.01 in	-25.7 mm	
Beam mass	$m = (\text{beam wt} + 20\% \text{ slab}) / (\text{gravity})$	$= 0.57 + 0.2 \times (14.4) / (386.4)$	0.0089 k-sec ² /in	1.56 kNsec ² /m	
Elastic Load Factor	K_{LM}	$= 0.5 / 0.64$	0.78	0.78	Table 6.1
Plastic Load Factor	K_{LM}	$= 0.33 / 0.5$	0.66	0.66	
Averaged Load Factor	K_{LM}	$= (0.78 + 0.66) / 2$	0.72	0.72	
Equivalent mass	$m_e = (K_{LM}) (\text{beam mass})$	$= 0.72 \times 0.0089$	0.0064 k-sec ² /in	1.121 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.0064 / 147.1)$	0.041 sec	0.041 sec	Eqn 6.8
For Support reactions	$V = 0.385R + 0.115F$				Table 6.1
Average of elastic and plastic conditions					

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

Roof Beam

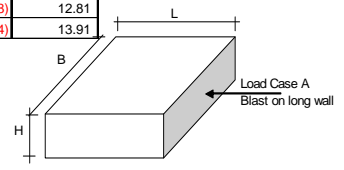
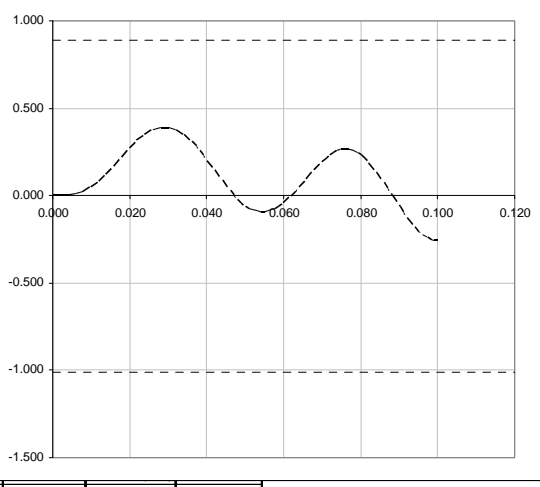
Equivalent Mass	m_e	0.0089 k-sec ² /in
Effective Stiffness	K	147.1 k/in
Peak Overpressure	F_o	2.17 kips
Effective duration	t_e	0.1 sec
Arrival time	t_a	0 sec
Rise time	t_r	0.005 sec
Time Increment	Δt	0.002 sec
Positive Yield Deflection	$+ \Delta y$	0.89 in
Negative Yield Deflection	$- \Delta y$	-1.01 in
Resistance Coefficient	R_{cc}	0.385
Force Coefficient	F_{cc}	0.115

Summary

Maximum deflection	ΔD	0.387 in at time	0.030 sec
No Plastic Deformation			
Rebound Peak Deflection	y_m	-0.096 in at time	0.054 sec
The peak reaction	R_o	-25.26 kips at time	0.020 sec
Peak Rebound reaction	R_o	3.83 kips at time	0.046 sec
Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.25 °	< 2° OK

Load = beam span x (slab reactions) + (slab reaction to 0.006 sec delay)

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0	0.00
0.002	0.002	0.000	0.000	0.000	0.000	1.65	0.00	185	0.19
0.004	0.004	0.001	0.001	0.000	0.000	8.70	0.15	961	1.06
0.006	0.006	0.006	0.006	0.000	0.000	20.25	0.88	2176	2.67
0.008	0.008	0.020	0.020	0.000	0.000	27.15	2.94	2720	4.25
0.010	0.010	0.045	0.045	0.000	0.000	27.45	6.62	2341	5.71
0.012	0.012	0.079	0.079	0.000	0.000	28.20	11.62	1863	7.72
0.014	0.014	0.120	0.120	0.000	0.000	30.75	17.65	1472	10.33
0.016	0.016	0.167	0.167	0.000	0.000	33.15	24.57	965	13.27
0.018	0.018	0.218	0.218	0.000	0.000	31.65	32.07	(47)	15.99
0.020	0.020	0.269	0.269	0.000	0.000	26.2			
0.022	0.022	0.314	0.314	0.000	0.000	24.6			
0.024	0.024	0.349	0.349	0.000	0.000	27.1			
0.026	0.026	0.373	0.373	0.000	0.000	29.7			
0.028	0.028	0.386	0.386	0.000	0.000	29.5			
0.030	0.030	0.387	0.387	0.000	0.000	25.3			
0.032	0.032	0.374	0.374	0.000	0.000	21.1			
0.034	0.034	0.346	0.346	0.000	0.000	21.0			
0.036	0.036	0.305	0.305	0.000	0.000	24.7			
0.038	0.038	0.255	0.255	0.000	0.000	25.9			
0.040	0.040	0.200	0.200	0.000	0.000	23.1			
0.042	0.042	0.142	0.142	0.000	0.000	18.9			
0.044	0.044	0.083	0.083	0.000	0.000	17.4			
0.046	0.046	0.026	0.026	0.000	0.000	19.9			
0.048	0.048	-0.024	-0.024	0.000	0.000	22.5			
0.050	0.050	-0.062	-0.062	0.000	0.000	22.3			
0.052	0.052	-0.086	-0.086	0.000	0.000	18.1			
0.054	0.054	-0.096	-0.096	0.000	0.000	13.9			
0.056	0.056	-0.093	-0.093	0.000	0.000	15.1			
0.058	0.058	-0.077	-0.077	0.000	0.000	18.9			
0.060	0.060	-0.047	-0.047	0.000	0.000	20.1			
0.062	0.062	-0.005	-0.005	0.000	0.000	15.9			
0.064	0.064	0.044	0.044	0.000	0.000	10.3			
0.066	0.066	0.095	0.095	0.000	0.000	10.2			
0.068	0.068	0.144	0.144	0.000	0.000	14.10	21.18	(796)	9.78
0.070	0.070	0.190	0.190	0.000	0.000	16.65	27.95	(1270)	12.68
0.072	0.072	0.231	0.231	0.000	0.000	-2.40	33.98	(4088)	12.81
0.074	0.074	0.256	0.256	0.000	0.000	-5.10	37.66	(4804)	13.91



Calculations

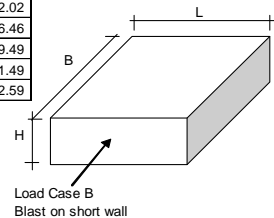
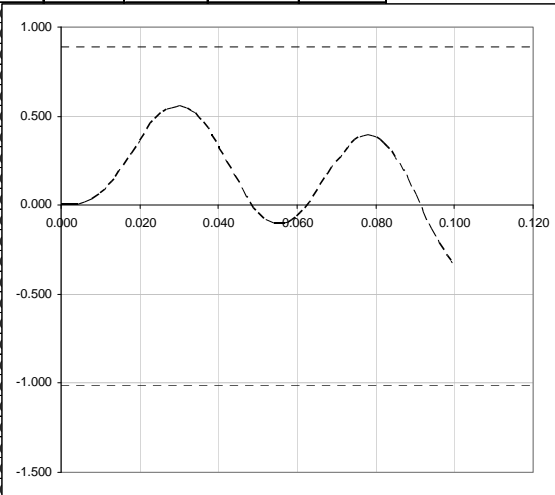
Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

Roof Beam

Equivalent Mass	m_e	0.0089 k-sec ² /in	Summary			
Effective Stiffness	K	147.1 k/in	Maximum deflection	ΔD	0.554 in at time	0.030 sec
Peak Overpressure	F_0	2.42 kips	No Plastic Deformation			
Effective duration	t_e	0.1 sec				
Arrival time	t_a	0 sec				
Rise time	t_r	0.001 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y_m	-0.106 in at time	0.056 sec
Positive Yield Deflection	+ Δy	0.89 in				
Negative Yield Deflection	- Δy	-1.01 in	The peak reaction	R_p	-36.45 kips at time	0.020 sec
Resistance Coefficient	R_{cc}	0.385	Peak Rebound reaction	R_p	3.95 kips at time	0.048 sec
Force Coefficient	F_{cc}	0.115	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.35 °	< 2° OK

Load = beam span x [average of delayed slab reaction to 0.014 sec] x 2 sides

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	1.62	0.00	182	0.19
0.002	0.002	0.000	0.000	0.000	0.000	6.00	0.00	674	0.69
0.004	0.004	0.003	0.003	0.000	0.000	15.50	0.44	1692	1.95
0.006	0.006	0.013	0.013	0.000	0.000	25.88	1.91	2693	3.71
0.008	0.008	0.034	0.034	0.000	0.000	31.57	5.00	2985	5.56
0.010	0.010	0.067	0.067	0.000	0.000				
0.012	0.012	0.110	0.110	0.000	0.000				
0.014	0.014	0.161	0.161	0.000	0.000				
0.016	0.016	0.220	0.220	0.000	0.000				
0.018	0.018	0.287	0.287	0.000	0.000				
0.020	0.020	0.359	0.359	0.000	0.000				
0.022	0.022	0.428	0.428	0.000	0.000				
0.024	0.024	0.484	0.484	0.000	0.000				
0.026	0.026	0.523	0.523	0.000	0.000				
0.028	0.028	0.546	0.546	0.000	0.000				
0.030	0.030	0.554	0.554	0.000	0.000				
0.032	0.032	0.545	0.545	0.000	0.000				
0.034	0.034	0.515	0.515	0.000	0.000				
0.036	0.036	0.463	0.463	0.000	0.000				
0.038	0.038	0.395	0.395	0.000	0.000				
0.040	0.040	0.320	0.320	0.000	0.000				
0.042	0.042	0.243	0.243	0.000	0.000				
0.044	0.044	0.165	0.165	0.000	0.000				
0.046	0.046	0.087	0.087	0.000	0.000				
0.048	0.048	0.014	0.014	0.000	0.000				
0.050	0.050	-0.045	-0.045	0.000	0.000				
0.052	0.052	-0.084	-0.084	0.000	0.000				
0.054	0.054	-0.103	-0.103	0.000	0.000				
0.056	0.056	-0.106	-0.106	0.000	0.000				
0.058	0.058	-0.094	-0.094	0.000	0.000	24.57	(13.83)	4315	(2.50)
0.060	0.060	-0.065	-0.065	0.000	0.000	31.77	(9.56)	4644	(0.03)
0.062	0.062	-0.017	-0.017	0.000	0.000	29.69	(2.50)	3617	2.45
0.064	0.064	0.045	0.045	0.000	0.000	19.67	6.62	1466	4.81
0.066	0.066	0.113	0.113	0.000	0.000	12.89	16.62	(420)	7.88
0.068	0.068	0.179	0.179	0.000	0.000	16.33	26.33	(1124)	12.02
0.070	0.070	0.241	0.241	0.000	0.000	24.42	35.45	(1240)	16.46
0.072	0.072	0.298	0.298	0.000	0.000	22.75	43.84	(2369)	19.49
0.074	0.074	0.346	0.346	0.000	0.000	16.49	50.90	(3866)	21.49
0.076	0.076	0.379	0.379	0.000	0.000	9.76	55.75	(5168)	22.59



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF GIRDER

Bending Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.29) 36$	51.1 ksi	352 MPa	
check flange	$\lambda_p = 65 / (F_y)^{0.5}$	$= 65 / 7.15$	9.09 > 7.03 OK		AISC LRFD Table B5.1
check web	$\lambda_w = 640 / (F_y)^{0.5}$	$= 640 / 7.15$	89.53 > 32.73 OK		AISC LRFD Table B5.1
Unbraced length for plastic design	$L_{pd} = (3600 + 2200 M_1/M_2) r_y / f_{dy}$	$= (3600 + 0) (2.9) / 51.1$	204.31 in	5189.4 mm	AISC LRFD Eqn F1-1
Plastic moment capacity	$M_p = Z f_{dy}$	$= 61.5 \times 51.1$	14257 in-k	1611.4 kNm	
	$R_b = 8 (M_p) / L$	$= 8 \times 14257 / (30 \times 12)$	316.8 kips	1409.7 kN	

Shear Resistance

for dynamic shear	$f_{dc} = (SIF)(DIF) f_y$	$= (1.1)(1.29) 36$	51.1 ksi	352.3 MPa	Appendix 5.A
	$V_n = 0.6 f_{dy} d t_w$	$= 0.6 \times 51.1 \times 21.5 \times 0.55$	362.6 kips	1613.5 kN	ACI 318, Eqn 11-3
At critical section	$R_s = 2 V_n$	$= 2 \times 362.6$	725.2 kips	3227.0 kN	

SDOF Equivalent System

because $R_b < R_s$ bending governs	R_{min}	minimum of R_s and R_b	316.8 kips	1409.7 kN	
Allowable response	θ_a	2.0°			Table 5.B.3
Allowable ductility	μ_a	3.0			LOW RESPONSE
slab weight	w	$= 0.15 \times 0.5$	0.075 ksf		
Static load	W	$= 3 \times 38 \times 15 + 111 \times 30 + \dots$ $\dots .30 \times 23 \times (0.075 + 0.025 DL)$	74 kips	329.3 kN	NB:3 beams incoming
Positive R_u	$R_u = R_b - W$	$= 316.8 - 74$	242.8 kips	1080.4 kN	
Negative R_u	$R_u = R_b + W$	$= - (316.8 + 74)$	-390.8 kips	-1739.0 kN	
Effective stiffness	$K = 384 E I / 5L^3$	$= (384 \times 29007.4 \times 2670) / (5 \times 360^3)$	127.5 k/in	22336 kN/m	Biggs Table 5.2
Positive yield deflection	$y_e = R_u / K$	$= 242.8 / 127.5$	1.9 in	48.3 mm	
Negative yield deflection	$y_e = R_u / K$	$= -390.8 / 127.5$	-3.07 in	-78.0 mm	
Beam mass	$m = (girder wt + 20\% slab) / (gravity)$	$= (3.33 + 0.2 \times (69+1.71)) / (386.4)$	0.045 k-sec ² /in	7.94 kNsec ² /m	
Elastic Load Factor	K_{LM}	$= 0.5 / 0.64$	0.78	0.78	Table 6.1
Plastic Load Factor	K_{LM}	$= 0.33 / 0.5$	0.66	0.66	
Averaged Load Factor	K_{LM}	$= (0.78 + 0.66) / 2$	0.72	0.72	
Equivalent mass	$m_e = (K_{LM}) (beam mass)$	$= 0.72 \times 0.0453$	0.0326 k-sec ² /in	5.71 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (m_e / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.0326 / 127.5)$	0.1 sec	0.1 sec	Eqn 6.8
For Support reactions	$V = 0.39R + 0.11F$				Table 6.1
Average of elastic and plastic conditions					

Calculations

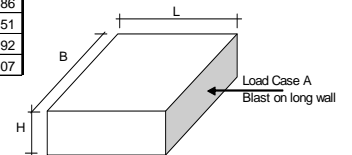
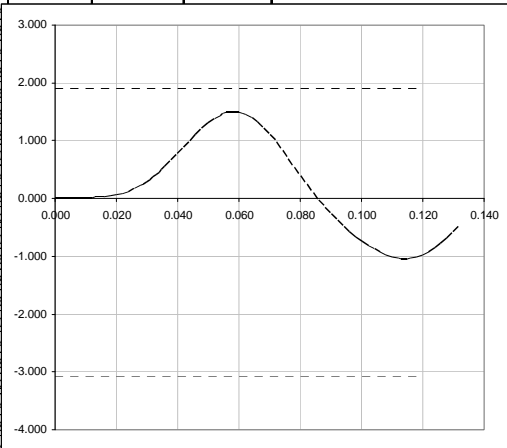
Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF GIRDER

Equivalent Mass	m_g	0.0326 k-sec ² /in	Summary			
Effective Stiffness	K	127.5 k/in	Maximum deflection	ΔD	1.490 in at time	0.058 sec
Peak Overpressure	F_o	2.17 kips	No Plastic Deformation			
Effective duration	t_e	0.1 sec				
Arrival time	t_a	0 sec				
Rise time	t_r	0.005 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y_m	-1.051 in at time	0.114 sec
Positive Yield Deflection	+ Δy	1.9 in				
Negative Yield Deflection	- Δy	-3.07 in	The peak reaction	R_o	-73.84 kips at time	0.048 sec
Resistance Coefficient	R_{cc}	0.390	Peak Rebound reaction	R_o	55.04 kips at time	0.104 sec
Force Coefficient	F_{cc}	0.110	Support rotation	$\theta_d = \tan^{-1}(y_m/0.5L)$	0.47°	< 2° OK

Load = 2 sides x [beam reaction + beam reaction with 0.006 sec delay + beam reaction with 0.012 sec delay]

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0	0.00
0.002	0.002	0.000	0.000	0.000	0.000	0.38	0.00	12	0.04
0.004	0.004	0.000	0.000	0.000	0.000	2.12	0.00	65	0.23
0.006	0.006	0.000	0.000	0.000	0.000	5.34	0.00	164	0.59
0.008	0.008	0.001	0.001	0.000	0.000	8.88	0.13	268	1.03
0.010	0.010	0.003	0.003	0.000	0.000	13.54			
0.012	0.012	0.007	0.007	0.000	0.000	20.71			
0.014	0.014	0.013	0.013	0.000	0.000	29.54			
0.016	0.016	0.022	0.022	0.000	0.000	40.00			
0.018	0.018	0.036	0.036	0.000	0.000	52.71			
0.020	0.020	0.056	0.056	0.000	0.000	65.68			
0.022	0.022	0.083	0.083	0.000	0.000	79.11			
0.024	0.024	0.118	0.118	0.000	0.000	93.21			
0.026	0.026	0.163	0.163	0.000	0.000	106.21			
0.028	0.028	0.218	0.218	0.000	0.000	118.21			
0.030	0.030	0.284	0.284	0.000	0.000	127.41			
0.032	0.032	0.361	0.361	0.000	0.000	132.81			
0.034	0.034	0.449	0.449	0.000	0.000	135.71			
0.036	0.036	0.547	0.547	0.000	0.000	135.61			
0.038	0.038	0.653	0.653	0.000	0.000	131.11			
0.040	0.040	0.765	0.765	0.000	0.000	122.51			
0.042	0.042	0.880	0.880	0.000	0.000	110.31			
0.044	0.044	0.995	0.995	0.000	0.000	95.41			
0.046	0.046	1.106	1.106	0.000	0.000	79.51			
0.048	0.048	1.209	1.209	0.000	0.000	63.11			
0.050	0.050	1.301	1.301	0.000	0.000	46.31			
0.052	0.052	1.378	1.378	0.000	0.000	29.91			
0.054	0.054	1.437	1.437	0.000	0.000	15.24	183.22	(5153)	73.13
0.056	0.056	1.475	1.475	0.000	0.000	4.48	188.06	(5631)	73.84
0.058	0.058	1.490	1.490	0.000	0.000	-2.40	189.98	(5901)	73.83
0.060	0.060	1.481	1.481	0.000	0.000	-5.90	188.83	(5973)	72.99
0.062	0.062	1.448	1.448	0.000	0.000	-8.82	184.62	(5842)	71.36
0.064	0.064	1.392	1.392	0.000	0.000	-11.58	177.48	(5523)	68.93
0.066	0.066	1.314	1.314	0.000	0.000	-14.04	167.54	(4994)	65.86
0.068	0.068	1.216	1.216	0.000	0.000	-15.62	155.04	(4277)	62.18
0.070	0.070	1.101	1.101	0.000	0.000	-16.34	140.38	(3437)	57.86
0.072	0.072	0.972	0.972	0.000	0.000	-16.08	123.93	(2635)	52.51
0.074	0.074	0.832	0.832	0.000	0.000	-14.88	106.08	(1706)	46.92
0.076	0.076	0.685	0.685	0.000	0.000	-12.74	87.34	(726)	41.07



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

ROOF GIRDER

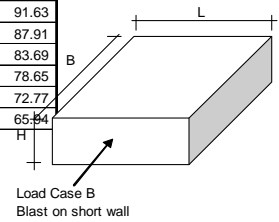
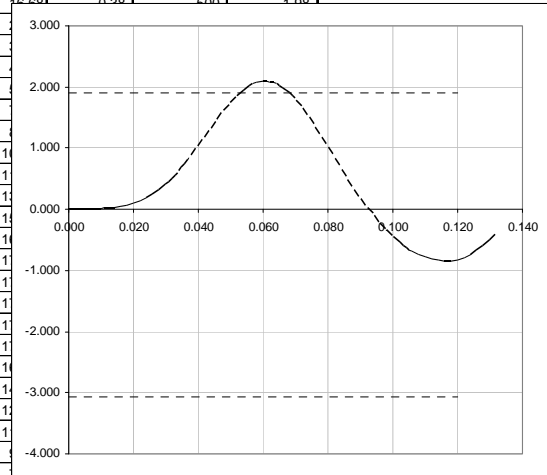
Equivalent Mass	m_b	0.0326 k-sec ² /in
Effective Stiffness	K	127.5 k/in
Peak Overpressure	F _o	2.17 kips
Effective duration	t _e	0.1 sec
Arrival time	t _a	0 sec
Rise time	t _r	0.005 sec
Time Increment	Δt	0.002 sec
Positive Yield Deflection	+ Δy	1.9 in
Negative Yield Deflection	- Δy	-3.07 in
Resistance Coefficient	R _{cc}	0.390
Force Coefficient	F _{cc}	0.110

Summary

Maximum deflection	ΔD	2.084 in at time	0.060 SEC
Plastic Deformation	yp = ym - ye	0.184 in	
ductility ratio		1.1	
Rebound Peak Deflection	y _m	-0.855 in at time	0.116 SEC
Rebound elastic Deformation	ye = ym - yp	-1.039 in	
The peak reaction	R _o	-100.93 kips at time	0.046 sec
Peak Rebound reaction	R _o	57.37 kips at time	0.106 sec
Support rotation	θ _s = tan ⁻¹ (y _m /0.5L)	0.66°	< 2° OK

Load = 3 beams x [beam reaction + beam reaction with 0.014 sec delay]

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.57	0.00	17	0.06
0.002	0.002	0.000	0.000	0.000	0.000	2.07	0.00	63	0.23
0.004	0.004	0.000	0.000	0.000	0.000	5.85	0.00	179	0.64
0.006	0.006	0.001	0.001	0.000	0.000	11.13	0.13	338	1.27
0.008	0.008	0.003	0.003	0.000	0.000	16.58	0.38	500	1.98
0.010	0.010	0.007	0.007	0.000	0.000	22.13	0.67	650	2.70
0.012	0.012	0.014	0.014	0.000	0.000	27.78	1.00	780	3.42
0.014	0.014	0.025	0.025	0.000	0.000	33.53	1.37	880	4.14
0.016	0.016	0.041	0.041	0.000	0.000	39.38	1.78	960	4.86
0.018	0.018	0.063	0.063	0.000	0.000	45.33	2.23	1010	5.58
0.020	0.020	0.093	0.093	0.000	0.000	51.38	2.72	1040	6.30
0.022	0.022	0.132	0.132	0.000	0.000	57.53	3.25	1050	7.02
0.024	0.024	0.181	0.181	0.000	0.000	63.78	3.82	1040	7.74
0.026	0.026	0.241	0.241	0.000	0.000	70.13	4.43	1010	8.46
0.028	0.028	0.314	0.314	0.000	0.000	76.58	5.08	960	9.18
0.030	0.030	0.401	0.401	0.000	0.000	83.13	5.77	900	9.90
0.032	0.032	0.502	0.502	0.000	0.000	89.78	6.50	830	10.62
0.034	0.034	0.616	0.616	0.000	0.000	96.53	7.27	750	11.34
0.036	0.036	0.742	0.742	0.000	0.000	103.38	8.08	660	12.06
0.038	0.038	0.878	0.878	0.000	0.000	110.33	8.93	560	12.78
0.040	0.040	1.022	1.022	0.000	0.000	117.38	9.82	460	13.50
0.042	0.042	1.171	1.171	0.000	0.000	124.53	10.75	370	14.22
0.044	0.044	1.322	1.322	0.000	0.000	131.78	11.72	290	14.94
0.046	0.046	1.470	1.470	0.000	0.000	139.13	12.73	220	15.66
0.048	0.048	1.611	1.611	0.000	0.000	146.58	13.78	170	16.38
0.050	0.050	1.740	1.740	0.000	0.000	154.13	14.87	140	17.10
0.052	0.052	1.853	1.853	0.000	0.000	161.78	16.00	130	17.82
0.054	0.054	1.947	1.900	0.047	0.000	169.53	17.17	130	18.54
0.056	0.056	2.018	1.900	0.118	0.000	177.38	18.38	130	19.26
0.058	0.058	2.064	1.900	0.164	0.000	185.33	19.63	130	19.98
0.060	0.060	2.084	1.900	0.184	0.000	193.38	20.92	130	20.70
0.062	0.062	2.077	1.893	0.184	0.000	201.53	22.25	130	21.42
0.064	0.064	2.043	1.859	0.184	0.000	209.78	23.62	130	22.14
0.066	0.066	1.982	1.798	0.184	0.000	218.13	25.03	130	22.86
0.068	0.068	1.895	1.711	0.184	0.000	226.58	26.48	130	23.58
0.070	0.070	1.784	1.600	0.184	0.000	235.13	27.97	130	24.30
0.072	0.072	1.653	1.469	0.184	0.000	243.78	29.50	130	25.02
0.074	0.074	1.505	1.321	0.184	0.000	252.53	31.07	130	25.74
0.076	0.076	1.344	1.160	0.184	0.000	261.38	32.68	130	26.46



Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

COLUMN

Compression Resistance

for dynamic bending	$f_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.19) 36$	47.1 ksi	325 MPa	
check compression	$\lambda_c = K L (F_y / E)^{0.5} / \pi (r)$	$= 12 \times 13.8 \times K \times 0.0403 / (3.142 \times 2.01)$	1.06 K < 1.5 K	OK	AISC LRFD Eqn E2-4
	$f_{cr} = (0.658)^{\lambda_c^2} (f_y)$	$= (0.658)^{(1.06)^2} \times 47.1$	29.4 ksi	203 MPa	AISC LRFD Eqn E2-2
Compression capacity	$P_n = A_g f_{dy}$	$= 29.4 \times 13.3$	391 kips	1740 kN	AISC LRFD Eqn E2-1

Tension Resistance

for dynamic shear	$f'_{dy} = (SIF)(DIF) f_y$	$= (1.1)(1.19) 36$	47.1 ksi	325 MPa	Appendix 5.A
	$P_n = A_g f_{dy}$	$= 47.1 \times 13.3$	626.4 kips	2787 kN	ACI 318, Eqn 11-3

SDOF Equivalent System

for compression	$R_u = P_n$		391 kips	1740 kN	
for tension	$R_u = P_n$		626 kips	2787 kN	
	R_{min}	minimum of R_u and R_b	0.0 kips	0.0 kN	
Allowable ductility	μ_a		1.0		LOW RESPONSE
slab weight	w_1	$= (0.075 + 0.025) \times 30 \times 23$	69 ksf	307.0 kN	
beam weight	w_2	$= 3 \times 15 \times 38$	1.7 kips	7.6 kN	
girder weight	w_3	$= 111 \times 30$	3.3 kips	14.7 kN	
column weight	w_4	$= 45 \times 13.8 / 2$	0.3 kips	1.4 kN	
Static load	ΣW	$= 69 + 1.7 + 3.3 + 0.3105$	74.3 kips	330.6 kN	NB:3 beams incoming
Positive R_u	$R_u = R_b - W$	$= 391.02 - 74.3$	316.7 kips	1409.3 kN	
Negative R_u	$R_u = R_b + W$	$= - (626.4 + 74.3)$	-701 kips	-3117.9 kN	
Effective stiffness	$K = A E / L$	$= (13.3 \times 29007.4) / (165.6)$	2329.7 k/in	408132 kN/m	Biggs Table 5.2
Positive yield deflection	$y_e = R_u / K$	$= 316.72 / 2329.7$	0.14 in	3.6 mm	
Negative yield deflection	$y_e = R_u / K$	$= -700.7 / 2329.7$	-0.3 in	-7.6 mm	
Include 20% of weight of supported components					Section 6.4.2
Beam mass	$M = (\text{girder wt} + 20\% \text{ roof}) / (\text{gravity})$	$= (0.3105 + 0.2 \times (69 + 1.7 + 3.3)) / (386.4)$	0.039 k-sec ² /in	6.85 kNsec ² /m	
Period of vibration	$t_n = 2 \pi (M / K)^{0.5}$	$= 2 \times 3.14 \times \text{sqrt}(0.0391 / 2329.7)$	0.026 sec	0.026 sec	Eqn 6.8
For Support reactions	$V = R$				

Calculations

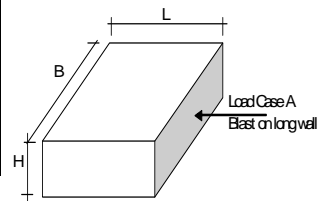
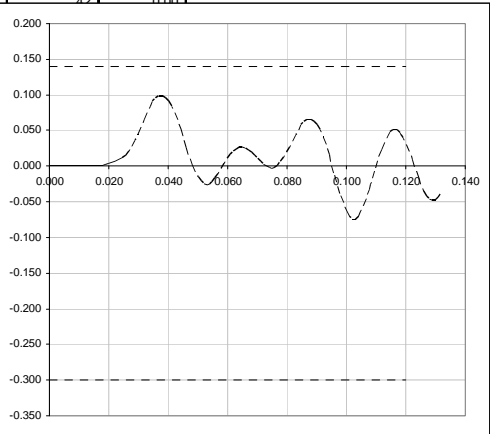
Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

COLUMN

Equivalent Mass	m_e	0.0391 k-sec ² /in	Summary			
Effective Stiffness	K	2329.7 k/in	Maximum deflection	ΔD	0.098 in at time	0.038 sec
Peak Overpressure	F_o	2.17 kips	No Plastic Deformation			
Effective duration	t_e	0.1 sec				
Arrival time	t_a	0 sec				
Rise time	t_r	0.005 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y_m	-0.025 in at time	0.052 sec
Positive Yield Deflection	+ Δy	0.14 in				
Negative Yield Deflection	- Δy	-0.3 in	The peak reaction	R_p	-228.31 kips at time	0.030 sec
Resistance Coefficient	R_{cc}	1.000	Peak Rebound reaction	R_r	174.73 kips at time	0.094 sec
Force Coefficient	F_{cc}	0.000	Support rotation	$\theta_s = \tan^{-1}(y_m/0.5L)$	0.03 °	< 2° OK

Load = girder reaction + 2 each (beam reaction with 0.012 sec delay) + girder reaction with 0.024 sec delay

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0	0.00
0.002	0.002	0.000	0.000	0.000	0.000	0.04	0.00	1	0.00
0.004	0.004	0.000	0.000	0.000	0.000	0.23	0.00	6	0.00
0.006	0.006	0.000	0.000	0.000	0.000	0.59	0.00	15	0.00
0.008	0.008	0.000	0.000	0.000	0.000	1.03	0.00	26	0.00
0.010	0.010	0.000	0.000	0.000	0.000	1.64	0.00	42	0.00
0.012	0.012	0.000	0.000	0.000	0.000	2.63	0.00	70	0.00
0.014	0.014	0.000	0.000	0.000	0.000	4.28	0.00	117	0.00
0.016	0.016	0.000	0.000	0.000	0.000	7.62	0.00	199	0.00
0.018	0.018	0.001	0.001	0.000	0.000	12.93	2.33	299	0.00
0.020	0.020	0.003	0.003	0.000	0.000	18.51	6.99	449	0.00
0.022	0.022	0.006	0.006	0.000	0.000	24.26	13.98	649	0.00
0.024	0.024	0.010	0.010	0.000	0.000	31.56	23.30	899	0.00
0.026	0.026	0.015	0.015	0.000	0.000	106.24	34.95	1599	0.00
0.028	0.028	0.027	0.027	0.000	0.000	118.28	62.90	1799	0.00
0.030	0.030	0.045	0.045	0.000	0.000	127.42	104.84	1899	0.00
0.032	0.032	0.065	0.065	0.000	0.000	132.80	151.43	1949	0.00
0.034	0.034	0.083	0.083	0.000	0.000	135.76	193.37	1959	0.00
0.036	0.036	0.095	0.095	0.000	0.000	135.68	221.32	1959	0.00
0.038	0.038	0.098	0.098	0.000	0.000	131.16	228.31	1919	0.00
0.040	0.040	0.091	0.091	0.000	0.000	122.50	212.00	1819	0.00
0.042	0.042	0.075	0.075	0.000	0.000	110.34	174.73	1679	0.00
0.044	0.044	0.052	0.052	0.000	0.000	95.48	121.14	1439	0.00
0.046	0.046	0.026	0.026	0.000	0.000	79.52	60.57	1219	0.00
0.048	0.048	0.002	0.002	0.000	0.000	63.14	4.66	1019	0.00
0.050	0.050	-0.016	-0.016	0.000	0.000	46.38	(37.24)	819	0.00
0.052	0.052	-0.025	-0.025	0.000	0.000	29.94	(58.24)	519	0.00
0.054	0.054	-0.025	-0.025	0.000	0.000	15.24	(58.24)	1879	(58.24)
0.056	0.056	-0.017	-0.017	0.000	0.000	4.48	(39.60)	1127	(39.60)
0.058	0.058	-0.004	-0.004	0.000	0.000	-2.40	(9.32)	177	(9.32)
0.060	0.060	0.010	0.010	0.000	0.000	-5.90	23.30	(747)	23.30
0.062	0.062	0.021	0.021	0.000	0.000	-5.82	48.92	(1400)	48.92
0.064	0.064	0.026	0.026	0.000	0.000	-2.58	60.57	(1615)	60.57
0.066	0.066	0.025	0.025	0.000	0.000	4.74	58.24	(1368)	58.24
0.068	0.068	0.019	0.019	0.000	0.000	15.62	44.26	(733)	44.26
0.070	0.070	0.010	0.010	0.000	0.000	28.34	23.30	129	23.30
0.072	0.072	0.002	0.002	0.000	0.000	38.02	4.66	853	4.66



Calculations

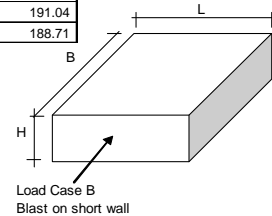
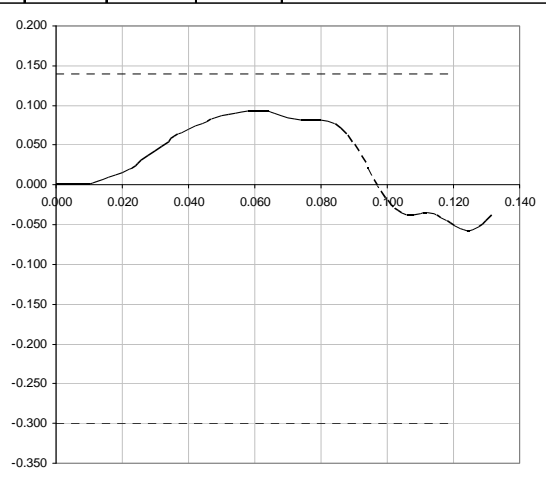
Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

COLUMN

Equivalent Mass	m_e	0.0391 k-sec ² /in	Summary			
Effective Stiffness	K	2329.7 k/in	Maximum deflection	ΔD	0.093 in at time	0.060 sec
Peak Overpressure	F _o	2.17 kips	No Plastic Deformation			
Effective duration	t _e	0.1 sec				
Arrival time	t _a	0 sec				
Rise time	t _r	0.005 sec				
Time Increment	Δt	0.002 sec	Rebound Peak Deflection	y _m	-0.058 in at time	0.124 sec
Positive Yield Deflection	+ Δy	0.14 in				
Negative Yield Deflection	- Δy	-0.3 in	The peak reaction	R _o	-216.66 kips at time	0.052 sec
Resistance Coefficient	R _{cc}	1.000	Peak Rebound reaction	R _o	135.12 kips at time	0.116 sec
Force Coefficient	F _{cc}	0.000	Support rotation	$\theta_s = \tan^{-1}(y_m/0.5L)$	0.03°	< 2° OK

Load = beam reaction + 2 each (girder reaction with 0.007 sec delay) + beam reaction with 0.014 sec delay

Time (sec)	Actual time (sec)	Deflection (in)	Elastic (in)	Plastic +ve (in)	Plastic -ve (in)	Load (kips)	Resistance (kips)	Acceleration (in/sec ²)	Reaction (kips)
0.000	0.000	0.000	0.000	0.000	0.000	0.19	0.00	5	0.00
0.002	0.002	0.000	0.000	0.000	0.000	0.69	0.00	18	0.00
0.004	0.004	0.000	0.000	0.000	0.000	1.95	0.00	50	0.00
0.006	0.006	0.000	0.000	0.000	0.000	3.83	0.00	98	0.00
0.008	0.008	0.000	0.000	0.000	0.000	6.02	0.00	154	0.00
0.010	0.010	0.001	0.001	0.000	0.000	8.82	2.33	166	2.33
0.012	0.012	0.003	0.003	0.000	0.000	12.74	6.99	147	6.99
0.014	0.014	0.006	0.006	0.000	0.000	16.66	11.98	128	11.98
0.016	0.016	0.009	0.009	0.000	0.000	20.58	16.97	109	16.97
0.018	0.018	0.012	0.012	0.000	0.000	24.50	21.96	90	21.96
0.020	0.020	0.015	0.015	0.000	0.000	28.42	26.95	71	26.95
0.022	0.022	0.019	0.019	0.000	0.000	32.34	31.94	52	31.94
0.024	0.024	0.024	0.024	0.000	0.000	36.26	36.93	33	36.93
0.026	0.026	0.030	0.030	0.000	0.000	40.18	41.92	14	41.92
0.028	0.028	0.036	0.036	0.000	0.000	44.10	46.91	-5	46.91
0.030	0.030	0.042	0.042	0.000	0.000	48.02	51.90	-15	51.90
0.032	0.032	0.048	0.048	0.000	0.000	51.94	56.89	-25	56.89
0.034	0.034	0.054	0.054	0.000	0.000	55.86	61.88	-35	61.88
0.036	0.036	0.060	0.060	0.000	0.000	59.78	66.87	-45	66.87
0.038	0.038	0.065	0.065	0.000	0.000	63.70	71.86	-55	71.86
0.040	0.040	0.069	0.069	0.000	0.000	67.62	76.85	-65	76.85
0.042	0.042	0.073	0.073	0.000	0.000	71.54	81.84	-75	81.84
0.044	0.044	0.077	0.077	0.000	0.000	75.46	86.83	-85	86.83
0.046	0.046	0.080	0.080	0.000	0.000	79.38	91.82	-95	91.82
0.048	0.048	0.083	0.083	0.000	0.000	83.30	96.81	-105	96.81
0.050	0.050	0.086	0.086	0.000	0.000	87.22	101.80	-115	101.80
0.052	0.052	0.088	0.088	0.000	0.000	91.14	106.79	-125	106.79
0.054	0.054	0.090	0.090	0.000	0.000	95.06	111.78	-135	111.78
0.056	0.056	0.091	0.091	0.000	0.000	98.98	116.77	-145	116.77
0.058	0.058	0.092	0.092	0.000	0.000	102.90	121.76	-155	121.76
0.060	0.060	0.093	0.093	0.000	0.000	106.82	126.75	-165	126.75
0.062	0.062	0.093	0.093	0.000	0.000	110.74	131.74	-175	131.74
0.064	0.064	0.092	0.092	0.000	0.000	114.66	136.73	-185	136.73
0.066	0.066	0.090	0.090	0.000	0.000	118.58	141.72	-195	141.72
0.068	0.068	0.087	0.087	0.000	0.000	122.50	146.71	-205	146.71
0.070	0.070	0.084	0.084	0.000	0.000	126.42	151.70	-215	151.70
0.072	0.072	0.082	0.082	0.000	0.000	130.34	156.69	-225	156.69
0.074	0.074	0.081	0.081	0.000	0.000	134.26	161.68	-235	161.68

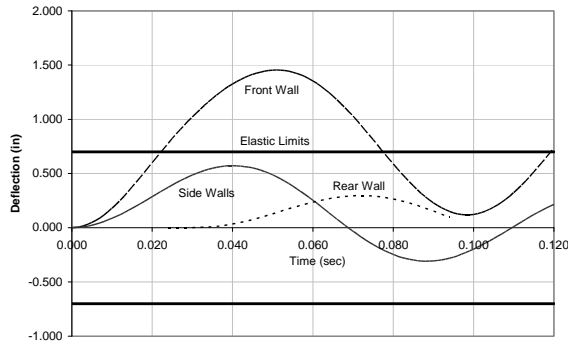


Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

2.2. RESULTS

		Front Wall	Side Wall	Rear Wall	Roof Slab Load A	Side Wall (In-plane)	Roof Slab OOP (A)	Roof Slab OOP (B)	Roof beam Load A	Roof beam Load B	Roof Girder Load A	Roof Girder Load B	Column Load A	Column Load B
		CALC-PART 1			CALC-PART 2	CALC-PART 3	CALC-PART 4		CALC-PART 5		CALC-PART 6		CALC-PART 7	
		NIM-1	NIM-2	NIM-3	NIM-4	NIM-5	NIM-6A	NIM-6B	NIM-7A	NIM-7B	NIM-8A	NIM-8B	NIM-9A	NIM-9B
Maximum deflection	ΔD	1.453	0.572	0.297	0.015	0.026	0.016	0.019	0.387	0.554	1.49	2.084	0.098	0.093
	at time (sec)	0.05	0.040	0.072	0.040	0.034	0.008	0.006	0.03	0.03	0.058	0.06	0.038	0.06
Plastic deformation	$y_p = y_m - y_e$	0.753										0.184		
ductility ratio	μ_d	2.08										1.1		
Rebound peak deflection	y_m	0.119	-0.308	-0.143	0.004	-0.021	0.001	-0.001	-0.096	-0.106	-1.051	-0.855	-0.025	-0.855
	at time (sec)	0.098	0.088	0.118	0.014	0.078	0.014	0.010	0.054	0.056	0.114	0.116	0.052	0.124
Rebound elastic deformation	$y_e = y_m - y_p$	-0.634										-1.039		
The peak reaction	R_o	-6.58	-4.88	-2.54	-201.43	-211.04	-1.70	-1.99	-25.26	-36.45	-73.84	-100.9	-228.31	-216.7
		0.024	0.04	0.066	0.024	0.034	0.008	0.006	0.02	0.02	0.048	0.106	0.03	0.116
Peak rebound reaction	R_o	-1.82	0.01	0.00	66.61	0.00	0.34	0.42	3.83	3.95	55.04	57.37	174.73	135.12
		0	0.07	#N/A	0.068	0	0.068	0.064	0.046	0.048	0.104	0.106	0.094	0.116
Support rotation	$\theta_H = \tan^{-1}(y_m/0.5L)$	0.82	0.32	0.17	0.01	0.01	0.03	0.03	0.25	0.35	0.47	0.66	0.03	0.03
Design status		OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK



Calculations

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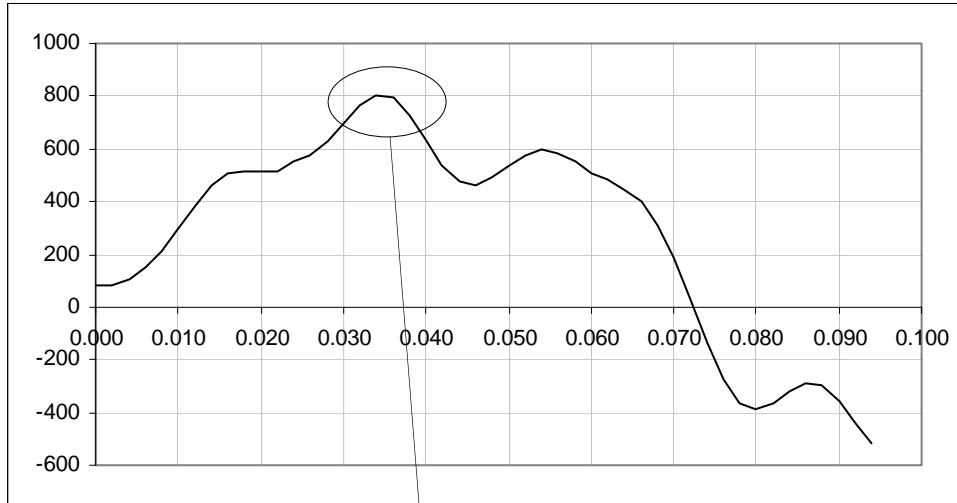
Foundation Loading, dynamic response (in Kips)

Allowing for time phasing
0.002

Time	NIM-1	NIM-3	(NIM-1 + NIM-3) x L	NIM-5	NIM-5 x 2	Total
0.000	1.82	0.00	83.6	0.00	0	83.6
0.002	1.83	0.00	84.1	0.00	0	84.1
0.004	1.95	0.00	89.6	8.12	16.24	105.8
0.006	2.19	0.00	100.6	24.35	48.7	149.3
0.008	2.52	0.00	115.7	48.70	97.4	213.1
0.01	2.95	0.00	135.5	81.17	162.34	297.8
0.012	3.45	0.00	158.5	113.64	227.28	385.7
0.014	4.01	0.00	184.2	137.99	275.98	460.2
0.016	4.62	0.00	212.2	146.11	292.22	504.4
0.018	5.26	0.00	241.6	137.99	275.98	517.6
0.02	5.92	0.00	271.9	121.76	243.52	515.4
0.022	6.56	0.00	301.3	105.52	211.04	512.3
0.024	6.58	1.17	356.0	97.40	194.8	550.8
0.026	6.53	1.33	361.0	105.52	211.04	572.1
0.028	6.48	1.50	366.5	129.87	259.74	626.3
0.03	6.43	1.67	372.0	162.34	324.68	696.7
0.032	6.38	1.83	377.1	194.81	389.62	766.7
0.034	6.33	1.98	381.7	211.04	422.08	803.8
0.036	6.28	2.12	385.8	202.93	405.86	791.7
0.038	6.23	2.25	389.5	170.46	340.92	730.4
0.04	6.18	2.35	391.8	121.76	243.52	635.3
0.042	6.13	2.44	393.6	73.05	146.1	539.7
0.044	6.08	2.50	394.1	40.59	81.18	475.3
0.046	6.03	2.54	393.6	32.47	64.94	458.6
0.048	5.98	2.54	391.3	48.70	97.4	488.7
0.05	5.93	2.52	388.1	73.05	146.1	534.2
0.052	5.88	2.47	383.5	97.40	194.8	578.3
0.054	5.75	2.38	373.4	113.64	227.28	600.7
0.056	5.54	2.27	358.7	113.64	227.28	586.0
0.058	5.26	2.13	339.4	105.52	211.04	550.5
0.06	4.91	1.97	316.0	97.40	194.8	510.8
0.062	4.48	1.78	287.5	97.40	194.8	482.3
0.064	3.98	1.58	255.4	97.40	194.8	450.2
0.066	3.43	1.37	220.5	89.29	178.58	399.0

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0



Total Lateral forces
 Design load 800 kips 3558 kN

Assumptions :
 pile capacities are doubled for dynamic events
 1.75 m spacing

Check for 36 piles
 Per pile H = 98.8 kN

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

Appendix A

Table 5.A.1 Strength Increase Factors (SIF)

Material	SIF
Structural Steel (fy < 50 ksi)	1.10
Structural Steel (fy < 60 ksi)	1.10
Cold-formed steel	1.21
Concrete	1.00

Table 5.A.2 Dynamic Increase Factors (DIF)

Stress Type	Reinforcing bars		Concrete
	F_{dy}/F_y	F_{du}/F_u	f_{dc}/f'_c
Flexure	1.17	1.05	1.19
Compression	1.10	1.00	1.12
Diagonal Tension	1.00	1.00	1.00
Direct Shear	1.10	1.00	1.10
Bond	1.17	1.05	1.00

Table 5.A.3 Dynamic Increase Factors(DIF)

Material	Yield Stress		Ultimate Stress F_{du}/F_u
	Bending / Shear	Tension / Compression	
	F_{dy}/F_y	F_{dy}/F_y	
A36	1.29	1.19	1.10
A588	1.19	1.12	1.05
A514	1.09	1.05	1.00
A446	1.10	1.10	1.00
Stainless Steel Type 304	1.18	1.15	1.00
Aluminium 6061-T6	1.02	1.00	1.00

Table 5.A.4 Dynamic Design Stress for Reinforced Concrete

Type of Stress	Type of reinforcement	Maximum Support rotation	Dynamic Design Stress F_{ds}
Bending	Tension	$0 < \lambda < 2$	F_{dy}
	Compression	$2 < \lambda < 5$	$F_{dy} + (F_{du} - F_{dy})/4$
		$5 < \lambda < 12$	$(F_{dy} + F_{du})/2$
Diagonal tension	Stirrups		F_{dy}
Direct Shear	Diagonal bars	$0 < \lambda < 2$	F_{dy}
		$2 < \lambda < 5$	$F_{dy} + (F_{du} - F_{dy})/4$
		$5 < \lambda < 12$	$(F_{dy} + F_{du})/2$
Compression	Columns	all	F_{dy}

Table 5.A.5 Dynamic Design Stress for Structural Steel

Type of stress	Maximum Ductility ratio	Dynamic Design Stress F_{ds}
All	$\lambda < 10$	F_{dy}
All	$\lambda > 10$	$F_{dy} + (F_{du} - F_{dy})/4$

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
Subject	Deluge Building 1500 Blast Resistance Design	Doc No	P23-00445-C101A	Rev	0

Table 5.B.1 Response Criteria for Reinforced Concrete

Element Type	Controlling Stress	J_a	Support Rotation J_a , (2)		
			Low	Medium	High
Beams	Flexure	N/A			
	Shear (1)				
	Concrete only	1.3	1	2	4
	Concrete + stirrups	1.6			
	stirrups only	3			
	Compression	1.3			
Slabs	Flexure	N/A			
	Shear (1)				
	Concrete only	1.3	2	4	8
	Concrete + stirrups	1.6			
	stirrups only	3			
	Compression	1.3			
Beam / Columns	Flexure				
	Compression (C)	1.3			
	Tension (T)	(3)	1	2	4
	Between C & T	10			
	Shear	1.3			
Shear walls	Flexure	3	1	1.5	2
Diaphragms	Shear (1)	1.5			

- (1) Shear controls when shear resistance is less than 120% of flexural resistance
- (2) Stirrups are required for support rotations greater than 2 degrees
- (3) Ductility ratio = $0.05 (J - J') < 10$

Table 5.B.3 Response Criteria for Structural Steel

Element Type	Response range					
	Low		Medium		High	
	J_a	J_a	J_a	J_a	J_a	J_a
Beams, girts, Purlins	3	2	10	6	20	12
Frame Members (1)	1.5	1	2	1.5	3	2
Cold-formed panels	1.75	1.25	3	2	6	4
Open web joists	1	1	2	1.5	4	2
Plates	5	3	10	6	20	12

- (1) Sidesway limits for frames
 - Low H/50
 - medium H/35
 - high H25

Calculations

Client	Getrich Development		Use in correspondences		
Project	Deepdown Sands	234	010455		
Location	Up in the North	Dept	Job	Reference	
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Simply Supported Boundary Conditions	Loading diagram	Strain range	Load Factor K_L	Lumped Mass Factor K_M	Uniform Mass Factor K_M	Bending Resistance R_b	Spring Constant $K \times EI/L^3$	Dynamic Reaction V
		Elastic Plastic	0.64 0.50		0.50 0.33	$8 M_{pc} / L$ $8 M_{pc} / L$	$384 / 5$ 0	$0.39 R + 0.11 F$ $0.38 R_u + 0.12 F$
	Elastic Plastic	1.00 1.00	1.00 1.00	0.49 0.33	$4 M_{pc} / L$ $4 M_{pc} / L$	48 0	$0.78 R - 0.28 F$ $0.75 R_u - 0.25 F$	
	Elastic Plastic	0.87 1.00	0.76 1.00	0.52 0.56	$6 M_{pc} / L$ $6 M_{pc} / L$	56.4 0	$0.52 R - 0.025 F$ $0.52 R_u - 0.02 F$	

Fixed Ends Boundary Conditions	Loading diagram	Strain range	Load Factor K_L	Lumped Mass Factor K_M	Uniform Mass Factor K_M	Bending Resistance R_b	Spring Constant $K \times EI/L^3$	Dynamic Reaction V
		Elastic E/P Plastic	0.53 0.64 0.50		0.41 0.50 0.33	$12 M_{ps} / L$ $8 (M_{ps} + M_{pc}) / L$ $8 (M_{ps} + M_{pc}) / L$	384 $384 / 5$ 0	$0.36 R + 0.14 F$ $0.39 R + 0.11 F$ $0.38 R_u + 0.12 F$
	Elastic Plastic	1.00 1.00	1.00 1.00	0.37 0.33	$4 (M_{ps} + M_{pc}) / L$ $4 (M_{ps} + M_{pc}) / L$	192 0	$0.71 R - 0.21 F$ $0.75 R_u - 0.25 F$	
	Elastic Plastic	0.87 1.00	0.76 1.00	0.52 0.56	$6 M_{pc} / L$ $6 M_{pc} / L$	56.4 0	$0.53 R - 0.03 F$ $0.52 R_u - 0.02 F$	

Simple-Fixed Boundary Conditions	Loading diagram	Strain range	Load Factor K_L	Lumped Mass Factor K_M	Uniform Mass Factor K_M	Bending Resistance R_b	Spring Constant $K \times EI/L^3$	Dynamic Reactions V
		Elastic E/P Plastic	0.58 0.64 0.50		45 0.50 0.33	$8 M_{pc} / L$ $4 (M_{ps} + 2M_{pc}) / L$ $8 (M_{ps} + 2M_{pc}) / L$	185 $384/5$ 0	$V1$ $V2$ $0.39 R + 0.11 F \pm M_{ps}/L$ $0.26 R + 0.12 F$ $0.43 R + 0.19 F$ $0.38 R_u + 0.12 F \pm M_{ps}/L$
	Elastic E/P Plastic	1.00 1.00 1.00	1.00 1.00 1.00	0.37 0.49 0.33	$16 M_{pc} / L$ $2 (M_{ps} + 2M_{pc}) / L$ $2 (M_{ps} + 2M_{pc}) / L$	107 48 0	$V1$ $V2$ $0.78 R - 0.28 F \pm M_{ps}/L$ $0.25 R + 0.07 F$ $0.54 R + 0.14 F$ $0.75 R_u - 0.25 F \pm M_{ps}/L$	
	Elastic E/P Plastic	0.81 0.87 1.00	0.67 0.76 1.00	0.45 0.52 0.56	$6 M_{pc} / L$ $2 (M_{ps} + 3M_{pc}) / L$ $2 (M_{ps} + 3M_{pc}) / L$	132 56 0	$V1$ $V2$ $0.525 R - 0.025 F \pm M_{ps}/L$ $0.17 R + 0.17 F$ $0.33 R + 0.33 F$ $0.52 R_u - 0.02 F \pm M_{ps}/L$	

M_{pc} is the ultimate moment capacity midspan
 M_{ps} is the ultimate moment capacity at the support