SBEDS

(Single degree of freedom Blast Effects Design Spreadsheets)

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U.S. Army Corps of Engineers
Protective Design Center

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Presentation Outline

- **Background & general description**
- **SBEDS technical capabilities**
- **Tour of workbook**
- **Obtaining SBEDS**
- **Future enhancements**

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Background

- Implementation of DoD antiterrorism construction standards requiring more blast design of 'conventional' facilities
- Existing blast resistant structural design tools developed for design of more robust structures and are cumbersome for design of more conventional structures
- USACE Protective Design Center, through Baker-Risk, developed SBEDS as a designer friendly tool for more typical construction
- SBEDS v1.0 released May 2004, v2.0 released June 2005

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SBEDS - General

- **SBEDS is an Excel© workbook that combines all steps to design/analyze a wide variety of blast-loaded structural components**
- **User inputs basic information related to geometry, boundary condition, material property, response mode, & blast load for component**
- **SBEDS calculates equivalent SDOF parameters & determines dynamic response w/ time-stepping SDOF calculator**
- **11 types of structural components available**
  - **Also allows for input of general SDOF system**
- **Outputs maximum response parameters and response history plots**

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SBEDS – General (continued)

- **Also performs shear check**
  - **stirrup design for concrete & CMU components**
- **Iteratively develops pressure-impulse (P-i) relationship and associated charge weight-standoff diagrams**
- **Designated metric or english units**
- **Detailed Users Guide hot-linked to workbook**
- **Based on Army TM 5-1300 & UFC 3-340-01 guidance but draws on other sources for best methodologies**

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Available Component Types

- One-way corrugated metal panel
- One-way or two-way steel plate
- Steel beam or beam-column
- One-way open-web steel joist
- One-way or two-way reinforced concrete slab
- Reinforced concrete beam or beam-column
- Prestressed concrete beam or panel
- One-way or two-way reinforced masonry
- One-way or two-way unreinforced masonry
- One-way or two-way wood panel
- One-way wood beam or beam-column
- General SDOF system

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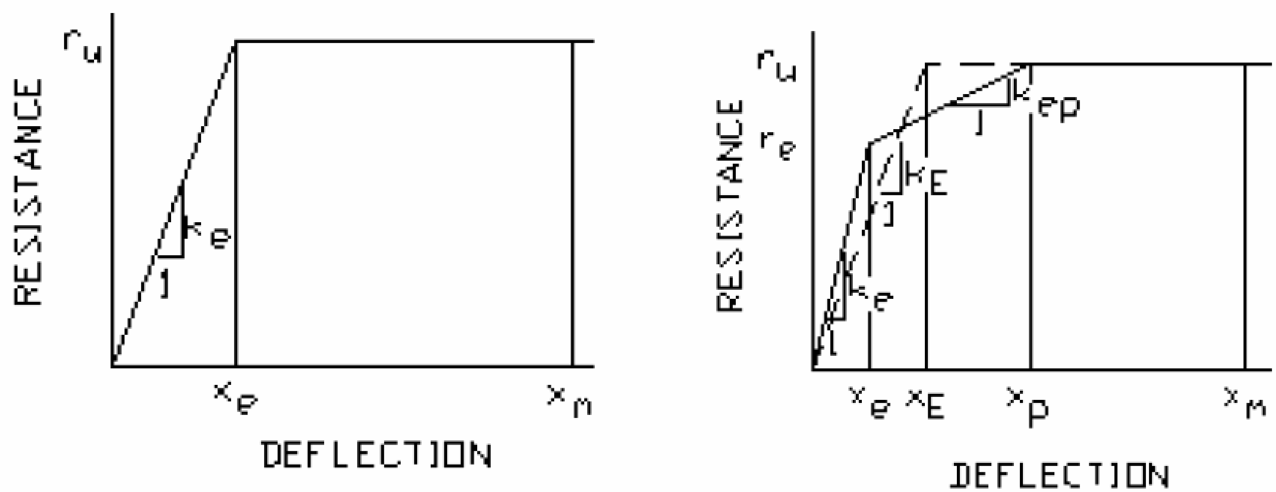
Available Response Modes

- Flexure
- Tension membrane
- Compression membrane
- Brittle flexure w/ axial load softening
- Arching with gap & non-solid section
- General

Flexure Resistance Functions

- TM 5-1300/UFC 3-340-01
- All components
- Option for shear based resistance for concrete slabs & masonry elements



Determinate Boundary Conditions

Indeterminate Boundary Conditions
(Solid Curve Used for Flexure Only)
(Dashed Curve for Flexure and Tension Membrane)

Figure 4. Resistance-Deflection Curve For Flexural Response

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Tension Membrane Resistance Function

- UFC 3-340-01

- **One-way corrugated metal panel**
- **One-way or two-way steel plate**
- **Steel beam or beam-column**

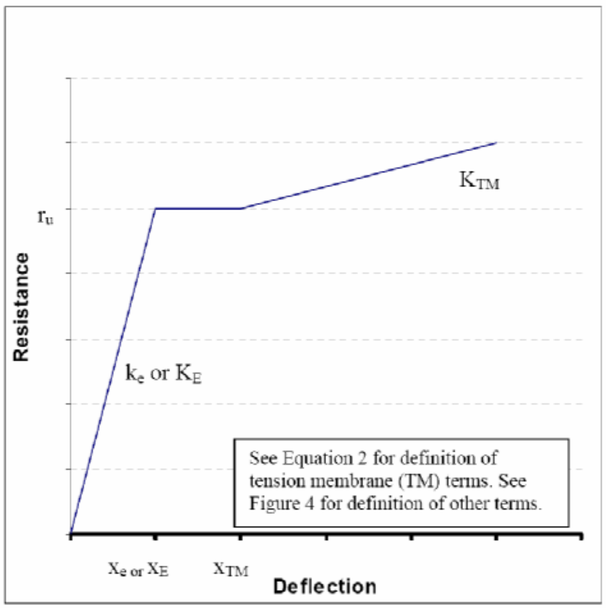

Figure 5. Resistance Deflection Curve for Steel Components with Tension Membrane

$$x_{TM} = x_E + \sqrt{\frac{4TL^2}{\pi^2 EA}} \quad \text{where} \quad T = \text{Minimum}\left[\left(f_{dy}A\right), V_c\right]$$

$$K_{TM\_1} = \frac{8T}{bL^2}$$

$$K_{TM\_2} = \frac{T\pi^3}{4L_y^2 \sum_{n=1,3,5,7} \left[\frac{1}{n^3}(-1)^{(n-1)/2} A\right]} \quad \text{where} \quad A = 1 - \frac{1}{\cosh \frac{n\pi L_x}{2L_y}} \quad \text{and} \quad L_x \geq L_y$$

Equation 2

where:
x_{TM} = assumed deflection at beginning of linear tension membrane response adding to flexural response for one and two-way response
K_{TM_i} = linear tension membrane slope for one-way (i=1) or two-way (i=2) response
x_E = equivalent elastic yield deflection
f_{dy} = dynamic yield strength
A = component cross sectional area within loaded width b

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Compression & Tension Membrane Resistance Function

- UFC 3-340-01
- User's option to consider compression only, tension only, or both
- One-way or two-way RC slab
- RC beam or beam-column
- One-way or two-way reinforced masonry

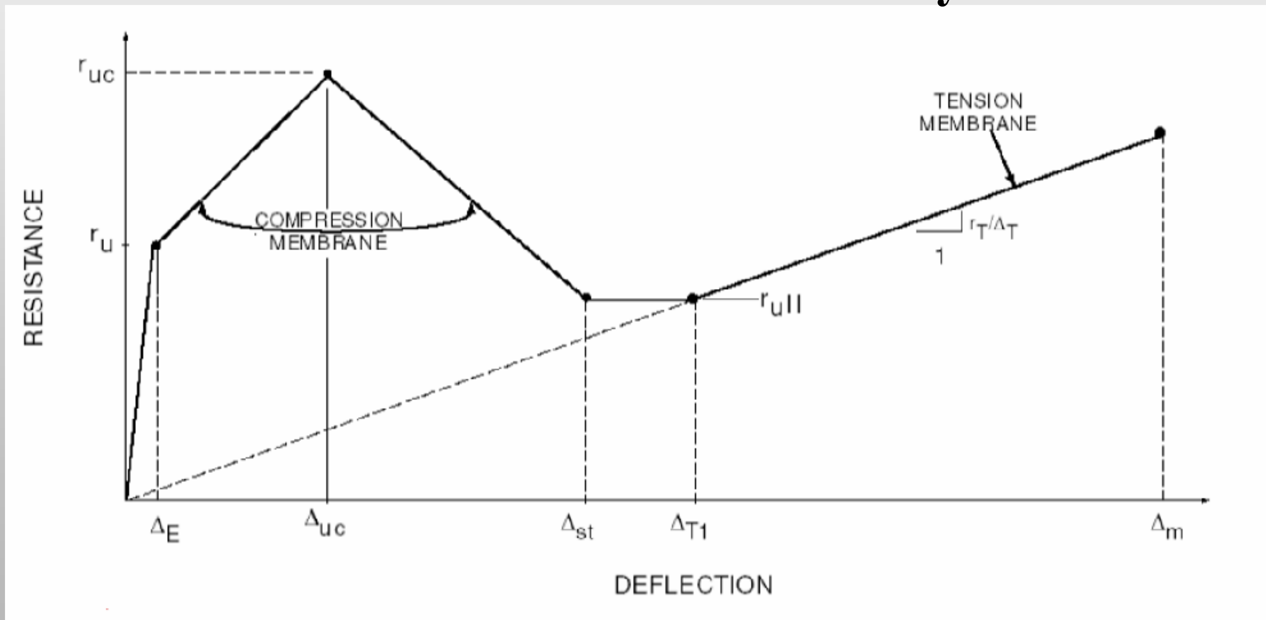

Figure 18. Resistance-Deflection Curve for Reinforced Concrete and Masonry Components with Compression and Tension Membrane (from UFC 3-340-01)

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Brittle Flexure w/ Axial Load Softening Resistance Function

- Wall Analysis Code (WAC)
- One-way or two-way unreinforced masonry

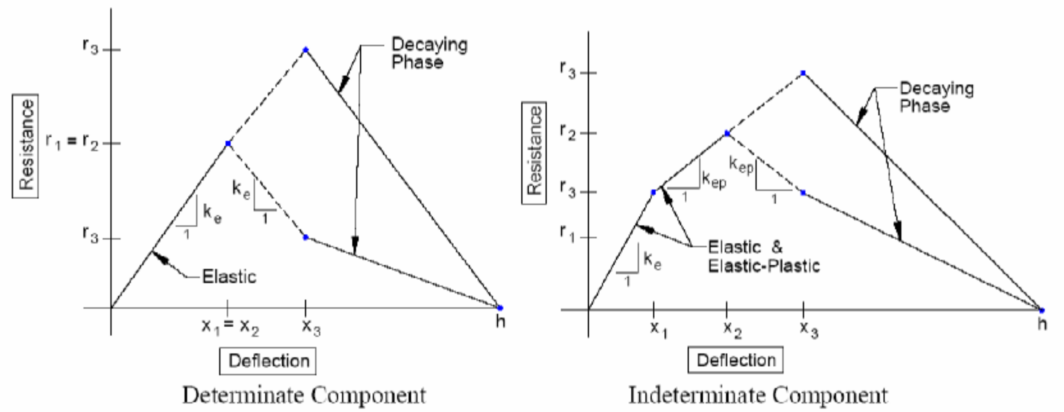

Figure 25. Resistance-Deflection Curves for Unreinforced Masonry with Brittle Flexural Response and Axial Load From WAC Program

$$r_3 = \frac{4}{L^2}(h-\Delta)\left(P+\frac{WL}{2}\right)$$

Equation 7

where:

r_3 = maximum resistance from axial load effects

x_3 = flexural deflection at $r_2 + (r_3 - r_2)/K_{ep}$

K_{ep} = elastic-plastic stiffness for indeterminate components, otherwise equal to elastic stiffness

h = overall wall thickness

P = input axial load per unit width along wall, P_{axial}

W = areal self-weight and supported weight of wall

L = span length equal to wall height

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Arching With Gap & Non-Solid Cross Section Resistance Function

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- Park and Gamble's Reinforced Concrete Slabs modified for gap between wall and rigid support for non-solid cross section
- One-way or two-way unreinforced masonry

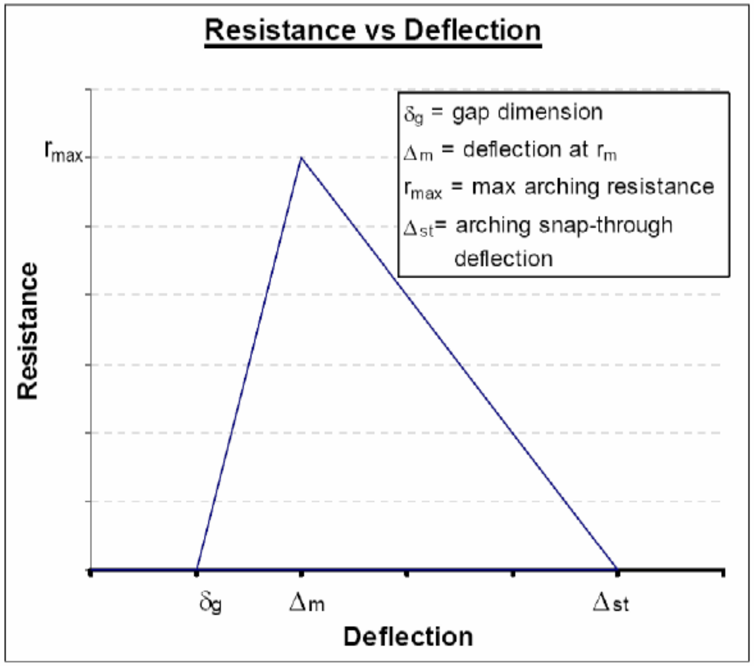

Figure 26. Arching Resistance-Deflection Curve

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General Resistance Function

- Up to 5 segments
- Systems with or without ‘softening’
- Different stiffness in rebound allowed
- Rules for rebound stiffness in systems using compressive membrane and arching

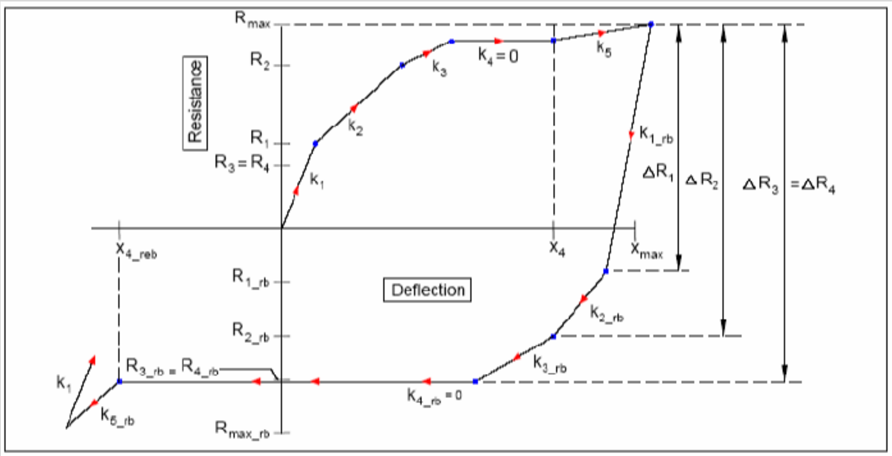

Figure 2. General Resistance-Deflection Diagram Without Softening

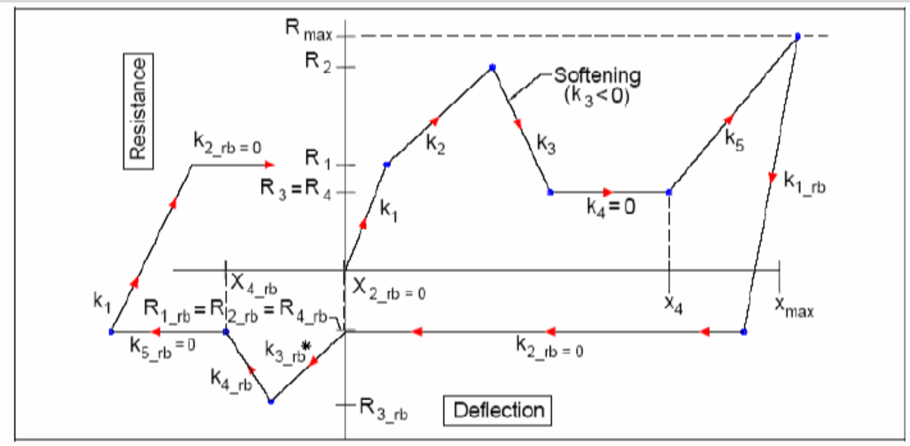

Figure 3. Typical Resistance-Deflection Diagram With Softening (See Figure 2 and Table 1 for Definition of Terms in Figure)

Available Boundary Conditions

- One-way components
  - Cantilever
  - Fixed-fixed
  - Fixed-simple
  - Simple-simple (only condition for open web joists)
- Two-way components
  - Four sides supported (all fixed or all simple)
  - Three sides supported (all fixed or all simple)
  - Two adjacent sides supported (both fixed or both simple)

Available Loadings

- Uniform loading for all components
- Concentrated loads for beam or beam-column components
  - load at free end of cantilevered elements
  - load at midspan for all other support conditions
- P-Δ
  - RC components except prestressed
  - Reinforced masonry
  - Unreinforced masonry
  - Wood beam or beam-column
  - General SDOF

Equivalent P-Δ Load

- SBEDS calculates the lateral force on component causing same maximum moment as P-Δ effect at each time step
  - P-Δ load based on axial load, geometry, and boundary conditions/load type of component and deflection at each time step
- Equivalent P-Δ load history is added to input load history and separately plotted in output
- Approach is consistent with other dynamic analyses methods considering P-Δ effects including FEA based approaches

SBEDS Structure

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- ReadMe sheet
- Intro sheet
- Input sheet
- Results sheet
- P-i Diagram sheet
- SDOF Output sheet
- SDOF sheet (hidden)
- Database sheet
- Positivephasedload sheet (hidden)
- Negativephaseload sheet (hidden)
- Wait sheet

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SBEDS Structure

- ReadMe sheet
  - General admin info
  - Support info
- Intro sheet
- Input sheet
- Results sheet
- P-i Diagram sheet
- SDOF Output sheet
- SDOF sheet (hidden)
- Database sheet
- Positivephasedload sheet (hidden)
- Negativephaseload sheet (hidden)
- Wait

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SBEDS Structure

- ReadMe sheet
- Intro sheet
  - Component selection
  - Units selection
  - Workbook instructions
  - Discussion of workbook design
- Input sheet
- Results sheet
- P-i Diagram sheet
- SDOF Output sheet
- SDOF sheet (hidden)
- Database sheet
- Positivephasedload sheet (hidden)
- Negativephaseload sheet (hidden)
- Wait

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SBEDS Structure

- ReadMe sheet
- Intro sheet
- Input sheet
  - Discussed later
- Results sheet
  - Discussed later
- P-i Diagram sheet
  - Discussed later
- SDOF Output sheet
  - Sample shown later
- SDOF sheet (hidden)
- Database sheet
- Positivephasedload sheet (hidden)
- Negativephaseload sheet (hidden)
- Wait

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SBEDS Structure

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- ReadMe sheet
- Intro sheet
- Input sheet
- Results sheet
- P-i Diagram sheet
- SDOF Output sheet
- SDOF sheet (hidden)
  - Time-stepping SDOF solution
- Database sheet
  - Properties of library members
  - SDOF constants
- Positivephasedload sheet (hidden)
- Negativephaseload sheet (hidden)
- Wait

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Input Sheet (Steel Beam or Beam-Column)

Building: ____ By: ____ Date: ____
Component: ____ Checked By: ____ Date: ____

Steel Beam or Beam-Column

Configuration		
Span, L:	50	ft
Spacing, B:	20	ft
Boundary Conditions:	Fixed-Fixed, Uniformly Loaded	
Response Type:	Flexural	

Structural & Material Properties		
Axis of Bending: Strong (X-X)	Shape: W12X50	
Self-Weight, w:	50.0	lb/ft
Moment of Inertia, I:	394	in^4
Section Modulus: Z (hot-rolled beam) or S (cold-formed beam):	72.4	in^3
Web Thickness, t_w:	0.37	in
Depth, d:	12.19	in
Area, A:	14.70	in^2
Supported Weight, W:	3	psf
Loaded Area Factor - Enter 1.0 for Uniform Load	1	
Inbound Unbraced Length for Compression Flange, $L_{br,i}$:	0	ft (0 for fully braced)
Rebound Unbraced Length for Compression Flange, $L_{br,r}$:	0	ft (0 for fully braced)
Steel Type:	A992, A913, A572, A529 (All Gr. 50) rolled shapes	
Yield Strength, f_y:	50,000	psi
Ultimate Strength, f_u:	70,000	psi
Elastic Modulus, E:	29000000	psi
Static Strength Increase Factor:	1.05	
Dynamic Increase Factor:	1.19	
Dynamic Yield Stress, f_{dy}:	62,475	psi
Axial Load for Compression/P-delta Effects, P: (Note: P>=0)	0	lb
Leave Blank	0	ft
Leave Blank	0	lb

Calculated Properties		
Inbound Moment Capacity, M_i:	4,523,190	lb-in
Rebound Moment Capacity, M_r:	4,523,190	lb-in
Rebound/Inbound Moment Capacity Ratio, MR:	1.00	

Retrieve | Save | RUN SDOF | Help | COE Response Limits

Blast Load Input Type
Manual input
Gravity Displacement
None (vertical component)

Pressure-Time Input	
Time (ms)	Pressure (psi)
0	9.7
10.1	0
20	0
30	0
40	0
50	0
60	0
70	0

Charge Weight and Standoff	
W (lbs TNT)	R (ft)
Blast Load Phase	
Positive and negative phase	
Charge Weight Load Type	
Reflected without Clearing	
Parameters for Reflected Loads	
Wall Height (ft)[1]	
Wall Width (ft)[1]	
Incidence Angle[2]	

See notes under error messages

Load file name
No File Selected

Input Design Criteria	
θ (deg)	μ
0	0
Design LOP	MLOP

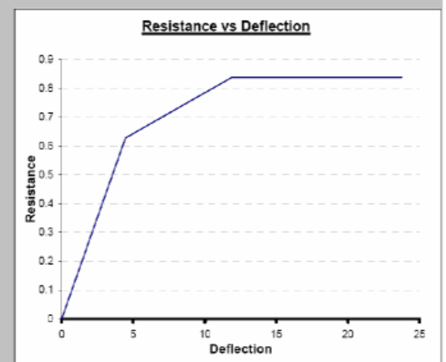
Dynamic Shear Factors		
Shear Constant	Elastic	Plastic
F (long side) =	0	0
R (long side) =	0	0
F (short side) =	0	0
R (short side) =	0	0

Note: Dynamic shear factor input is optional

Solution Control		
Inbound Natural Period:	145.85	ms
Rebound Natural Period:	145.85	ms
Max Recommended Time Step:	0.40	ms
Time Step:	0.2	ms
% of Critical Damping:	0	%
Initial Velocity:	0	in/ms

Stiffness Code
3

SDOF Properties			
Property	Inbound	Rebound	Units
Mass, M	98.8	98.8	psi-ms²/in
Load-Mass Factors, K_{LM}			
K_{LM1}	0.77	0.77	
K_{LM2}	0.78	0.78	
K_{LM3}	0.66	0.66	
Stiffness, K			
K_1	0.14	0.14	psi/in
K_2	0.03	0.03	psi/in
K_3	0.00	0.00	psi/in
Resistance, R			
R_1	0.63	-0.63	psi
R_2	0.84	-0.84	psi
Yield Displacement, x			
x1	4.45	-4.45	in
x2	11.88	-11.88	in
Equiv Elastic Displacement x_E	7.43	-7.43	in



Error/Warning Messages

Notes:
[1] Used for clearing of reflected load
[2] Angle in degrees from normal

Results Summary							
θ_{max} =	0.00	deg.	LOP Design Criteria =	MLOP			
μ =	0.00		Response OK compared to input design criteria				
X_{max} Inbound =	0.00	in	at time =	0.00	msec		
X_{min} Rebound =	0.00	in	at time =	0.00	msec		
R_{max} =	0.00	psi	at time =	0.00	msec		
R_{min} =	0.00	psi	at time =	0.00	msec		
Shortest Yield Line Distance to Determine θ:				300.0	in		

Equivalent Static Reactions*		
Peak Reactions from Flexural Response		
$V_{max,L}$ =	0	lb
$V_{max,F}$ =	0	lb
Shear Capacity		
V_c =	154,980	lb
Results:	Shear is OK	
* Based only on larger of R_{max} or R_{min}, not including tension membrane		

Supporting Calculations For Flexure with Axial Load		
Euler Buckling Load, Pe:	#DIV/0!	lb
Kl/r	0.00	
Cc for Axial Load Capacity	0.00	
Axial Load Capacity, P_a:	918383	lb
Radius of gyration for weak bending axis, r:	1.96	in
Braced Inbound Moment Capacity, M_{bi}	4523190	lb-in
Braced Rebound Moment Capacity, M_{br}:	4523190	lb-in
Equivalent P-delta load factor	0.00	psi/in

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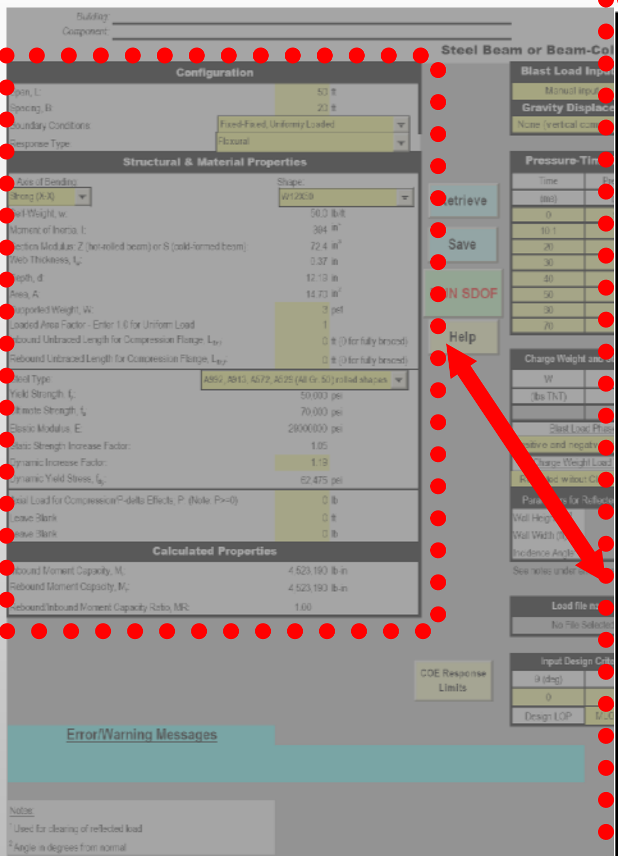
Component Input



Configuration

Span, L:	50	ft
Spacing, B:	20	ft
Boundary Conditions:	Fixed-Fixed, Uniformly Loaded	
Response Type:	Flexural	

Structural & Material Properties

Axis of Bending: Strong (X-X)	Shape: W12X50	
Self-Weight, w:	50.0	lb/ft
Moment of Inertia, I:	394	in^4
Section Modulus: Z (hot-rolled beam) or S (cold-formed beam):	72.4	in^3
Web Thickness, t_w:	0.37	in
Depth, d:	12.19	in
Area, A:	14.70	in^2
Supported Weight, W:	3	psf
Loaded Area Factor - Enter 1.0 for Uniform Load	1	
Inbound Unbraced Length for Compression Flange, $L_{br,i}$:	0	ft (0 for fully braced)
Rebound Unbraced Length for Compression Flange, $L_{br,r}$:	0	ft (0 for fully braced)
Steel Type:	A992, A913, A572, A529 (All Gr. 50) rolled shapes	
Yield Strength, f_y:	50,000	psi
Ultimate Strength, f_u:	70,000	psi
Elastic Modulus, E:	29000000	psi
Static Strength Increase Factor:	1.05	
Dynamic Increase Factor:	1.19	
Dynamic Yield Stress, f_{dy}:	62,475	psi
Axial Load for Compression/P-delta Effects; P: (Note: P>=0)	0	lb
Leave Blank	0	ft
Leave Blank	0	lb

Calculated Properties

Inbound Moment Capacity, M_i:	4,523,190	lb-in
Rebound Moment Capacity, M_r:	4,523,190	lb-in
Rebound/Inbound Moment Capacity Ratio, MR:	1.00	

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SBEDS Drop-Down Menus

- Support conditions
- Response mode
- Beam sizes (AISC and cold-formed girts/purlins)
- Open web steel joist sizes (K and LH series)
- Masonry (Brick, European block, Heavy-Medium-Lightweight CMU)
- Corrugated metal panel sizes (MBCI and Vulcraft sizes, traditional and standing-seam deck)
- Typ. steel plate, beam, and rebar material properties
- All drop-downs automatically insert properties of selected size/type into spreadsheet
- User-defined option available for all drop-down menus

Calculated Resistance-Deflection Relationship on Input Sheet

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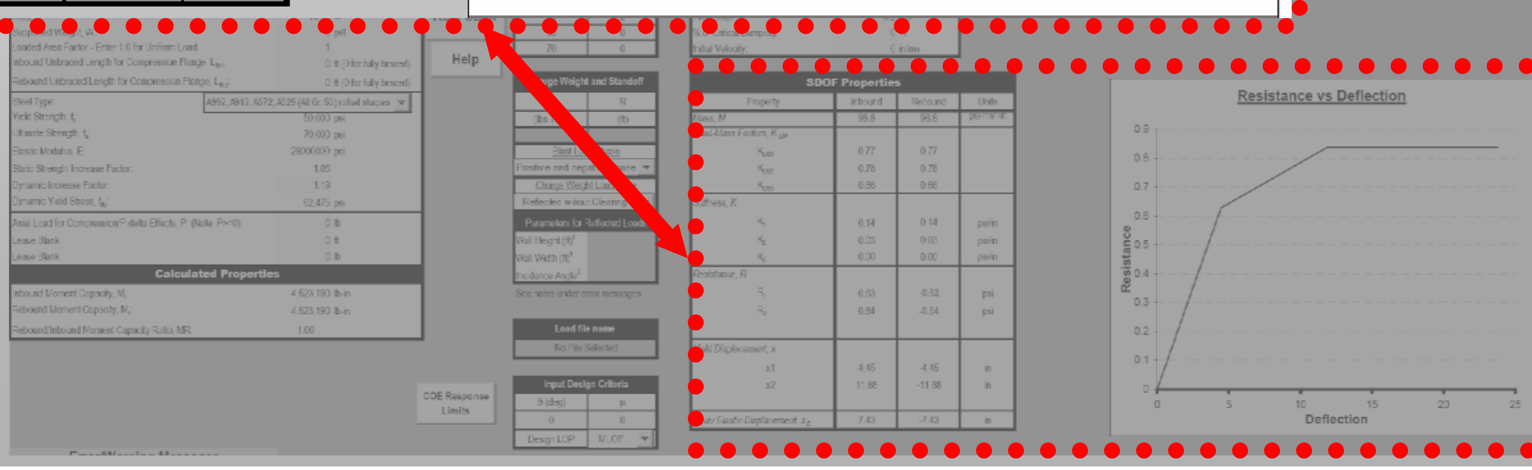
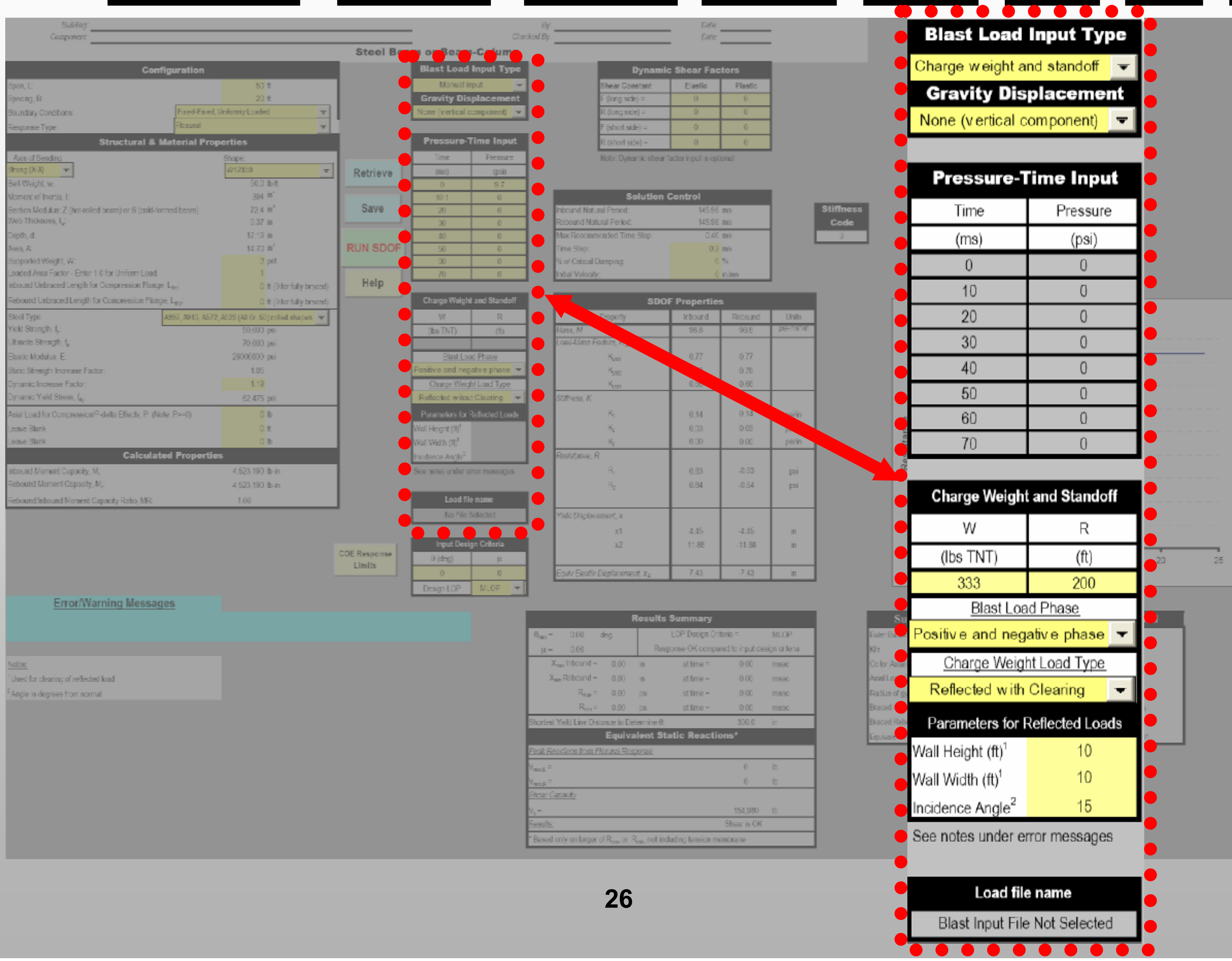
SDOF Properties			
Property	Inbound	Rebound	Units
Mass, M	98.8	98.8	psi-ms^2/in
Load-Mass Factors, K_{LM}			
K_{LM1}	0.77	0.77	
K_{LM2}	0.78	0.78	
K_{LM3}	0.66	0.66	
Stiffness, K			
K_1	0.14	0.14	psi/in
K_2	0.03	0.03	psi/in
K_3	0.00	0.00	psi/in
Resistance, R			
R_1	0.63	-0.63	psi
R_2	0.84	-0.84	psi
Yield Displacement, x			
x1	4.45	-4.45	in
x2	11.88	-11.88	in
Equiv Elastic Displacement, x_E	7.43	-7.43	in



Loading Input



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Loading Options

- Directly input up to 8 time-pressure pairs defining a piecewise linear pressure history
- User inputs charge weight and standoff distance
  - Pressure history for hemispherical surface burst is calculated based on Kingery-Bulmash parameters
  - Side-on or reflected load
    - angle of incidence can be specified for reflected loads
  - With or without negative phase
  - With or without clearing effects
- User designated file with up to 2,000 time-pressure pairs
  - One time-pressure pair separated by commas per line
  - Consistent with DPLOT file saved using the ASCII file option
- Member orientation

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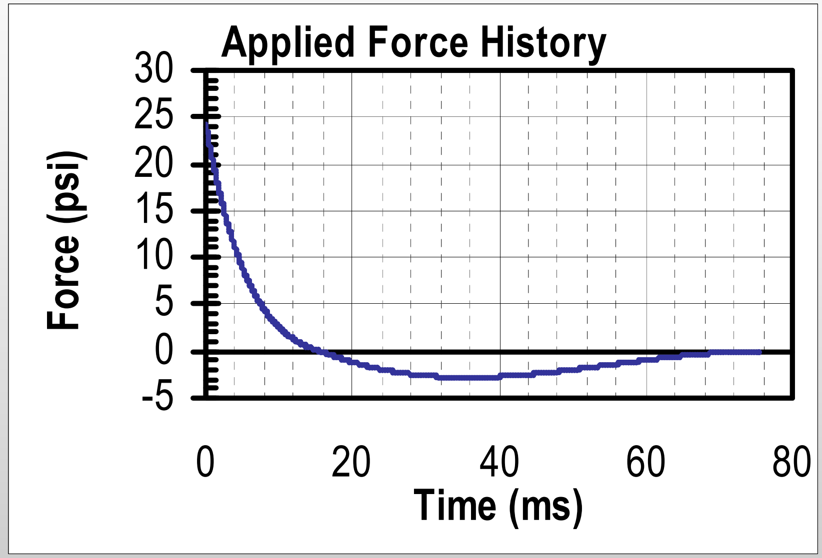
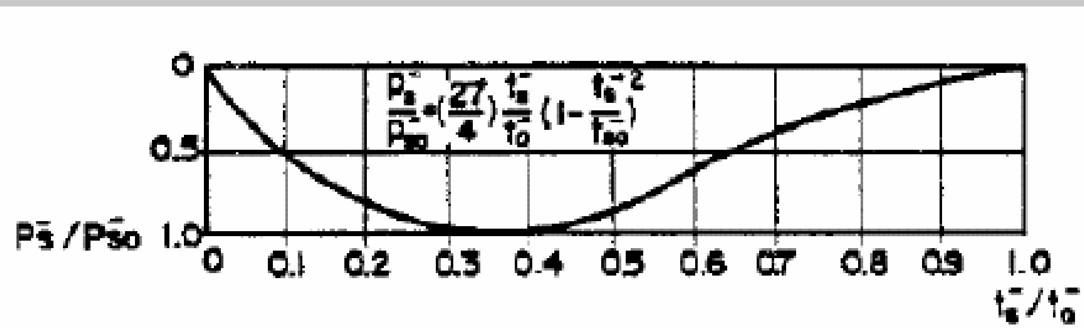
SBEDS Generated Loading

- **Exponential decay in positive phase pressure-history using curve-fit to decay constant from CONWEP**
- **Curve-fit to negative phase using method from Navy document "Blast Resistant Structures, Design Manual 2.08, December 1986" (see below)**





P^-_{so} = peak negative pressure
$t^-_{so} = 2*i/ P^-_{so}$
i = negative phase impulse
Note: Used for reflected and side-on blast loads

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Solution Options

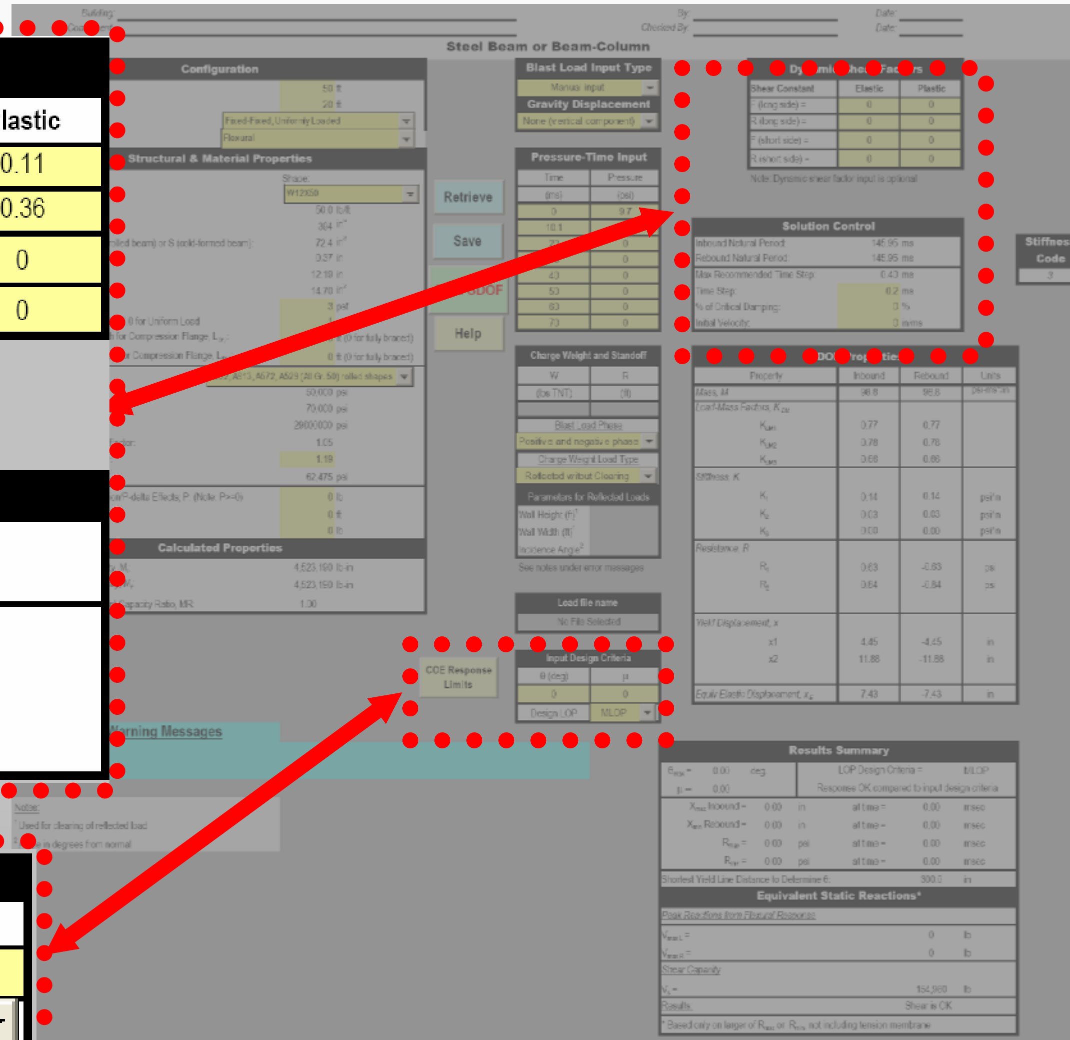
Dynamic Shear Factors		
Shear Constant	Elastic	Plastic
F (long side) =	0.14	0.11
R (long side) =	0.36	0.36
F (short side) =	0	0
R (short side) =	0	0

Note: Dynamic shear factor input is optional

Solution Control		
Inbound Natural Period:	145.95	ms
Rebound Natural Period:	145.95	ms
Max Recommended Time Step:	0.40	ms
Time Step:	0.2	ms
% of Critical Damping:	0	%
Initial Velocity:	0	in/ms

COE Response Limits

Input Design Criteria	
θ (deg)	μ
2	5
Design LOP	MLOP



Solution Options (continued)

- **Response limits/level of protection desired (optional)**
  - **Does not effect calculations, bookkeeping aid**
- **Dynamic shear constants (optional)**
- **Damping**
  - **0.05% of critical used by default, greater values can be input**
- **Initial velocity**
- **Time step (recommended value provided)**

Recommended Time Step – Smallest Value Based On:

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- 10% of the natural period
- 10% of the smallest time increment in a manually input blast load
- 3% of the equivalent triangular positive phase duration or 1.5% of the equivalent triangular negative phase duration of an input charge weight-standoff blast load
- 3% of the smallest calculated time between local maxima and minima points of a input blast load file
- The total 2900 time steps in the time-stepping SDOF method in SBEDS divided by 8 natural periods (but not less than 0.01 ms)

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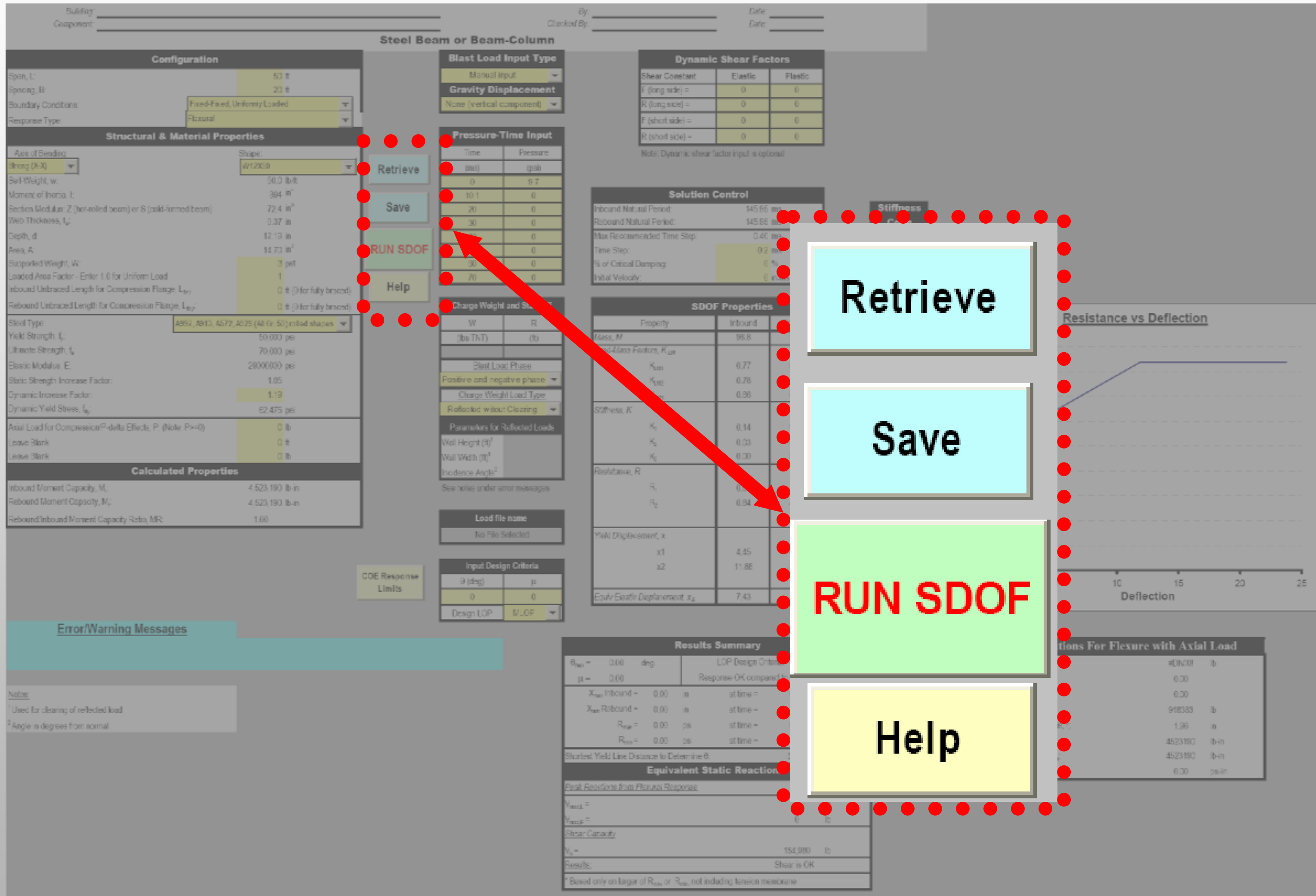
General Commands



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SDOF Solver in SBEDS

- Constant velocity integration method used to numerically solve SDOF equation of motion at each time step
  - Very stable solutions if small enough time step used
- 2900 time steps in program so very small time steps are usually recommended (less than 1 ms)

Validation

- Generally within 1%-2% when checked against the SOLVER and WAC codes for numerous cases (27) with multiple yield and stiffness combinations
- Constant velocity method has also been validated against finite element calculations performed by BakerRisk

Analysis Description	Response Range	SDOF Model Maximum Displacement (in)	SDOF Model Time of Max. Displacement (msec)	ADINA Model Maximum Displacement (in)	ADINA Model Time of Max. Displacement (msec)	Percent Difference
Rectangular Beam	μ=3	5.507	35	5.232	33	**5.0**
	μ=10	17.17	51	15.19	47	**11.5**
	μ=20	33.73	65	28.58	58	**15.3**
	μ=20	26.11 **SDOF based on Z**	55	28.58	58	**-9.5**
I-Shaped Beam (W8x24)	Elastic	2.297	23	2.250	24	**2.0**
	μ=2	5.962	29	5.853	29	**1.8**
	μ=10	29.81	51	26.26	47	**11.9**
	μ=20	59.55	66	49.98	58	**16.1**

SBEDS Output

- Maximum deflection and resistance in inbound/outbound response
  - Maximum support rotation, ductility ratio, strain rate(s), and equivalent static and dynamic shears
- Response history plots for deflection, resistance, equivalent P-Δ load, and dynamic shear and resistance-deflection plot

SBEDS Results Summary

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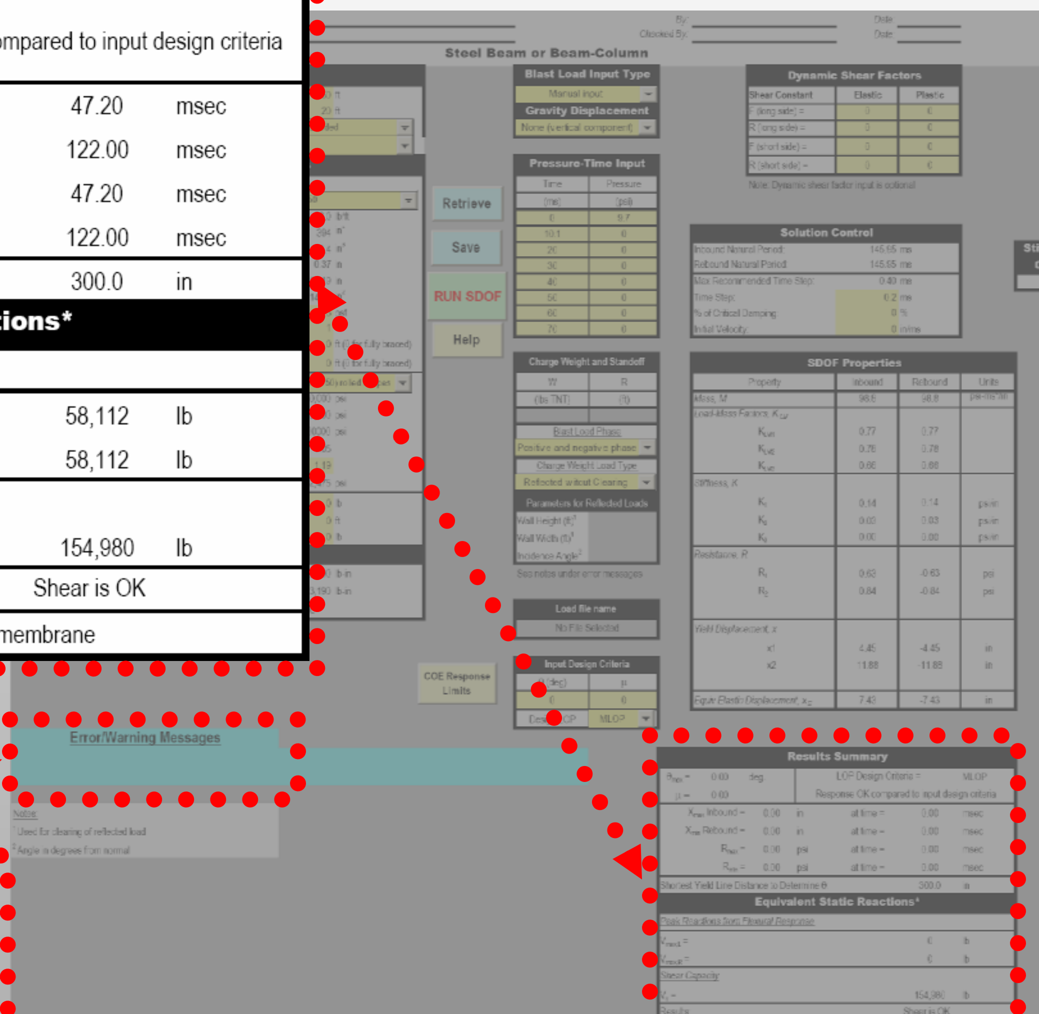
Results Summary						
θ_{max} =	2.06	deg.	LOP Design Criteria =		MLOP	
μ =	1.45		Response NOT OK compared to input design criteria			
X_{max} Inbound =	10.80	in	at time =	47.20	msec	
X_{min} Rebound =	-5.05	in	at time =	122.00	msec	
R_{max} =	0.81	psi	at time =	47.20	msec	
R_{min} =	-0.79	psi	at time =	122.00	msec	
Shortest Yield Line Distance to Determine θ:				300.0	in	
Equivalent Static Reactions*						
Peak Reactions from Flexural Response						
$V_{max,L}$ =				58,112	lb	
$V_{max,R}$ =				58,112	lb	
Shear Capacity						
V_s =				154,980	lb	
Results:				Shear is OK		
* Based only on larger of R_{max} or R_{min}, not including tension membrane						



Error/Warning Messages

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SBEDS Detailed Output (Results Sheet)

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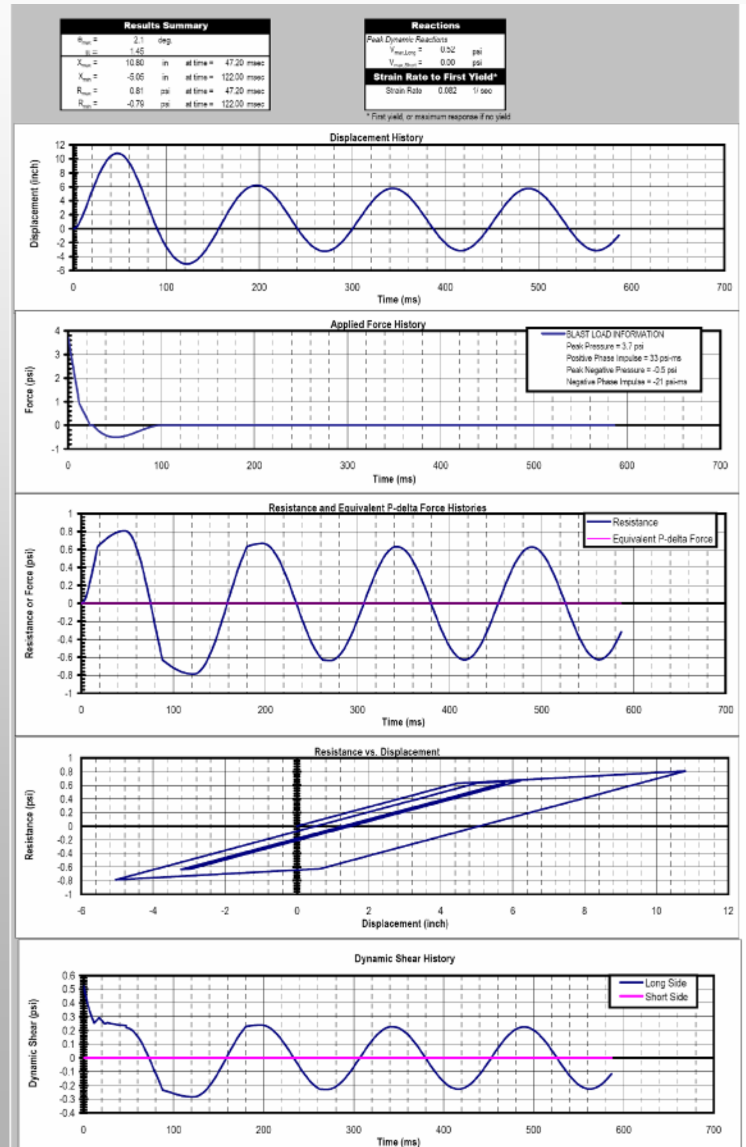

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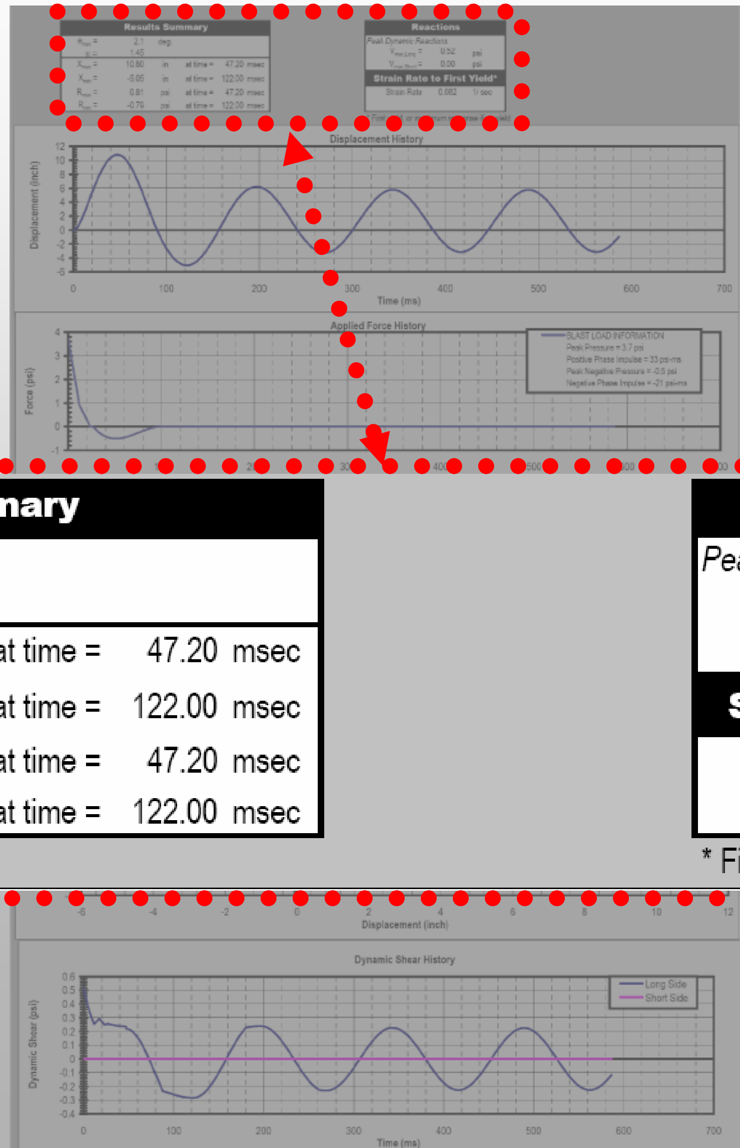
Peaks



Results Summary				
θ_{max} =	2.1	deg.		
μ =	1.45			
X_{max} =	10.80	in	at time =	47.20 msec
X_{min} =	-5.05	in	at time =	122.00 msec
R_{max} =	0.81	psi	at time =	47.20 msec
R_{min} =	-0.79	psi	at time =	122.00 msec

Reactions		
Peak Dynamic Reactions		
$V_{max,Long}$ =	0.52	psi
$V_{max,Short}$ =	0.00	psi
Strain Rate to First Yield*		
Strain Rate	0.082	1/ sec

* First yield, or maximum response if no yield

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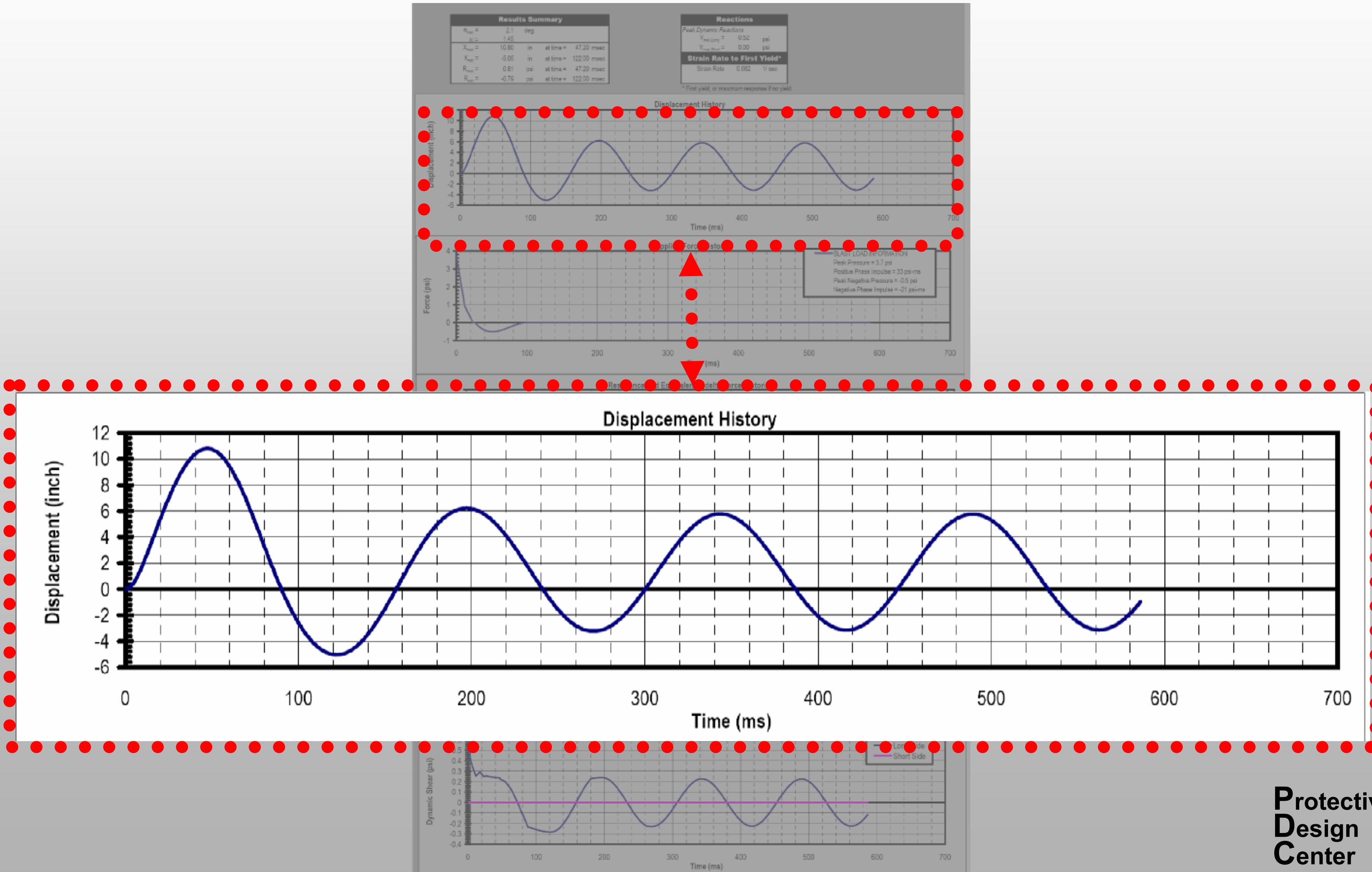
Displacement History



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Applied Force History

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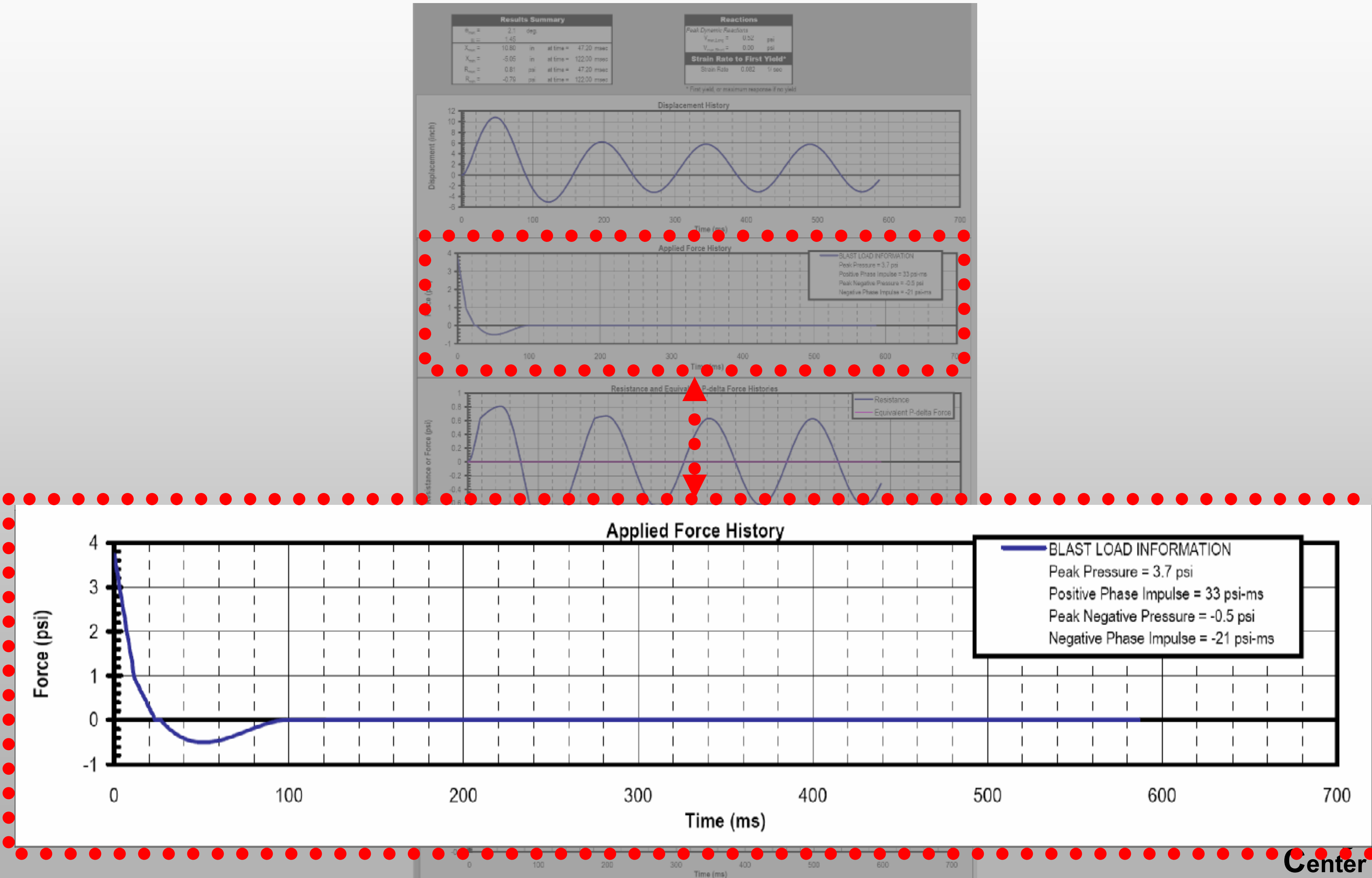

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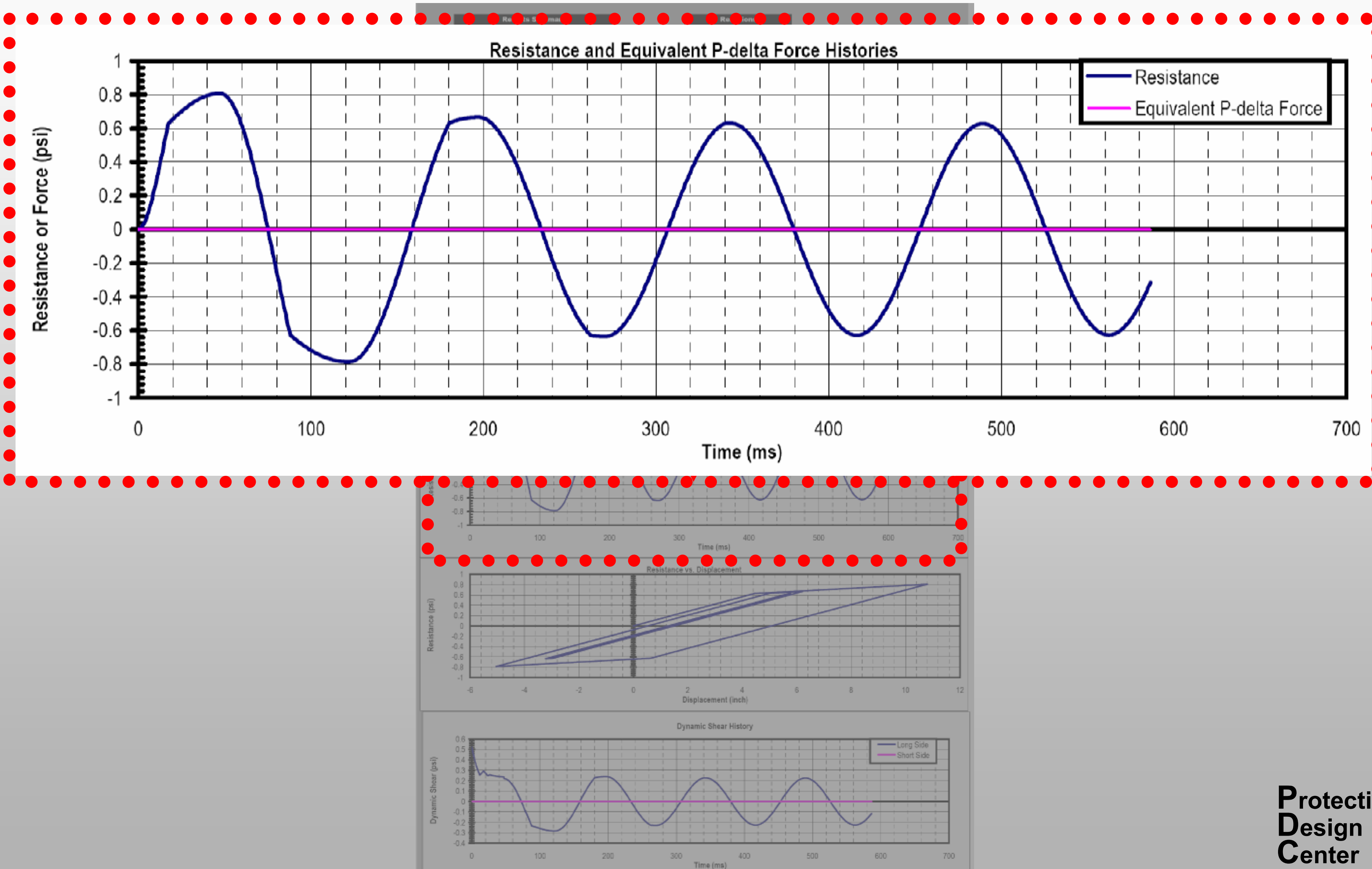
Resistance and Equivalent P-Δ Force History



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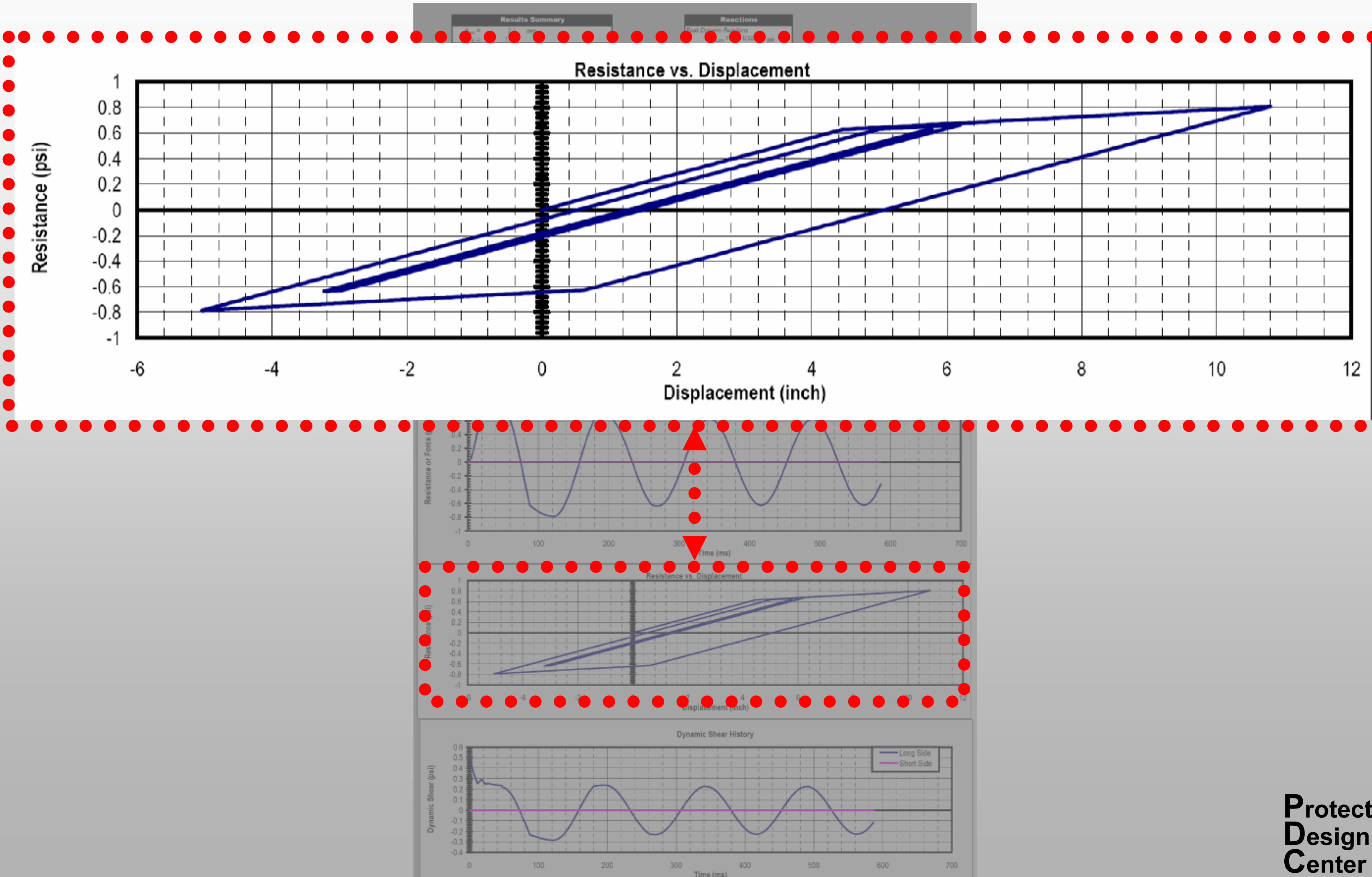
Resistance – Displacement Function



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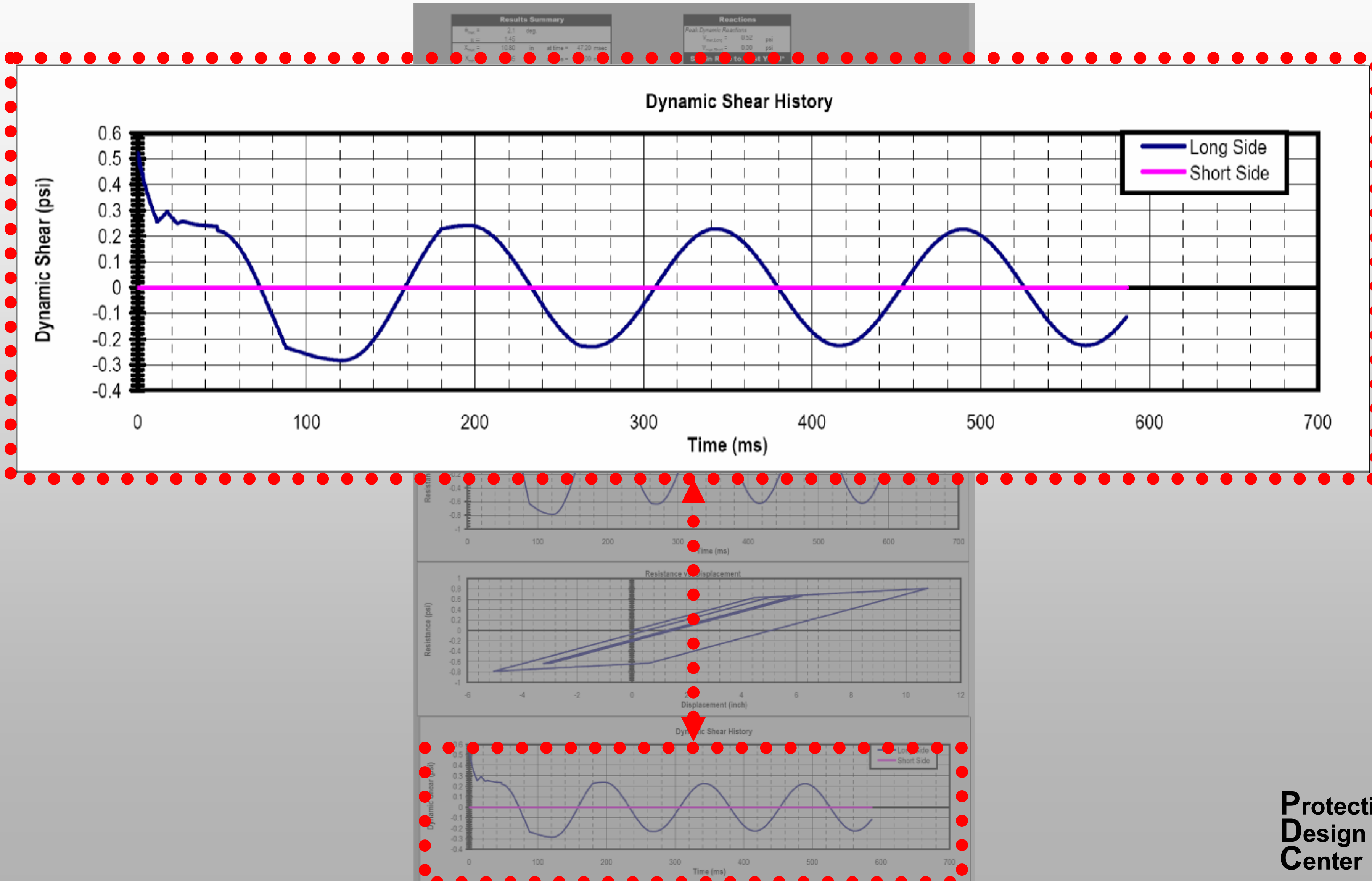
Dynamic Shear History



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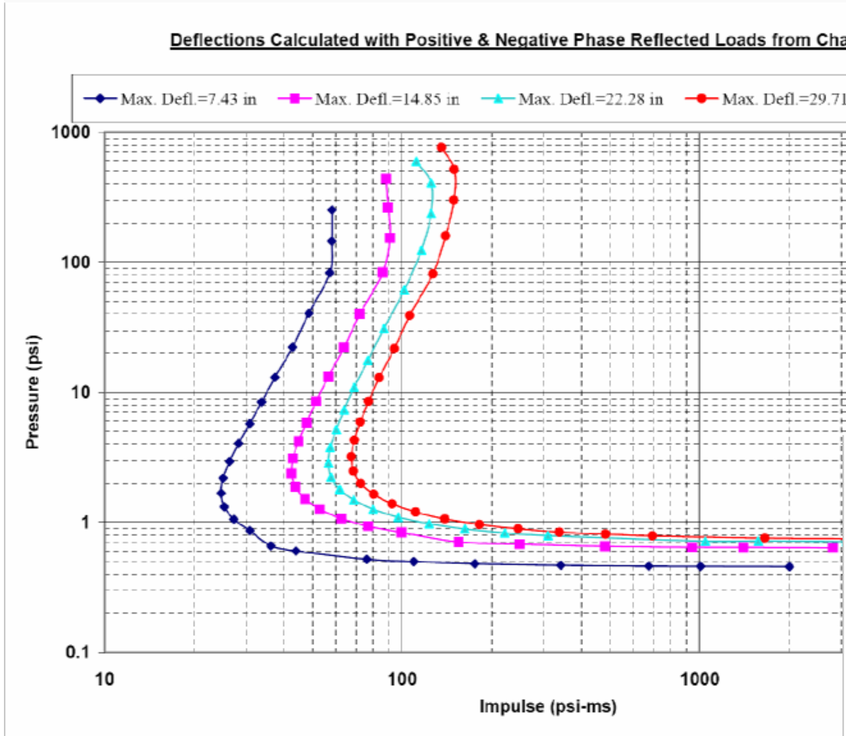
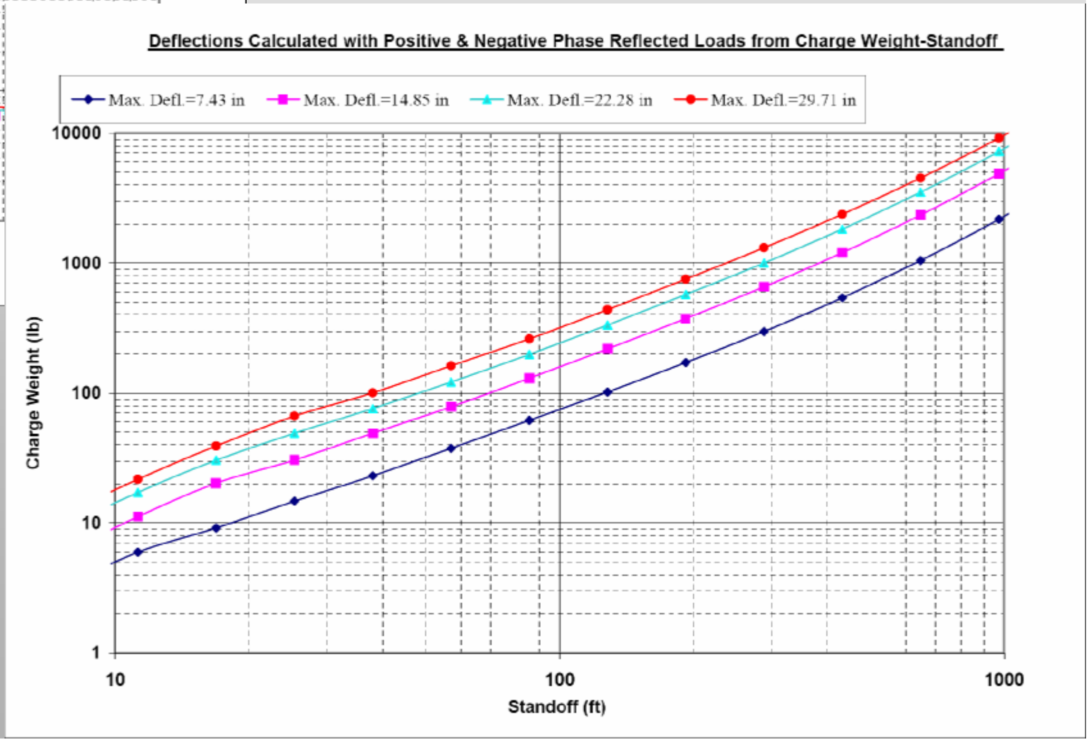
SDOF Output Sheet

Time (ms)	Applied Force (psi)	Equiv P-delta Force (psi)	Deflection (in)	Velocity (in/ms)	Acceleration (psi/in)	Stiffness (psi/in)	Resistance (psi)
0	3.729287	0	0	3.73E-09	0.048997282	0.14106173	0
0.2	3.681363	0	0.00097995	0.009799	0.048365391	0.14106173	0.00013823
0.4	3.633438	0	0.00389451	0.019409	0.047729923	0.14106173	0.00054937
0.6	3.585514	0	0.00871827	0.028892	0.047090922	0.14106173	0.00122981
0.8	3.53759	0	0.01542566	0.038246	0.046448435	0.14106173	0.00217597
1	3.489666	0	0.023991	0.047472	0.045802511	0.14106173	0.00338421
1.2	3.441742	0	0.03438843	0.056567	0.045153197	0.14106173	0.00485089
1.4	3.393817	0	0.04659199	0.065533	0.044500541	0.14106173	0.00657235
1.6	3.345893	0	0.06057557	0.074368	0.043844591	0.14106173	0.0085449
1.8	3.297969	0	0.07631294	0.083071	0.043185397	0.14106173	0.01076484
2	3.250045	0	0.09377772	0.091642	0.042523007	0.14106173	0.01322845
2.2	3.202121	0	0.11294343	0.100081	0.04185747	0.14106173	0.015932
2.4	3.154196	0	0.13378343	0.108386	0.041188836	0.14106173	0.01887172
2.6	3.106272	0	0.15627098	0.116557	0.040517155	0.14106173	0.02204386
2.8	3.058348	0	0.18037923	0.124593	0.039842475	0.14106173	0.02544461
3	3.010424	0	0.20608117	0.132494	0.039164848	0.14106173	0.02907017
3.2	2.9625	0	0.2333497	0.140259	0.038484323	0.14106173	0.03291671
3.4	2.914575	0	0.26215761	0.147888	0.037800951	0.14106173	0.03698041

P-i & CW-S Diagrams





P-i & CW-S Diagrams (cont.)

- **User specifies ductility and/or support rotation for up to four levels of response**
  - **if ductility and support rotation are entered, the one resulting in the smallest deflection is used**
- **Negative phase is optional**
- **User selects either P-i, CW-S for side-on loading, or CW-S for fully reflected loading**
- **Clearing and angle of incidence are not considered**
- **SBEDS iterates to determine the charge weight and standoff resulting in the specified level of response and then plots either the P-i or CW-S point**

SBEDS Availability

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- Distribution Statement A – Approved for public release; distribution is unlimited
- https://pdc.usace.army.mil/
- Registration required (Armadillo protection)
- Limited support available
  - PDC website has FAQ, discussion forum, & issue tracker

Future

- Methodology manual
- Routine to transfer graphic output to DPLOT
- Additional boundary condition options for 2-way concrete, steel, and masonry slabs and plates
- Cavity wall component (unreinforced masonry)
- Metal stud w/ fascia component
- Account for openings in two-way members

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Summary

- SBEDS is a valuable tool for implementing DoD antiterrorism standards
- Designer friendly tool for conventional construction that combines all steps to design/analyze a wide variety of blast-loaded structural components
- SBEDS calculates single degree of freedom (SDOF) response for 11 types of structural components
  - Also allows for input of general SDOF system
- Based on Army TM 5-1300 &UFC 3-340-01 guidance but draws on other sources for best methodologies
- Approved for public release and available from https://pdc.usace.army.mil/

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CEDAW

(Component Explosive Damage Assessment Workbook)

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Background

- DODI 2000.16 requires vulnerability assessments of installations that include the consideration of explosive threats
- P-i methodology provides a means of rapidly assessing expected damage to structural components
- Many blast assessment tools utilize the P-i methodology in the PDC FACEDAP (1991)
- Recent developments have left FACEDAP 'dated'
  - refined SDOF techniques considering more complex response modes
  - more test data for component response to blast loads
  - better understanding of importance of the negative phase
- These factors accounted for in CEDAW, as well as incorporation of the new DOD definitions for LOP

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CEDAW Methodology

- P-i relationships developed from scaled relationships specifically for defined DoD levels of protection
- Near instantaneous results (not an iterative process as used in SBEDS)

CEDAW Components

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- One-way corrugated metal panel
- Steel beam or beam-column
- Metal stud wall
- Open-web steel joist
- One-way or two-way reinforced concrete slab
- Reinforced concrete beam
- One-way reinforced masonry
- One-way or two-way unreinforced masonry
- Wood stud wall
- Steel column (assuming connection failure)*
- Reinforced concrete column

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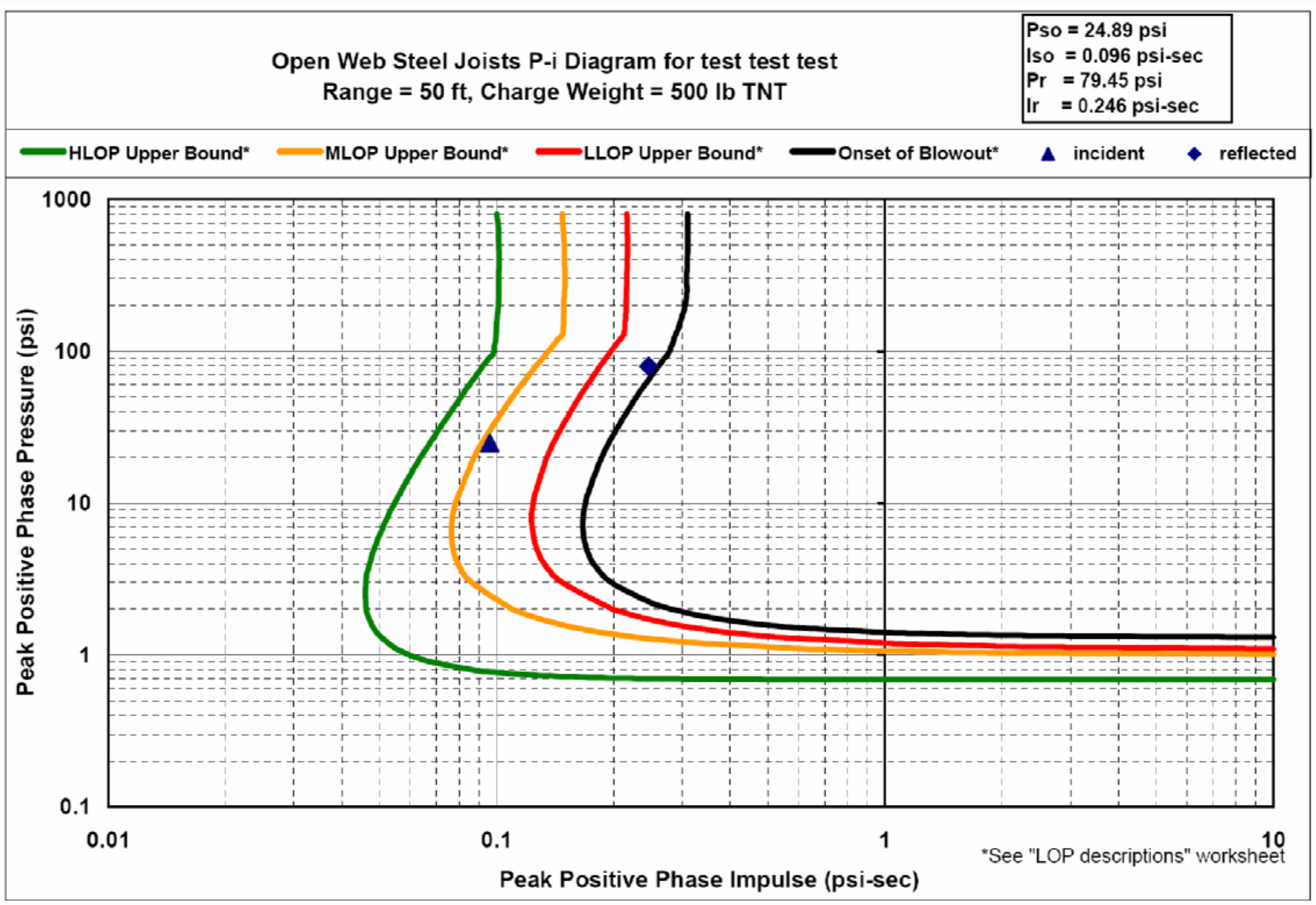
CEDAW P-i Output



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CEDAW CW-S Output

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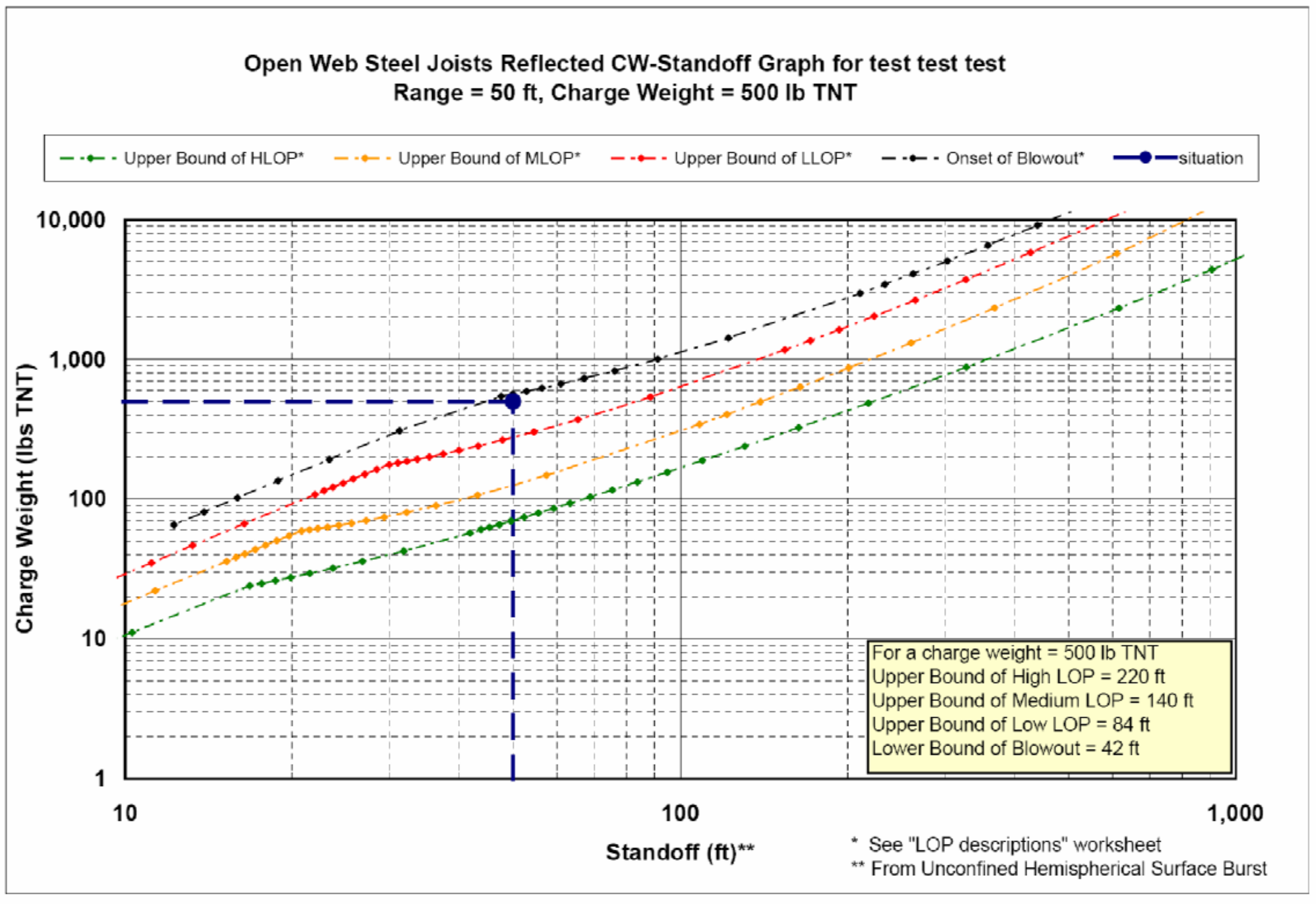

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Questions