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METAL STAIR STRUCTURAL CALCULATIONS SUBMITTAL

Rejected Review: Structural Review
Reviewed By: Tom Umscheid
Correction Comment 7
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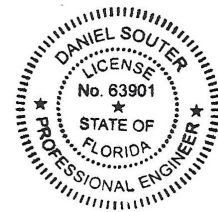
STRUCTURAL CALCULATIONS

ARTHREX STAIRS

GEM INDUSTRIES PROJECT #18-6159

PREPARED BY: DANIEL SOUTER, P.E. – FL#63901

Rev. 07/05/18



Daniel Souter
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All Plans and Calculations prepared using FBC 2017

Stair Loading

100 psf LL
35 psf DL

Spans

Stair Pans = 5'-0"	12 gauge plate
Stringer - Worst case = 16'-0" (Diag.)	MC12x14.3
Typical Landing Member - Small = 6'-4" (1'-10" spacing)	L4x3x1/4
Typical Landing Member - Small = 8'-4" (1'-10" spacing)	L6x4x5/16
Main Landing Member = 11'-2"	C12x20.7

(See following pages for individual member design)

Stringer to Landing Member max reaction = 2.79k.
Welded connection, 3/16" fillet weld, 4" x 2.39k = 9.56k > 2.79k.

Stair Pans

(12 gauge steel, 0.105" steel thickness, stair pan is 11" deep by 7" high)

$S_x \text{ act. (12 gauge Z purlin 8"x2" leg [conservative])} = 2.4 \text{ in}^3$

$I_x \text{ act. (12 gauge Z purlin 8"x2" leg [conservative])} = 11.2 \text{ in}^4$

$M_{\max} = wL^2/8 = 135 \text{ plf} \times 5'-0''^2 / 8 = 0.45 \text{ k.ft}$

$S_x \text{ req.} = 0.45 \text{ k.ft} \times 12'' / (36 \text{ ksi} \times 0.6) = 0.25 \text{ in}^3$

$S_x \text{ act.} = 2.34 \text{ in}^3 > 0.23 \text{ in}^3$

Stair Pan OK

$\text{Defl. Max} = 5 wL^4/384EI = 5 \times 145 \text{ plf} \times 5'-0''^4 / 384 \times 29 \times 10^6 \times 11.2 \text{ in}^4 = 0.03 \text{ in}$

$L/360 = 5'-0'' \times 12'' / 360 = 0.17 \text{ in} > 0.03 \text{ in}$

Stair Pan Deflection OK

Landing to concrete wall connection

Max Reaction = 672plf.

5/8" Wedge-All Anchors @ 2'-0" o.c. max, 4.5" embed.

3.145k allowable load > 1.34k (2'x672plf)

O.K.

Main landing to concrete wall Connection

Max Reaction = 9.39 k

3/4" dia. threaded rod (A193 GR B7) in Simpson SET epoxy, 5" embed

2 threaded rods x 6.31k x 0.9 spacing reduction (6 inches). = 11.3k > 9.39k

O.K.

Handrails/Guardrails

Concentrated Load of 200lb at any point and in any direction
50plf uniform load applied in any direction

Member Properties

Steel 35ksi

1 1/4" dia. pipe (STD)

Schedule 40, OD = 1.66", ID = 1.38", wall thick. = 0.140", $S_x = 0.235\text{in}^3$, $Z_x = 0.324\text{in}^3$

1 1/4" dia. pipe (X-STR)

Schedule 80, OD = 1.66", ID = 1.278", wall thick. = 0.191", $S_x = 0.291\text{in}^3$, $Z_x = 0.414\text{in}^3$

1 1/2" dia. pipe (STD)

Schedule 40, OD = 1.9", ID = 1.61", wall thick. = 0.145", $S_x = 0.326\text{in}^3$, $Z_x = 0.448\text{in}^3$

1 1/2" dia. pipe (X-STR)

Schedule 80, OD = 1.90", ID = 1.50", wall thick. = 0.200", $S_x = 0.412\text{in}^3$, $Z_x = 0.581\text{in}^3$

Horizontal Member (Toprail/Grabrail)

$$M_{\max} = wL^2/8 = 50\text{plf} \times 4'-0''^2 / 8 = 100\text{b.ft}$$

$$Z_x \text{ req.} = 0.100\text{k.ft} \times 12'' / (35\text{ksi} \times 0.6) = 0.056\text{in}^3 < 0.324\text{in}^3$$

1 1/4" Dia. Sch 40 or 1 1/2" Dia. Sch 40 Pipe OK

3'-6" Handrail Vertical Member

50plf x 4'-0" post spacing = 200lb point load

$$M_{\max} = PL = 200\text{lb} \times 3'-6'' = 700 \text{ lb.ft}$$

$$Z_x \text{ req.} = 0.700 \text{ k.ft} \times 12'' / (35\text{ksi} \times 0.6) = 0.400\text{in}^3 < 0.448\text{in}^3$$

1 1/2" Dia. Schedule 40 Pipe OK

Handrail Vertical Member weld to stringer

$$700\text{lb.ft} \times 12'' / 1.9''\text{dia.}/2 = 8.8\text{k}$$

$$1/8'' \text{ fillet weld all around, } 1.8\text{k per inch} \times 5.97 \text{ (circumference)} = 10.75 \text{ k} > 8.8\text{k} \quad \text{OK}$$

Scope :

Rev: 580005
User: KW-0606544, Ver 5.8.0, 1-Dec-2003
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Steel Beam Design

Page 1
GEM ARTHREX.ECW:Calculations

Description	Stringer (MC12X14.3 also works by observation)
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General Information

Code Ref: AISC 9th ASD, 1997 UBC, 2003 IBC, 2003 NFPA 5000

Steel Section : MC12X10.6

Center Span	16.00 ft
Left Cant.	0.00 ft
Right Cant	0.00 ft
Lu : Unbraced Length	1.00 ft

Pinned-Pinned Bm Wt. Added to Loads LL & ST Act Together

Fy	36.00ksi
Load Duration Factor	1.00
Elastic Modulus	29,000.0 ksi

Distributed Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7
DL	0.088						k/ft
LL	0.250						k/ft
ST							k/ft
Start Location							ft
End Location							ft

Summary

Beam OK
Static Load Case Governs Stress

Using: MC12X10.6 section, Span = 16.00ft, $F_y = 36.0\text{ksi}$
End Fixity = Pinned-Pinned, $L_u = 1.00\text{ft}$, $LDF = 1.000$

	<u>Actual</u>	<u>Allowable</u>		
Moment	11.153 k-ft	18.216 k-ft	Max. Deflection	-0.320 in
fb : Bending Stress	14.547 ksi	23.760 ksi	Length/DL Defl	2,119.4 : 1
fb / Fb	0.612 : 1		Length/(DL+LL Defl)	599.1 : 1
Shear	2.788 k	32.832 k		
fv : Shear Stress	1.223 ksi	14.400 ksi		
fv / Fv	0.085 : 1			

Force & Stress Summary

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<-- These columns are Dead + Live Load placed as noted -->
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	Maximum	DL Only	LL @ Center	LL+ST @ Center	LL @ Cants	LL+ST @ Cants	
Max. M +	11.15 k-ft	3.15	11.15				k-ft
Max. M -							k-ft
Max. M @ Left							k-ft
Max. M @ Right							k-ft
Shear @ Left	2.79 k	0.79	2.79				k
Shear @ Right	2.79 k	0.79	2.79				k
Center Defl.	-0.320 in	-0.091	-0.320	-0.320	0.000	0.000	in
Left Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
Right Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
...Query Defl @	0.000 ft	0.000	0.000	0.000	0.000	0.000	in
Reaction @ Left	2.79	0.79	2.79	2.79			k
Reaction @ Rt	2.79	0.79	2.79	2.79			k
Fa calc'd per Eq. E2-1, $K^*L/r < Cc$							
I Beam Passes Table B5.1, Fb per Eq. F1-1, $F_b = 0.66 F_y$							

Title :
Dsgnr:
Description :

Job #
Date: 12:55PM, 24 MAY 18

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Steel Beam Design

Page 2
GEM ARTHREX.ECW:Calculations

Description Stringer (MC12X14.3 also works by observation)

Section Properties MC12X10.6

Depth	12.000 in	Weight	10.53 #/ft
Web Thick	0.190 in	Ixx	55.300 in4
Width	1.500 in	Iyy	0.378 in4
Flange Thick	0.309 in	Sxx	9.200 in3
Area	3.10 in2	Syy	0.307 in3
Xcg Dist.	0.269 in	R-xx	4.220 in
Values for LRFD Design....		R-yy	0.349 in
J	0.060 in4	Zx	11.600 in3
Cw	11.70 in6	Zy	0.635 in3
		K	0.750 in

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Steel Beam Design

Page 1
GEM ARTHREX.ECW:Calculations

Description Typical Landing Member - Up to 6'-4" L4x3x1/4 also OK by comparison.
Sxx 0.98 > 0.96, lxx 2.75 > 1.7.

General Information

Code Ref: AISC 9th ASD, 1997 UBC, 2003 IBC, 2003 NFPA 5000

Steel Section : LL2.5X2.5X5/16

Center Span 6.33 ft
Left Cant. 0.00 ft
Right Cant 0.00 ft
Lu : Unbraced Length 1.00 ft

Pinned-Pinned
Bm Wt. Added to Loads
LL & ST Act Together

Fy 36.00 ksi
Load Duration Factor 1.00
Elastic Modulus 29,000.0 ksi

Distributed Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7	
DL	0.070							k/ft
LL	0.200							k/ft
ST								k/ft
Start Location								ft
End Location								ft

Summary

Beam OK
Static Load Case Governs Stress

Using: LL2.5X2.5X5/16 section, Span = 6.33ft, Fy = 36.0ksi
End Fixity = Pinned-Pinned, Lu = 1.00ft, LDF = 1.000

	Actual	Allowable		
Moment	1.402 k-ft	1.909 k-ft	Max. Deflection	-0.205 in
fb : Bending Stress	17.454 ksi	23.760 ksi	Length/DL Defl	1,296.6 : 1
fb / Fb	0.735 : 1		Length/(DL+LL Defl)	370.3 : 1
Shear	0.886 k	11.250 k		
fv : Shear Stress	2.268 ksi	14.400 ksi		
fv / Fv	0.158 : 1			

Force & Stress Summary

<<-- These columns are Dead + Live Load placed as noted -->>

	Maximum	DL Only	LL @ Center	LL+ST @ Center	LL @ Cants	LL+ST @ Cants	
Max. M +	1.40 k-ft	0.40	1.40				k-ft
Max. M -							k-ft
Max. M @ Left							k-ft
Max. M @ Right							k-ft
Shear @ Left	0.89 k	0.25	0.89				k
Shear @ Right	0.89 k	0.25	0.89				k
Center Defl.	-0.205 in	-0.059	-0.205	-0.205	0.000	0.000	in
Left Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
Right Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
...Query Defl @	0.000 ft	0.000	0.000	0.000	0.000	0.000	in
Reaction @ Left	0.89	0.25	0.89	0.89			k
Reaction @ Rt	0.89	0.25	0.89	0.89			k

Section Properties LL2.5X2.5X5/16

Depth	2.500 in	Weight	9.95 #/ft
Thickness	0.313 in	lxx	1.700 in ⁴
Width	2.500 in	lyy	3.292 in ⁴
		Sxx	0.964 in ³
Area	2.93 in ²	Syy	1.317 in ³
Angle Spacing	0.000 in	R-xx	0.761 in
Values for LRFD Design....		R-yy	1.060 in

Title :
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Description :

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Steel Beam Design

Page 1
GEM ARTHREX.ECW:Calculations

Description Typical Landing Member - Up to 8'-4" L6x4x5/16 also OK by
comparison. Sxx 2.7 > 2.09, Ixx 11.3 > 6.08.

General Information

Code Ref: AISC 9th ASD, 1997 UBC, 2003 IBC, 2003 NFPA 5000

Steel Section : LL4X4X1/4

Center Span	8.33 ft	Pinned-Pinned	Fy	36.00 ksi
Left Cant.	0.00 ft	Bm Wt. Added to Loads	Load Duration Factor	1.00
Right Cant	0.00 ft	LL & ST Act Together	Elastic Modulus	29,000.0 ksi
Lu : Unbraced Length	1.00 ft			

Distributed Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7	
DL	0.070							k/ft
LL	0.200							k/ft
ST								k/ft
Start Location								ft
End Location								ft

Summary

Beam OK
Static Load Case Governs Stress

Using: LL4X4X1/4 section, Span = 8.33ft, Fy = 36.0ksi
End Fixity = Pinned-Pinned, Lu = 1.00ft, LDF = 1.000

	Actual	Allowable		
Moment	2.456 k-ft	3.430 k-ft	Max. Deflection	-0.174 in
fb : Bending Stress	14.103 ksi	19.696 ksi	Length/DL Defl	1,956.0 : 1
fb / Fb	0.716 : 1		Length/(DL+LL Defl)	574.5 : 1
Shear	1.179 k	14.400 k		
fv : Shear Stress	2.359 ksi	14.400 ksi		
fv / Fv	0.164 : 1			

Force & Stress Summary

	Maximum	DL Only	LL @ Center	LL+ST @ Center	LL @ Cants	LL+ST @ Cants	
Max. M +	2.46 k-ft	0.72	2.46				k-ft
Max. M -							k-ft
Max. M @ Left							k-ft
Max. M @ Right							k-ft
Shear @ Left	1.18 k	0.35	1.18				k
Shear @ Right	1.18 k	0.35	1.18				k
Center Defl.	-0.174 in	-0.051	-0.174	-0.174	0.000	0.000	in
Left Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
Right Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
...Query Defl @	0.000 ft	0.000	0.000	0.000	0.000	0.000	in
Reaction @ Left	1.18	0.35	1.18	1.18			k
Reaction @ Rt	1.18	0.35	1.18	1.18			k

Section Properties LL4X4X1/4

Depth	4.000 in	Weight	13.18 #/ft
Thickness	0.250 in	Ixx	6.080 in4
Width	4.000 in	Iyy	10.692 in4
		Sxx	2.090 in3
Area	3.88 in2	Syy	2.673 in3
Angle Spacing	0.000 in	R-xx	1.250 in
Values for LRFD Design....		R-yy	1.660 in

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Steel Beam Design

Page 1
GEM ARTHREX.ECW:Calculations

Description Main Landing Member

General Information

Code Ref: AISC 9th ASD, 1997 UBC, 2003 IBC, 2003 NFPA 5000

Steel Section : C12X20.7

Center Span 11.17 ft
Left Cant. 0.00 ft
Right Cant 0.00 ft
Lu : Unbraced Length 1.00 ft

Pinned-Pinned
Bm Wt. Added to Loads
LL & ST Act Together

Fy 36.00 ksi
Load Duration Factor 1.00
Elastic Modulus 29,000.0 ksi

Distributed Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7	
DL	0.143							k/ft
LL	0.408							k/ft
ST								k/ft
Start Location								ft
End Location								ft

Point Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7	
Dead Load	1.000	1.000	1.000	1.000				k
Live Load	2.100	2.100	2.100	2.100				k
Short Term								k
Location	5.000	6.167	0.083	11.083				ft

Summary

Beam OK
Static Load Case Governs Stress

Using: C12X20.7 section, Span = 11.17ft, Fy = 36.0ksi
End Fixity = Pinned-Pinned, Lu = 1.00ft, LDF = 1.000

	Actual	Allowable		
Moment	24.670 k-ft	42.570 k-ft	Max. Deflection	-0.137 in
fb : Bending Stress	13.769 ksi	23.760 ksi	Length/DL Defl	3,169.2 : 1
fb / Fb	0.580 : 1		Length/(DL+LL Defl)	977.4 : 1
Shear	9.392 k	48.730 k		
fv : Shear Stress	2.775 ksi	14.400 ksi		
fv / Fv	0.193 : 1			

Force & Stress Summary

<<-- These columns are Dead + Live Load placed as noted -->>

	Maximum	DL Only	LL @ Center	LL+ST @ Center	LL @ Cants	LL+ST @ Cants	
Max. M +	24.67 k-ft	7.63	24.67				k-ft
Max. M -							k-ft
Max. M @ Left							k-ft
Max. M @ Right							k-ft
Shear @ Left	9.39 k	2.91	9.39				k
Shear @ Right	9.39 k	2.91	9.39				k
Center Defl.	-0.137 in	-0.042	-0.137	-0.137	0.000	0.000	in
Left Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
Right Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
...Query Defl @	0.000 ft	0.000	0.000	0.000	0.000	0.000	in
Reaction @ Left	9.39	2.91	9.39	9.39			k
Reaction @ Rt	9.39	2.91	9.39	9.39			k

Fa calc'd per Eq. E2-1, $K^*L/r < C_c$

I Beam Passes Table B5.1, Fb per Eq. F1-1, Fb = 0.66 Fy

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Steel Beam Design

Page 2
GEM ARTHREX.ECW:Calculations

Description Main Landing Member

Section Properties C12X20.7

Depth	12.000 in	Weight	20.65 #/ft
Web Thick	0.282 in	Ixx	129.000 in4
Width	2.940 in	Iyy	3.860 in4
Flange Thick	0.501 in	Sxx	21.500 in3
Area	6.08 in2	Syy	1.720 in3
Xcg Dist.	0.698 in	R-xx	4.610 in
Values for LRFD Design....		R-yy	0.797 in
J	0.369 in4	Zx	25.600 in3
Cw	112.00 in6	Zy	3.470 in3
		K	1.125 in