SFA Design Group, LLC
STRUCTURAL | GEOTECHNICAL | SPECIAL INSPECTIONS
PORTLAND, OR | LIVERMORE, CA | SEATTLE, WA
503.641.8311 | www.sfadg.com

STRUCTURAL CALCULATIONS REVISION #1

Bennett Residence Underpinning

4105 Red Hill Church Rd, Coats, NC 27521

Regional Foundation Solutions

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 051166 JESSE L. DEAN

EXPIRES:	12/31/22
DATE SIGNED:	10/31/22

LIMITATIONS

ENGINEER WAS RETAINED IN A LIMITED CAPACITY FOR THIS PROJECT. DESIGN IS BASED UPON INFORMATION PROVIDED BY THE CLIENT WHO IS SOLELY RESPONSIBLE FOR ACCURACY OF SAME. NO RESPONSIBILITY AND/OR LIABILITY IS ASSUMED BY, OR IS TO BE ASSIGNED TO THE ENGINEER FOR ITEMS BEYOND THAT SHOWN ON THESE SHEETS.

Project No. RBC22-030
July 15, 2022

Revised: October 31, 2022

PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT	DATE
Bennett Residence Underpinning	10/31/2022
SUBJECT	BY
Push Pier Design Requirements	MEK

Structural Narrative

The structural calculations and drawings enclosed are in reference to the design of the foundation underpinning of the 1-story residence located in Coats, NC as referenced on the coversheet. The round steel tubes and retrofit brackets are used to stabilize and/or lift settling foundations. The bottom and back portion of the bracket is securely seated against the existing concrete footing. Using the weight of the existing structure, pier sections are continuously hydraulically driven through the foundation bracket and into the soil below until a load bearing stratum is encountered. Lateral earth confinement and a driven external sleeve with a starter pier provide additional stiffness to resist eccentric loading from the foundation. Once all piers are installed, they are simultaneously loaded with individual hydraulic jacks and closely monitored as pressure is applied to achieve desired stabilization and/or lift prior to locking off the pier cap. The piers are required to resist vertical loading from the roof framing, wall framing, floor framing, and concrete foundation. Underpinning the structure will remove lateral resistance provided by soil friction acting on the concrete foundation. Per the following calculation lateral resistance will be provided by soil friction acting on the unpiered portions of the concrete footing/concrete slab on grade and passive pressure acting on the buried footings perpendicular to the piered gridlines.

General

Building Department	City of Coats
Building Code Conformance (Meets Or Exceeds Requirements)	
2015 International Building Code (IBC)	
2015 International Residential Code (IRC)	
2018 North Carolina Building Code	
2018 North Carolina Residential Code	

Dead Loads

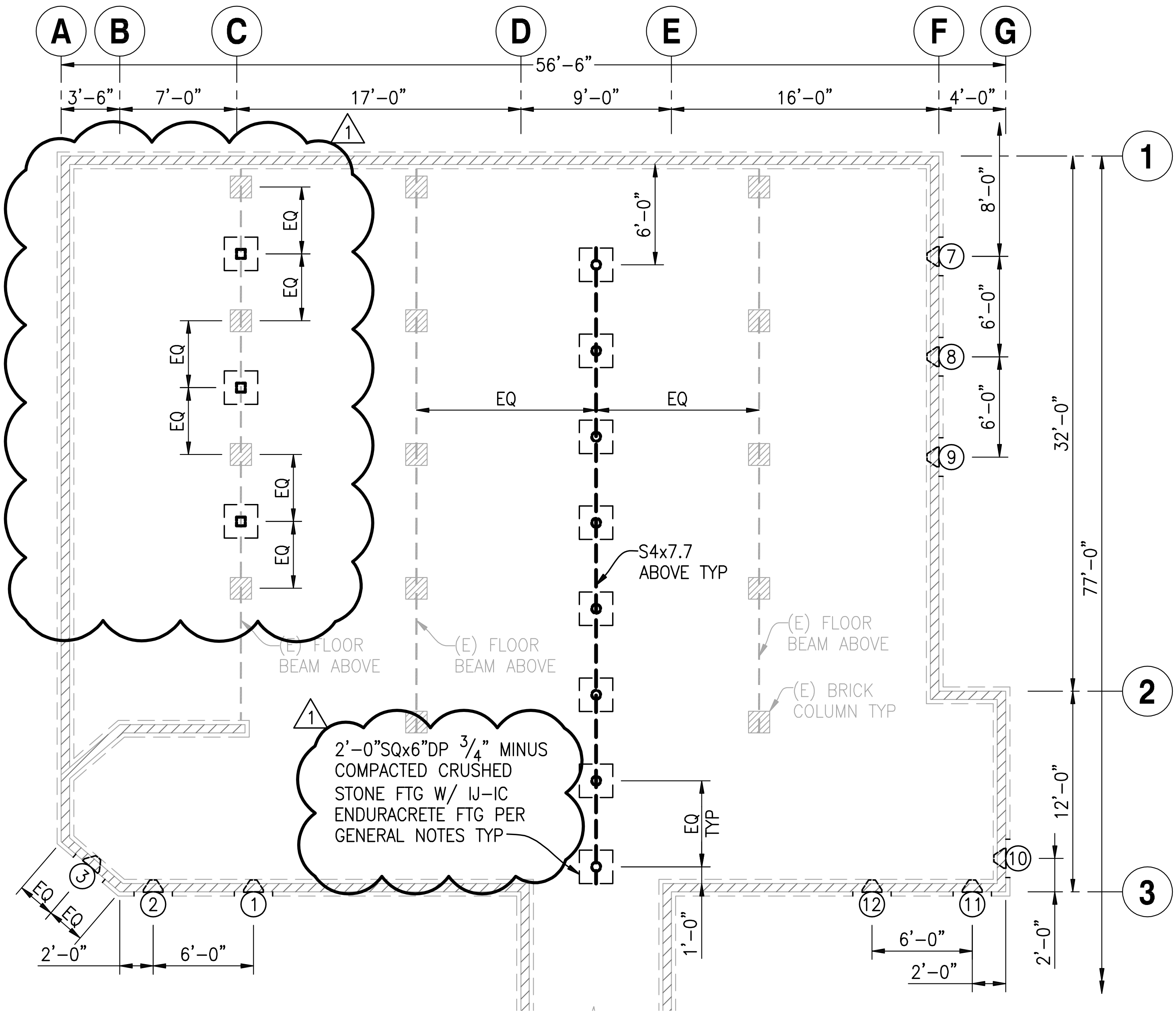
Roof Dead Load	15.0 psf
Floor Dead Load	15.0 psf
Wood Wall Dead Load	12.0 psf
Interior Wall Dead Load	9.0 psf
Brick Wall Dead Load	78.0 psf
Concrete	150.0 pcf

Live Loads

Roof Live Load	20.0 psf
Floor Live Load (Residential)	40.0 psf

SFA Design Group, LLC STRUCTURAL | GEOTECHNICAL | SPECIAL INSPECTIONS	PROJECT NO. RBC22-030	SHEET NO.
PROJECT Bennett		DATE 10/31/2022
SUBJECT Pier Layout		BY MEK

Pier Layout (See S2.1 for Enlarged Plan)



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PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT Bennett Residence Underpinning	DATE 10/31/2022
SUBJECT Design Loads	BY MEK

Worst Case Vertical Design Loads (Gridline 3)

Tributary Width To Pier = = 6.00 ft

Load Type	Design Load	Tributary Length		Line Load		
$Roof_{DL}$ =	(15 psf)	(24.00 ft)		= 360 plf	Dead Load	5.266 kips
RoofLL =	(20 psf)	(24.00 ft)		= 480 plf	Floor Live Load	0.480 kips
$1stFloor_{DL}$ =	(15 psf)	(2.00 ft)		= 30 plf	Roof Live Load	2.880 kips
$1stFloor_{LL}$ =	(40 psf)	(2.00 ft)		= 80 plf	Controlling ASD Load Combination:	
$InteriorWall_{DL}$ =	(9 psf)	(2.00 ft)		= 18 plf	D+Lr	
$ExteriorWall_{DL}$ =	(12 psf)	(9.00 ft)		= 108 plf		
Brick $Wall_{DL}$ =	(78 psf)	(30.00 in)		= 195 plf		
$Footing_{DL}$ =	(150 pcf)	(10.00 in)	(16.00 in)	= 167 plf		

Max Vertical Load to Worst Case Pier	**8.146 kips**
Max Unsupported Ftg Span from Arching Action	**6.67 ft**

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PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT Bennett Residence Underpinning	DATE 10/31/2022
SUBJECT Design Loads	BY MEK

Worst Case Vertical Design Loads (Gridline 1)

Tributary Width To Pier = 6.00 ft

Load Type	Design Load	Tributary Length		Line Load
$Roof_{DL}$ =	(15 psf)	(16.00 ft)		= 240 plf
RoofLL =	(20 psf)	(16.00 ft)		= 320 plf
$1stFloor_{DL}$ =	(15 psf)	(10.50 ft)		= 158 plf
$1stFloor_{LL}$ =	(40 psf)	(10.50 ft)		= 420 plf
$InteriorWall_{DL}$ =	(9 psf)	(10.50 ft)		= 95 plf
$ExteriorWall_{DL}$ =	(12 psf)	(9.00 ft)		= 108 plf
$Brick\ Wall_{DL}$ =	(78 psf)	(30.00 in)		= 195 plf
$Footing_{DL}$ =	(150 pcf)	(10.00 in)	(16.00 in)	= 167 plf

Dead Load	5.770 kips
Floor Live Load	2.520 kips
Roof Live Load	1.920 kips

Controlling ASD Load Combination:
D+0.75L+0.75Lr

Max Vertical Load to Worst Case Pier	**9.100 kips**
Max Unsupported Ftg Span from Arching Action	**6.67 ft**

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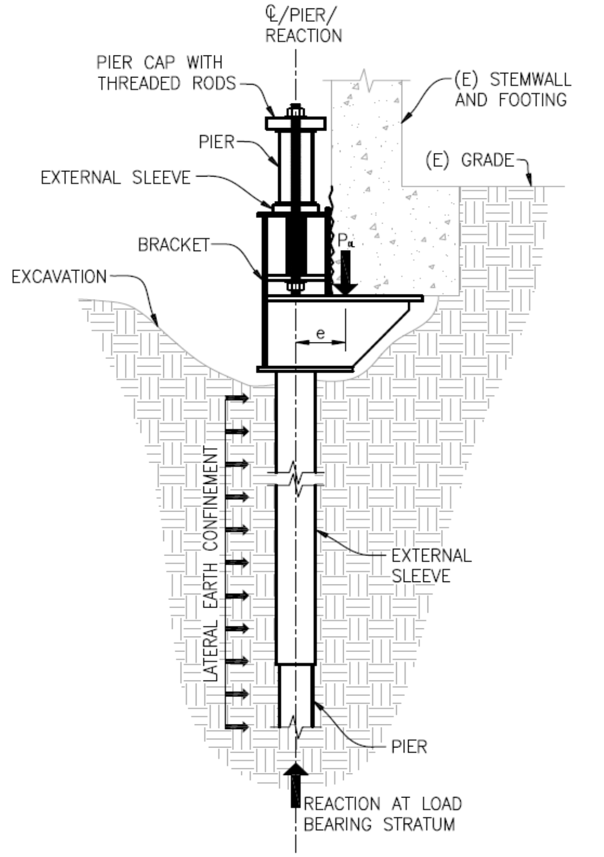
STRUCTURAL | GEOTECHNICAL | SPECIAL INSPECTIONS

PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT	DATE
Bennett Residence Underpinning	10/31/2022
SUBJECT	BY
2.875 in Ø Push Pier System	MEK

Design Input

Pier System Designation =	2.875 in Ø
Pier Material =	Galvanized
External Sleeve Material =	Black Steel
Vertical Load to Pier, P_{TL} =	9.100 kips
Minimum Installation Depth, L =	10.000 ft
Unbraced Length, l =	1.000 ft
Eccentricity, e =	4.250 in
Friction Factor of Safety, FS =	2
Normal Surface Force, F_n =	4.550 kips
Design Load (Vertical), P_{DL} =	9.100 kips
Design Moment, $Moment_{PierDL}$ =	38.675 kip-in



Note: Section above is a general representation of piering system, refer to plan for layout and project specific details.

Sleeve Property Input

Sleeve Length =	48.000 in
Design Sleeve OD =	3.398 in
Design Wall Thickness =	0.165 in
r =	1.144 in
A =	1.674 in²
S =	1.291 in³
Z =	1.725 in³
I =	2.193 in⁴
E =	29000 ksi
F_y =	50 ksi

Note: Sleeve reduces bending stress on main pier from eccentricty

Pier Property Input

Design Tube OD =	2.833 in
Design Wall Thickness =	0.141 in
k =	2.10
r =	0.953 in
A =	1.192 in²
c =	1.416 in
S =	0.764 in³
Z =	1.022 in³
I =	1.083 in⁴
E =	29000 ksi
F_y =	50 ksi
Hyrdraulic Ram Area =	**9.620 in²**

Note: Design thickness of pier and sleeve based on 93% of nominal thickness per AISC and the ICC-ES AC358 based on a corrosion loss rate of 50 years for zinc-coated steel

Pier Output Per AISC 360-10 Doubly and Singly Symmetric Members Subject To Flexure and Axial Force

kl/r =	26.44	**OK, <200**	§E2
F_e =	409.224 ksi		§(E3-4)
$4.71*(E/F_y)^{.5}$ =	113.43		§E3
F_{cr} =	47.507 ksi		§(E3-2 & E3-3)
P_n =	56.6 kips		§(E3-1)
Safety Factor for Compression, Ω_c =	1.67		
Allowable Axial Compressive Strength, P_n/Ω_c =	**33.9 kips**		§E1
Actual Axial Compressive Demand, P_r =	**9.100 kips**		
D/t_{Pier} =	20.1	**OK, <.45E/Fy**	§F8
M_n =	137.3 kip-in		§(F8-1)
Safety Factor for Flexure, Ω_b =	1.67		
Allowable Flexural Strength, M_n/Ω_b =	**82.2 kip-in**		§F1
Actual Flexural Demand, M_r =	**38.7 kip-in**		
Combined Axial & Flexure Check =	**0.69**	**OK**	§(H1-1a & 1b)

Note: Flexural design capacity based on combined plastic section modulus of pier and sleeve

Results

Max Load To Pier = Design Load = 9100 lb
2.875" Diameter Pipe Pier with 0.165" Thick Wall
3.5"Diameterx48" Long Pipe Sleeve With 0.216"ThickWall
Minimum 10'-0" Installation Depth And Minimum 2000 psi Installation Pressure
Minimum ¼" Foundation Lift During Installation

PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT Bennett Residence Underpinning	DATE 10/31/2022
SUBJECT Design Loads	BY MEK

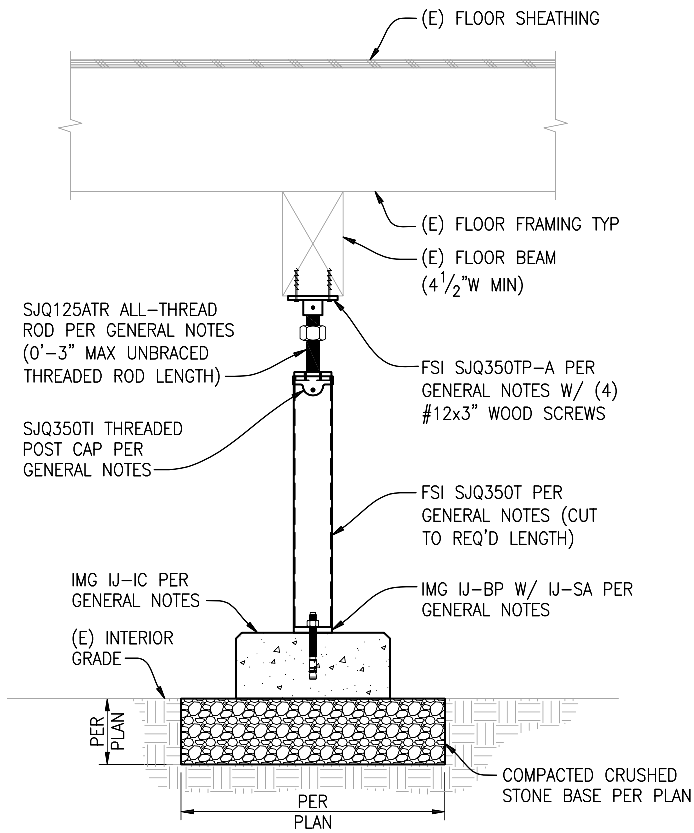
Worst Case Vertical Design Loads (Existing Beam)

Tributary Width To Pier = = 8.00 ft

Load Type	Design Load	Tributary Length	Line Load		
				Dead Load	2.016 kips
				Floor Live Load	3.360 kips
$1stFloor_{DL}$ =	(15 psf)	(10.50 ft)	= 158 plf	Roof Live Load	0.000 kips
$1stFloor_{LL}$ =	(40 psf)	(10.50 ft)	= 420 plf	Controlling ASD Load Combination:	
$InteriorWall_{DL}$ =	(9 psf)	(10.50 ft)	= 95 plf	D+L	

Max Vertical Load to Worst Case Pier	**5.376 kips**

SFA Design Group, LLC STRUCTURAL | GEOTECHNICAL | SPECIAL INSPECTIONS	PROJECT NO. RBC22-030	SHEET NO.
PROJECT Bennett Residence Underpinning		DATE 10/31/2022
SUBJECT Foundation Supportworks SJQ350 Smart Jack System		BY MEK



Note: Section above is a general representation of smartjack system, refer to plan for layout and project specific details.

Smart Jack System =	**SJQ350**	
Footing Type =	**Gravel**	
P_{max} =	**5.376**	**kips**
Maximum Tube Unbraced Length, d_t =	**3.000**	**ft**
Maximum Threaded Rod Unbraced Length, d_{tr} =	**3.000**	**in**
Eccentricity, e_{max} =	**1.000**	**in**
Moment =	**5.376**	**in-kips**

Tube Properties

Design Tube OD =	**3.500**	**in**
Design Wall Thickness =	**0.095**	**in**
k =	**1.00**	
r =	**1.380**	**in**
A =	**1.261**	**in^2**
c =	**1.750**	**in**
S =	**1.373**	**in^3**
I =	**2.402**	**in^4**
E =	**29000**	**ksi**
Fy =	**50**	**ksi**

Tube Output

kl/r =	26.09		Slenderness OK
Cc =	107.00		
F'e =	219.35	ksi	
Fa =	27.62	ksi	
fa =	4.26	ksi	
Fb =	33.00	ksi	
fb =	3.92	ksi	
Cm =	1.00		
fa/Fa =	0.15		Eq H1-1 and Eq H1-2
Eq H1-1	0.27534		Tube OK
Eq H1-2	0.26076		Tube OK
Eq H1-3	NA		

Threaded Rod Properties

Threaded Rod Dia. =	1.250	in
k =	1.00	
r =	0.313	in
A =	1.227	in^2
c =	0.625	in
S =	0.192	in^3
I =	0.120	in^4
E =	29000	ksi
Fy =	70	ksi

Threaded Rod Output

kl/r =	9.60		Slenderness OK
Cc =	90.43		
F'e =	1619.74	ksi	
Fa =	40.79	ksi	
fa =	4.38	ksi	
Fb =	46.20	ksi	
fb =	28.04	ksi	
Cm =	1.00		
fa/Fa =	0.11		Eq H1-3 may be used
Eq H1-1	NA		
Eq H1-2	NA		
Eq H1-3	0.71		Tube OK

Bearing Capacity of Crushed Stone Footing

Footing Depth =	6 in		
Footing Width =	24 in		
Footing Length =	24 in		
Soil Bearing Capacity =	1500	psf	
Capacity =	6.00	k	OK

Results

MAX LOAD TO SMART JACK = 5376LB
3.5 IN DIAMETER SMART JACK TUBE WITH 0.095 IN. THICK WALL AND MAX HEIGHT OF 3FT
1.25 IN DIAMETER SOLID THREADED ROD WITH MAX HEIGHT OF 3 IN
14 IN SQ x 6 IN H PRE-CAST ENDURACRETE FTG W/ FIBER REINF ON 24 IN SQ x 6 IN DP STRUCTURAL FILL
EMBED THREADED ROD A MINIMUM OF 3/4 IN INTO CONFINING RING AND THREADED INSERT

Project Title:
Engineer:
Project ID:
Project Descr:

Steel Beam

Project File: Calcs.ec6

LIC# : KW-06015057, Build:20.22.3.31 SFA ENGINEERING LLC

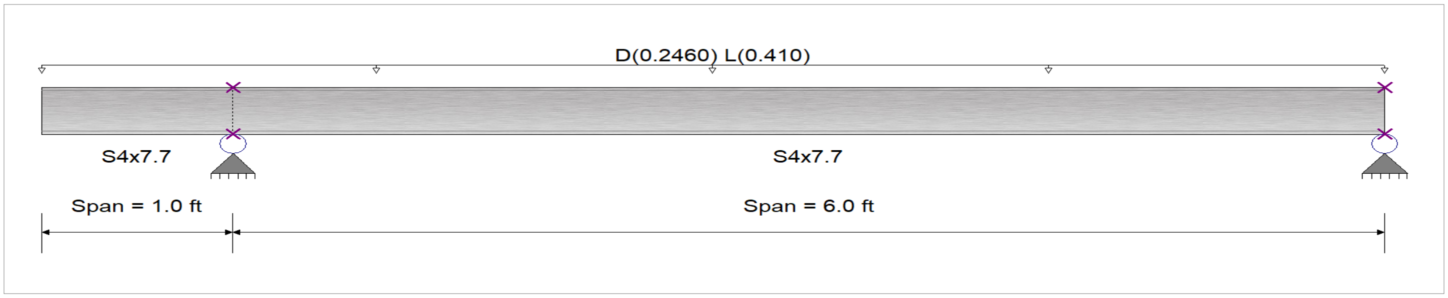
DESCRIPTION: Supplemental Steel Beam Span Calcs (End Cond)

CODE REFERENCES

Calculations per AISC 360-16, IBC 2018, CBC 2019, ASCE 7-16
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Allowable Strength Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Completely Unbraced	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight NOT internally calculated and added
Loads on all spans...
Uniform Load on ALL spans : D = 0.0240, L = 0.040 ksf, Tributary Width = 10.250 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.340** : 1	Maximum Shear Stress Ratio =	**0.131** : 1
Section used for this span	**S4x7.7**	Section used for this span	**S4x7.7**
Ma : Applied	2.790 k-ft	Va : Applied	2.023 k
Mn / Omega : Allowable	8.199 k-ft	Vn/Omega : Allowable	15.440 k
Load Combination	+D+L	Load Combination	+D+L
		Location of maximum on span	1.000 ft
Span # where maximum occurs	Span # 2	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.064 in	Ratio = 1,125	>=180	Span: 2 : L Only
Max Upward Transient Deflection	-0.032 in	Ratio = 754	>=180	Span: 2 : L Only
Max Downward Total Deflection	0.102 in	Ratio = 703	>=180	Span: 2 : +D+L
Max Upward Total Deflection	-0.051 in	Ratio = 472	>=180	Span: 2 : +D+L

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
	1	0.0000	0.000	+D+L	-0.0509	0.000
+D+L	2	0.1024	3.048		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1 Values in KIPS

Load Combination	Support 1	Support 2	Support 3
Overall MAXimum		2.679	1.913
Overall MINimum		0.603	0.431
D Only		1.005	0.718
+D+L		2.679	1.913
+D+0.750L		2.260	1.614
+0.60D		0.603	0.431
L Only		1.674	1.196

Steel Beam

Project File: Calcs.ec6

LIC# : KW-06015057, Build:20.22.3.31 SFA ENGINEERING LLC

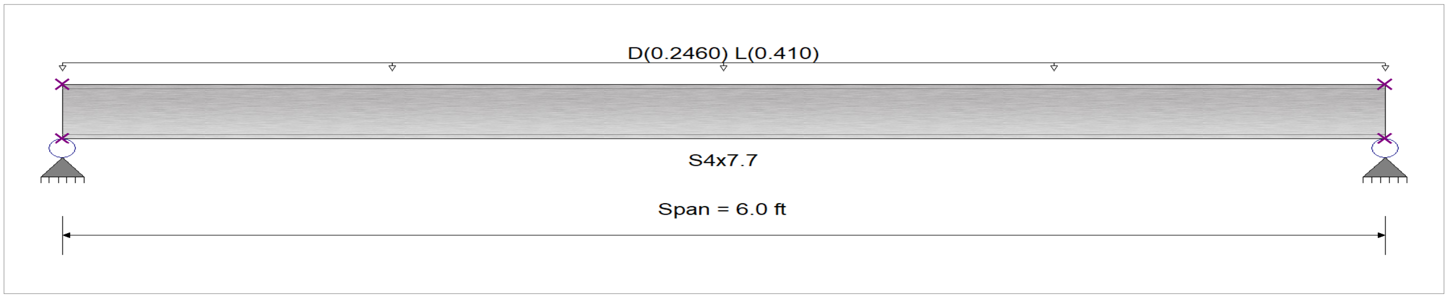
DESCRIPTION: Supplemental Steel Beam Span Calcs (Mid Cond)

CODE REFERENCES

Calculations per AISC 360-16, IBC 2018, CBC 2019, ASCE 7-16
Load Combination Set : ASCE 7-16

Material Properties

Analysis Method :	Allowable Strength Design	Fy : Steel Yield :	50.0 ksi
Beam Bracing :	Completely Unbraced	E: Modulus :	29,000.0 ksi
Bending Axis :	Major Axis Bending		



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight NOT internally calculated and added
Loads on all spans...
Uniform Load on ALL spans : D = 0.0240, L = 0.040 ksf, Tributary Width = 10.250 ft

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	**0.363** : 1	Maximum Shear Stress Ratio =	**0.127** : 1
Section used for this span	**S4x7.7**	Section used for this span	**S4x7.7**
Ma : Applied	2.952 k-ft	Va : Applied	1.968 k
Mn / Omega : Allowable	8.127 k-ft	Vn/Omega : Allowable	15.440 k
Load Combination	+D+L	Load Combination	+D+L
		Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1

Maximum Deflection

Max Downward Transient Deflection	0.068 in	Ratio = 1,051	>=180	
Max Upward Transient Deflection	0.000 in	Ratio = 0	<180	Span: 1 : L Only
Max Downward Total Deflection	0.110 in	Ratio = 657	>=180	Span: 1 : +D+L
Max Upward Total Deflection	0.000 in	Ratio = 0	<180	

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+L	1	0.1095	3.017		0.0000	0.000

Vertical Reactions

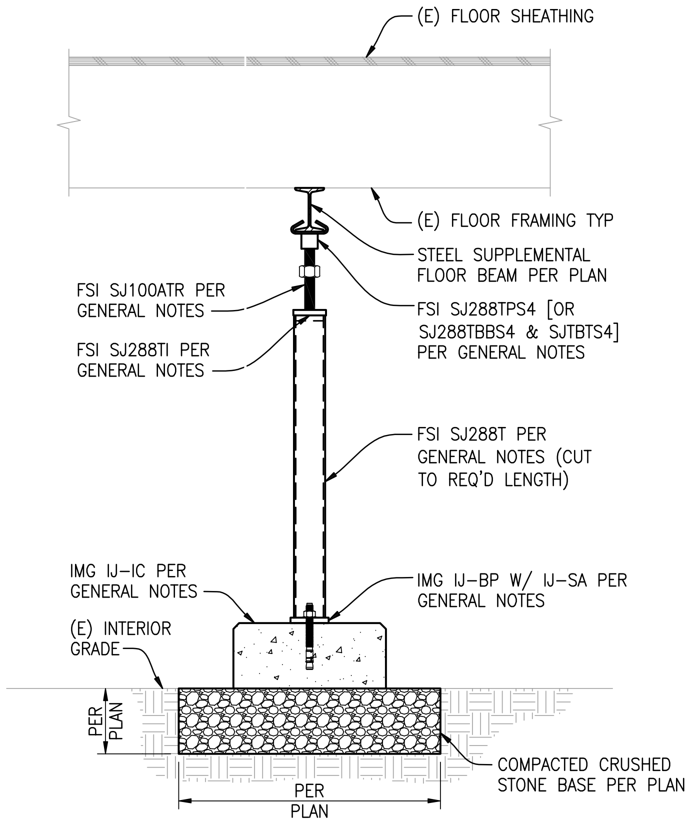
Support notation : Far left is #: Values in KIPS

Load Combination	Support 1	Support 2	
Overall MAXimum	1.968	1.968	1.196
Overall MINimum	0.443	0.443	1.196
D Only	0.738	0.738	1.196
+D+L	1.968	1.968	1.196
+D+0.750L	1.661	1.661	1.196
+0.60D	0.443	0.443	1.196
L Only	1.230	1.230	1.196

SFA Design Group, LLC
STRUCTURAL | GEOTECHNICAL | SPECIAL INSPECTIONS

PROJECT NO.	SHEET NO.
RBC22-030	

PROJECT	DATE
Bennett Residence Underpinning	10/31/2022
SUBJECT	BY
Foundation Supportworks SJ288 Smart Jack System	MEK



Note: Section above is a general representation of smartjack system, refer to plan for layout and project specific details.

Smart Jack System =	**SJ288**	
Footing Type =	**Gravel**	
P_{max} =	**3.936**	**kips**
Maximum Tube Unbraced Length, d_t =	**3.000**	**ft**
Maximum Threaded Rod Unbraced Length, d_{tr} =	**3.000**	**in**
Eccentricity, e_{max} =	**1.000**	**in**
Moment =	**3.936**	**in-kips**

Tube Properties

Design Tube OD =	**2.875**	**in**
Design Wall Thickness =	**0.165**	**in**
k =	**1.00**	
r =	**0.960**	**in**
A =	**1.405**	**in^2**
c =	**1.438**	**in**
S =	**0.900**	**in^3**
I =	**1.294**	**in^4**
E =	**29000**	**ksi**
Fy =	**50**	**ksi**

Tube Output

kl/r =	37.50		Slenderness OK
Cc =	107.00		
F'e =	106.13	ksi	
Fa =	26.18	ksi	
fa =	2.80	ksi	
Fb =	33.00	ksi	
fb =	4.37	ksi	
Cm =	1.00		
fa/Fa =	0.11		Eq H1-3 may be used
Eq H1-1	NA		
Eq H1-2	NA		
Eq H1-3	0.24		Pier OK

Threaded Rod Properties

Threaded Rod Dia. =	1.000	in
k =	1.00	
r =	0.250	in
A =	0.785	in^2
c =	0.500	in
S =	0.098	in^3
I =	0.049	in^4
E =	29000	ksi
Fy =	70	ksi

Threaded Rod Output

kl/r =	12.00		Slenderness OK
Cc =	90.43		
F'e =	1036.63	ksi	
Fa =	40.43	ksi	
fa =	5.01	ksi	
Fb =	46.20	ksi	
fb =	40.09	ksi	
Cm =	1.00		
fa/Fa =	0.12		Eq H1-3 may be used
Eq H1-1	NA		
Eq H1-2	NA		
Eq H1-3	0.99		Tube OK

Bearing Capacity of Crushed Stone Footing

Footing Depth =	6 in		
Footing Width =	24 in		
Footing Length =	24 in		
Soil Bearing Capacity =	1500	psf	
Capacity =	6.00	k	OK

Results

MAX LOAD TO SMART JACK = 3936LB
2.875 IN DIAMETER SMART JACK TUBE WITH 0.165 IN. THICK WALL AND MAX HEIGHT OF 3FT
1 IN DIAMETER SOLID THREADED ROD WITH MAX HEIGHT OF 3 IN
14 IN SQ x 6 IN H PRE-CAST ENDURACRETE FTG W/ FIBER REINF ON 24 IN SQ x 6 IN DP STRUCTURAL FILL
EMBED THREADED ROD A MINIMUM OF 3/4 IN INTO CONFINING RING AND THREADED INSERT