GreyFox CONSULTING, Inc.

Structural & Civil
Engineering Solutions

FEASIBILITY REPORT

Date: February 1, 2021

To: Ben Aparo and Nate Greenberg
Summit Ridge Energy

From: Ramin Abbaszadeh, PE

Re: 320 Fairfield Road
Fairfield, New Jersey

Subject: Roof Capacity Evaluation

Project No.: 20-039

General

As requested, Grey Fox Consulting Engineering (GF) evaluated the above-referenced building's roof structural capacity. The purpose of this evaluation was to determine if the existing roof could support the additional load from solar arrays. The building was constructed in the late 1970s. There are no drawings available that we could rely on for the structural framing information. We conducted a site visit to measure the roof deck, steel bar joists, steel girders, and columns that constitute this building's roof framing.

Two companies occupy this building. Precision Mechanical occupies the back half of the building. Robinson Tech International Corporation occupies the middle portion. Pictures 1 through 7 show inside of the Robinson Tech warehouse. We could not get a lift in this area and maneuver it to measure roof framing. Hence, we only extrapolated the roof framing in this area from our investigation of the Precision Mechanical warehouse. Pictures 8 through 15 show the interior of Precision Mechanical. Although this portion of the building was also congested, we gathered enough sampling to put together a presumed roof framing plan. The front portion of the building facing Fairfield Road is a vacant office space with a drop ceiling that did not allow reaching the roof framing.

We used the following documents for our analysis:

- International Building Code 2018 edition (IBC 108) is the current code adopted by New Jersey.
- IBC 2018 references American Society of Civil Engineers Standard 7-16, "Minimum Design Loads for Buildings and Other Structures" (ASCE 7-16).
- We referred to the Steel Joist Institutes (SJI) Historical Data to obtain the existing steel bar joists' capacity.

The building is a rectangular one-story steel structure (see pictures 2 and 3). The building has an approximate length of 200 ft length in the north-south direction and an approximate width of 96 feet in the east-west direction. The roof structure is comprised of a steel deck supported by steel bar joists. In turn, the joists are supported on the cantilever steel beam system. Non-bearing masonry walls surround the perimeter of this building.

As shown in pictures 16 through 18 from inside the building, the roof structure in the storage area supports very little mechanical and electrical equipment. The building has a sprinkler system for fire protection.

Criteria and Assumptions:

We based our structural analysis on the following criteria and assumptions:

- Structural steel beams and columns with a yield stress of 36 ksi per historical data
- Roof loads:
  - Dead Load: Steel decking, insulation & Builtup Roof = 6 pounds per square foot (psf) was assumed
  - Dead Load: Sprinkler system = 2 psf was assumed
  - Dead Load: Collateral (lights, piping, ductwork, electrical) = 3 psf was assumed for future application
  - Dead load: Structural joists = 2 psf from historical data
  - Dead load: Structural girders—as calculated in our modeling of the framing
  - No ceilings in the area that we measured the roof framing
  - Roof Live Load: 20 psf per Code
  - Snow Load: 20 psf per Code.
  - Building code prescribes to use Live Load or Snow Load, but not both simultaneously
  - Building code prescribes to use Live Load or Solar Panel load, but not both simultaneously
  - Existing total load at storage area = 33 psf + steel weight
- Solar Array Dead Load (including accessories, attachments & ballast blocks) assumed to range between 2 to 12 psf.

Snowdrift Loads

We have not considered snowdrift for this roof because of the roof composition.

Analysis of Roof Structure

BAR JOISTS

The steel bar joists are running from east to west with an approximate span of 32 ft- 4 in. The bar joists are supported on the cantilevered steel beam system.

The approximate spacing between bar joists is 6'-8". Based on our field measurement, the joists are 24 inch-deep with 1.75 inches by 1.75 inches double angles top and 1.5 by 1.5 double angles bottom

chords. The thickness of the top chords is 0.18 inches. The bottom chords have a thickness of 0.18 inches. The web members are comprised of 0.71 inches diameter round bars.

The historical data from SJI designates bar joists with similar cord and web elements as 24J7 or 24H7 joists. The J series was in effect from 1961 to 1978 with the steel strength of 22,000 psi. The H series was fabricated between 1961 and 1986 with the steel strength of 30,000 psi. Because of the difference in steel strength, 24J6 has a lower capacity than 24H6. The table below shows the total load for each joist taken from the historical table:

Joist Designation	Total Uniform Load (Pounds per Linear Foot plf)
24J7	290
24H7	359

Based on the assumption of 33 psf existing load and the joist spacing of 6'-8", each joist's uniform load would be 220 plf. From the table above, we can conclude that 24J7 has 70 plf or 10 psf reserved capacity left for solar panels. In comparison, 24H7 is stronger and has a little over 20 psf additional capacity to support solar panels. Both designations' reserved capacity will be reduced further at the office areas by 2 to 5 psf because of the drop ceilings and additional mechanical and lighting fixtures. Further evaluation of the office area is required to determine the additional existing dead load supported by the roof joists.

If this building is selected for the installation of solar panels, further testing must be conducted to determine the bar joists' actual strength.

ROOF DECK

The roof deck is a 1.5-inch type B wide rib (see picture 19). We were not able to measure the thickness of the deck. Based on the joist spacing, it is most likely that the deck is 22 gage with a minimum of three continuous spans. Under these assumptions, the deck can carry more than 50 psf uniform loads. The deck's total uniform load (deck, roofing, insulation, and snow load), plus 12 psf for solar panel load, is approximately 37 psf. The deck capacity can support the additional load from solar panels.

STEEL BEAMS

Based on our field measurements, we extrapolated that the cantilever steel beam systems comprised of five spans about 40 feet each. The steel beams supporting the bar joists are spaced about 32 ft - 4 in apart. The Cantilevered Beams system has two beams that cantilever and three beams simply supported off of the cantilevered beams.

The cantilevered beams on the exterior of the building to the east and west are W21x44. The simply supported beams on the exterior frames are W18x35.

The cantilevered beams on the interior frames of the building are W21x44. The simply supported beams are W21x55.

The W18x35 on the exterior frames and W21x44 on the interior frames are the controlling members. Based on these members' capacity, the roof system can support solar panels of up to 10 psf.

STEEL COLUMNS

The perimeter columns are W8x24, and the interior columns are W8x31. Both of these columns have sufficient capacity to support additional loads of up to 12 psf from solar panels.

Conclusions

Our professional opinion is that this building's roof structure can support solar panels up to 10 psf over the areas that do not have additional loads due to dropped ceiling and additional HVAC ducts for an office space.

If this building is selected for the installation of solar panels, bar joist steel's strength has to be evaluated.

Furthermore, the building's entire roof frame has to be investigated to confirm that the assumptions we made about the areas we could not measure were correct. The tenets have to make accommodations for access to the entire roof framing at the next phase.

The existing column footings must also be investigated to ensure they are of the size that could support additional loads from the solar panels. A geotechnical engineer should be consulted for the best way to explore the columns' foundation size.

GF did not evaluate the overall structure to determine if the building systems, foundations, and lateral resisting elements conform to the current building codes' requirements.

If we can be of further assistance in this matter, please contact us.

Sincerely,
Grey Fox Consulting, Inc.

Ramin Abbaszadeh, PE, SE
Principal

NOT
INVESTIGATED
INVESTIGATED
AREA
OFFICE AREA
WITH DROPED
CEILING
320 Fairfield Rd

Picture 1

Picture 2

Picture 3

Picture 4

Picture 5

Picture 6

Picture 7

Picture 8

Picture 9

Picture 10

Picture 11

Picture 12

Picture 13

Picture 14

Picture 15

Picture 16

Picture 17

Picture 18

Picture 19

SUMMIT RIDGE ENERGY

320 Fairfield Road
Fairfield, New Jersey

Roof Evaluation
Structural Calculations

GreyFox CONSULTING, Inc.

Structural & Civil
Engineering Solutions

DATE: 2/1/2021
Project No. 20-035
Prepared by: Ramin Abbaszadeh, PE, SE
NJ Lic. No. 34277

Grey Fox Consulting, Inc. 57 Cooper Avenue Cherry Hill, NJ 08002	Project 320 Fairfield Road, Fairfield New Jersey				Job Ref.	
	Section Snow Load				Sheet no./rev. 1	
	Calc. by RA	Date 2/1/2021	Chk'd by	Date	App'd by	Date

SNOW LOADING

In accordance with ASCE7-10

Tedds calculation version 1.0.09

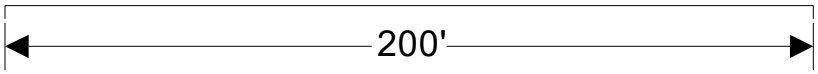
Building details

Roof type	Flat
Width of roof	b = **200.00** ft

Ground snow load

Ground snow load (Figure 7-1)	p_g = **30.00** lb/ft^2
Density of snow	$\gamma = \min(0.13 * p_g / 1ft + 14lb/ft^3, 30lb/ft^3)$ = **17.90** lb/ft^3
Terrain typeSect. 26.7	B
Exposure condition (Table 7-2)	Fully exposed
Exposure factor (Table 7-2)	C_e = **0.90**
Thermal condition (Table 7-3)	All
Thermal factor (Table 7-3)	C_t = **1.00**
Importance category (Table 1.5-1)	II
Importance factor (Table 1.5-2)	I_s = **1.00**
Min snow load for low slope roofs (Sect 7.3.4)	$p_{f_min} = I_s * 20$ lb/ft^2 = **20.00** lb/ft^2
Flat roof snow load (Sect 7.3)	$p_f = 0.7 * C_e * C_t * I_s * p_g$ = **18.90** lb/ft^2

Balanced load 20.0 psf



Roof elevation

GreyFox CONSULTING, Inc.
1415 Route 70 E., Ste. 201
Cherry Hill, NJ 08034
(856) 216-9373
Fax (856) 216-9376
Structural & Civil Engineering Solutions

JOB 320 FAIRFIELD RD.
SHEET NO. 1 OF
CALCULATED BY RA DATE 2/1/21
CHECKED BY DATE
SCALE

ROOF DL

ROOFING.	6PSF
SPRINKLER	2PSF
MISC.	3PSF
JOIST	2PSF
	13PSF
SNOW	20PSF
TOTAL	33PSF

33 X 6.67 = 220 PLF

(24J7) 32' 294
33' 282
12

12/12 X 4 = 4
294 - 4 = 290 PLF

290 - 220 = 70 PLF RESERVED

OR 70/6.67 = 10.49 PSF

24H7 32' 363
33' 352
11

11/12 X 4 = 3.67
363 - 3.67 = 359.33 PLF

359.33 - 220 = 139.33 PLF

OR 139.33/6.67 = 20.9 PSF

Ramin Abbaszadeh

From: Ken Charles <kcharles@steeljoist.org>
Sent: Thursday, January 28, 2021 4:48 PM
To: Ramin Abbaszadeh
Subject: RE: Joist Investigation Form submitted at Steel Joist Institute

The joist you have presented resembles a 24J7 / 24H7 if manufactured by an SJI member company.

1929-1958	**SJ-Series**
1958-1961	**S-Series**
1961-1978	**J-Series**
1961-1986	**H-Series**
1986-Present	**K-Series**

All SJI load tables (1928 – present) are available here: TABLES

J. Kenneth Charles, III
Managing Director
Steel Joist Institute
140 West Evans Street, Suite 203, Florence, SC 29501
T 843-407-4091
steeljoist.org

From: Steel Joist Institute <no-reply@steeljoist.org>
Sent: Thursday, January 28, 2021 4:36 PM
To: kcharles@steeljoist.org
Subject: Joist Investigation Form submitted at Steel Joist Institute

Ramin Abbaszadeh submitted a Joist Investigation Form.

Case Number	26652
First Name	Ramin
Last Name	Abbaszadeh
Company	Grey Fox Consulting, Inc.
Email Address	ramin@greyfox.biz
Preferred phone	8567451668

Jobsite Location City/State	Fairfield, New Jersey
Project Name	320 Fairfield Rd
Why are you requesting this information?	Evaluation
Other	
What year was the building constructed (or approximate age of the structure)?	1970s
Who was the joist manufacturer?	Standard Building Systems
Is there a tag on the joist?	Yes
Yes? Provide tag information	31162 B1
What type of trusses are the joists?	Warren
Other	
What were the joists used for?	Roof loading
What type of bridging is used?	Horizontal
What is the joist span or length of joist?	32'-4"
What is the joist spacing?	6'- 8"
What is the interior panel point spacing?	24"
What is the joist depth?	24"
What is the height of the joist seat?	2-1/2"
Other, describe or attach sketch	
Top chord shape	2 Angles
Top chord leg size	1.75x1.75
Top chord thickness	0.18

Top chord diameter	
Bottom chord shape	2 Angles
Bottom chord leg size	1.5 x 1.5
Bottom chord thickness	0.18
Bottom chord diameter	
Vertical web shape	Other (provide sketch)
Vertical web leg size	
Vertical web thickness	
Vertical web diameter	
Diagonal web shape	1 Round
Diagonal web leg size	
Diagonal web thickness	
Diagonal web diameter	0.71
Measurement device	Micrometer
Other device	

For Joist Depths 24" to 30" inclusive

Joist Designation	24J6	24J7	24J8	24J9	24J10	24J11	26J8	26J9	26J10	26J11	28J8	28J9	28J10	28J11	30J8	30J9	30J10	30J11
Nominal *Depth (in.)	24	24	24	24	24	24	26	26	26	26	28	28	28	28	30	30	30	30
Resist. Moment (in.-lbs.)	367,000	460,000	540,000	627,000	701,000	813,000	574,000	682,000	763,000	885,000	621,000	737,000	824,000	957,000	667,000	793,000	885,000	1,029,000
Max. End React. (lbs.)	4400	4700	5000	5600	5900	6400	5400	5900	6300	6800	5700	6200	6600	7100	5900	6400	6800	7400
†Approx. Wt. (lbs./ft.)	9.9	11.1	12.4	13.3	14.8	16.7	12.2	14.1	15.4	17.1	13.0	14.3	15.9	17.9	13.8	14.9	16.6	18.3
Span in Feet 24	367	392	417	467	492	533												
25	352	376	400	448	472	512												
26	338	362	385	431	454	492	415	454	485	523								
27	326	348	370	415	437	474	400	437	467	504								
28	312	336	357	400	421	457	386	421	450	486	407	443	471	507				
29	291	324	345	386	407	441	372	407	434	469	393	428	455	490				
30	272	313	333	373	393	427	360	393	420	453	380	413	440	473	393	427	453	493
31	255 248	303 299	323	361	381	413	348	381	406	439	368	400	426	458	381	413	439	477
32	239 225	294 272	313	350	369	400	338	369	394	425	356	388	413	444	369	400	425	463
33	225 205	282 248	303	339	358	388	327	358	382	412	345	376	400	430	358	388	412	448
34	212 188	265 227	294 283	329 314	347	376	318 317	347	371	400	335	365	388	418	347	376	400	435
35	200 172	250 208	286 259	320 288	337 323	366	309 290	337	360	389	326	354	377	406	337	366	389	423
36	189 158	237 191	278 238	311 264	328 297	356 339	295 267	338 312	350	378	317 311	344	367	394	328	356	378	411
37	179 146	224 176	263 219	303 243	319 274	346 312	280 246	319 288	341 324	368	302 287	335	357	384	319	346	368	400
38	169 135	212 162	249 202	289 225	311 253	337 288	265 227	311 266	332 299	358 341	287 265	326 310	347	374	308 305	337	358	389
39	161 124	202 150	237 187	275 208	303 234	328 266	252 210	299 246	323 276	349 316	272 245	318 287	338 322	364	292 282	328	349	379
40	153 115	192 139	225 174	261 193	292 217	320 247	239 194	284 228	315 256	340 292	259 227	307 266	330 299	355 342	278 262	320 306	340	370
41	146 107	182 129	214 161	249 179	278 201	312 229	228 181	270 211	303 238	332 272	246 211	292 247	322 278	346 318	265 243	312 285	332 320	361
42	139 100	174 120	204 150	237 166	265 187	305 213	217 168	258 197	288 221	324 253	235 196	279 229	311 258	338 295	252 226	300 265	324 298	352 341
43	132 93	166 112	195 140	226 155	253 174	293 199	207 156	246 183	275 206	316 235	224 183	266 214	297 241	330 275	240 211	286 247	316 278	344 318
44	126 87	158 105	186 130	216 145	241 163	280 186	198 146	235 171	263 193	305 220	214 171	254 200	284 225	323 257	230 196	273 230	305 259	336 297
45	121 81	151 98	178 122	206 135	231 152	268 173	189 137	225 160	251 180	291 205	204 159	243 187	271 210	315 240	220 184	261 215	291 242	329 278
46	116 76	145 92	170 114	198 127	221 142	256 162	181 128	215 150	240 168	279 192	196 149	232 175	260 197	302 225	210 172	250 202	279 227	322 260
47	111 71	139 86	163 107	189 119	212 133	245 152	173 120	206 140	230 158	267 180	187 140	222 164	249 184	289 211	201 161	239 189	267 213	311 244
48	106 67	133 81	156 100	181 111	203 125	235 143	166 112	197 132	221 148	256 169	180 131	213 154	238 173	277 198	193 151	229 177	256 200	298 229
49							159 106	189 124	212 139	246 159	172 124	205 144	229 163	266 186	185 142	220 167	246 188	286 215
50							153 100	182 117	203 131	236 150	166 116	197 136	220 153	255 175	178 134	211 157	236 177	274 202
51							147 94	175 110	196 124	227 141	159 110	189 128	211 144	245 165	171 .6	203 148	227 166	264 191
52							142 88	168 104	188 117	218 133	153 103	182 121	203 136	236 156	164 119	196 139	218 157	254 180
53											147 98	175 114	196 128	227 147	158 112	188 132	210 148	244 170
54											142 92	168 108	188 121	219 139	152 106	181 125	202 140	235 161
55											137 87	162 102	182 115	211 132	147 101	175 118	195 133	227 152
56											132 83	157 97	175 109	203 125	142 95	169 112	188 126	219 144
57															137 90	163 106	182 119	211 137
58															132 86	157 101	175 113	204 130
59															128 81	152 95	169 .08	197 123
60															124 77	147 91	164 102	191 117

*Indicates Nominal Depth of steel joists only.

†Approximate Weights per Linear Foot of steel joists only. Accessories and nailer strip not included.

*†See manufacturers' catalogs for detailed information on specific joist types.

**Section 5.9 of the "Standard Specifications for Open Web Steel Joists, J- and H-Series" limits the design LIVE load deflection as follows:

FLOORS, 1/360 span. ROOFS, 1/360 of span where a plaster ceiling is attached or suspended; 1/240 of span for all other cases.

For Joist Depths 24" to 30" inclusive

Joist Designation	24H6	24H7	24H8	24H9	24H10	24H11	26H8	26H9	26H10	26H11	28H8	28H9	28H10	28H11	30H8	30H9	30H10	30H11
Nominal *Depth (in.)	24	24	24	24	24	24	26	26	26	26	28	28	28	28	30	30	30	30
Resist. Moment (in.-lbs.)	462,000	576,000	716,000	851,000	957,000	1,106,000	784,000	925,000	1,040,000	1,203,000	846,000	1,000,000	1,124,000	1,300,000	909,000	1,075,000	1,207,000	1,397,000
Max. End React. (lbs.)	5600	5800	6000	7000	7500	8200	6700	7200	7600	8300	6700	7200	7700	8400	6800	7500	8100	8700
†Approx. Wt. (lbs./ft.)	10.3	11.5	12.7	14.0	15.5	17.5	12.8	14.8	16.2	17.9	13.5	15.2	16.8	18.3	14.2	15.4	17.3	18.8
Span in Feet 24	467	483	500	583	625													
25	448	464	480	560	600													
26	431	446	462	538	577	631	515	554	585	638								
27	415 375	430	444	519	556	607	496	533	563	615								
28	393 336	414 406	429	500	536	586	479	514	543	593	479	514	550	600				
29	366 303	400 365	414	483	517	566	462	497	524	572	462	497	531	579				
30	342 273	387 330	400	467 457	500	547	447	480	507	553	447	480	513	560	453	500	540	580
31	320 248	374 299	387 373	452 414	484 465	529	432 418	465	490	535	432	465	497	542	439	484	523	561
32	301 225	363 272	375 339	438 376	469 423	513 482	419 380	450 445	475	519	419	450	481	525	425	469	506	544
33	283 205	352 248	364 309	424 343	455 386	497 440	406 346	436 405	461 456	503	406 404	436	467	509	412	455	491	527
34	266 188	332 227	353 283	412 314	441 353	482 402	394 317	424 371	447 417	488 476	394 370	424	453	494	400	441	476	512
35	251 172	313 208	343 259	400 288	429 323	469 369	383 290	411 340	434 383	474 437	383 339	411 396	440	480	389	429	463	497
36	238 158	296 191	333 238	389 264	417 297	456 339	372 267	400 312	422 352	461 401	372 311	400 364	428 410	467	378 359	417	450	483
37	225 146	280 176	324 219	378 243	405 274	443 312	362 246	389 288	411 324	449 370	362 287	389 336	416 378	454 432	368 330	405 387	438 436	470
38	213 135	266 162	316 202	368 225	395 253	432 288	353 227	379 266	400 299	437 341	353 265	379 310	405 349	442 399	358 305	395 357	426 402	458
39	202 124	252 150	308 187	359 208	385 234	421 266	344 210	369 246	390 276	426 316	344 245	369 287	395 322	431 369	349 282	385 331	415 372	446 426
40	193 115	240 139	298 174	350 193	375 217	410 247	327 194	360 228	380 256	415 292	335 227	360 266	385 299	420 342	340 262	375 306	405 345	435 395
41	183 107	228 129	284 161	337 179	366 201	400 229	311 181	351 211	371 238	405 272	327 211	351 247	376 278	410 318	332 243	366 285	395 320	424 367
42	175 100	218 120	271 150	322 166	357 187	390 213	296 168	343 197	362 221	395 253	319 196	343 229	367 258	400 295	324 226	357 265	386 298	414 341
43	167 93	208 112	258 140	307 155	345 174	381 199	283 156	334 183	353 206	386 235	305 183	335 214	358 241	391 275	316 211	349 247	377 278	405 318
44	159 87	198 105	247 130	293 145	330 163	373 186	270 146	319 171	345 193	377 220	291 171	327 200	350 225	382 257	309 196	341 230	368 259	395 297
45	152 81	190 98	236 122	280 135	315 152	364 173	258 137	305 160	338 180	369 205	279 159	320 187	342 210	373 240	299 184	333 215	360 242	387 278
46	146 76	181 92	226 114	268 127	302 142	348 162	247 128	291 150	328 168	361 192	267 149	313 175	335 197	365 225	286 172	326 202	352 227	378 260
47	139 71	174 86	216 107	257 119	289 133	334 152	237 120	279 140	314 158	353 180	255 140	302 164	328 184	357 211	274 161	319 189	345 213	370 244
48	134 67	167 81	207 100	246 111	277 125	320 143	227 112	268 132	301 148	346 169	245 131	289 154	321 173	350 198	263 151	311 177	338 200	363 229
49							218 106	257 124	289 139	334 159	235 124	278 144	312 163	343 186	252 142	298 167	331 188	355 215
50							209 100	247 117	277 131	321 150	226 116	267 136	300 153	336 175	242 134	287 157	322 177	348 202
51							201 94	237 110	267 124	308 141	217 110	256 128	288 144	329 165	233 126	276 148	309 166	341 191
52							193 88	228 104	256 117	297 133	209 103	247 121	277 136	321 156	224 119	265 139	298 157	335 180
53											201 98	237 114	267 128	309 147	216 112	255 132	286 148	328 170
54											193 92	229 108	257 121	297 139	208 106	246 125	276 140	319 161
55											186 87	220 102	248 115	287 132	200 101	237 118	266 133	308 152
56											180 83	213 97	239 109	276 125	193 95	229 112	257 126	297 144
57															187 90	221 106	248 119	287 137
58															180 86	213 101	239 113	277 130
59															174 81	206 95	231 108	268 123
60															168 77	199 91	224 102	259 117

*Indicates Nominal Depth of steel joists only.

†Approximate Weights per Linear Foot of steel joists only. Accessories and nailer strip not included.

*†See manufacturers' catalog for detailed information on specific joist types.

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FLOORS, 1/360 span. ROOFS, 1/360 of span where a plaster ceiling is attached or suspended; 1/240 of span for all other cases.

Current Date: 1/31/2021 6:20 AM
Units system: English
File name: S:\Projects\20-039 Summit Ridge NJ Roof Evaluation\320 Fairfield Rd\CALCS\EXTERIOR CANT BEAM.retx

Geometry data

GLOSSARY

Cb22, Cb33	: Moment gradient coefficients
Cm22, Cm33	: Coefficients applied to bending term in interaction formula
d0	: Tapered member section depth at J end of member
DJX	: Rigid end offset distance measured from J node in axis X
DJY	: Rigid end offset distance measured from J node in axis Y
DJZ	: Rigid end offset distance measured from J node in axis Z
DKX	: Rigid end offset distance measured from K node in axis X
DKY	: Rigid end offset distance measured from K node in axis Y
DKZ	: Rigid end offset distance measured from K node in axis Z
dL	: Tapered member section depth at K end of member
Ig factor	: Inertia reduction factor (Effective Inertia/Gross Inertia) for reinforced concrete members
K22	: Effective length factor about axis 2
K33	: Effective length factor about axis 3
L22	: Member length for calculation of axial capacity
L33	: Member length for calculation of axial capacity
LB pos	: Lateral unbraced length of the compression flange in the positive side of local axis 2
LB neg	: Lateral unbraced length of the compression flange in the negative side of local axis 2
RX	: Rotation about X
RY	: Rotation about Y
RZ	: Rotation about Z
TO	: 1 = Tension only member 0 = Normal member
TX	: Translation in X
TY	: Translation in Y
TZ	: Translation in Z

Nodes

Node	X [ft]	Y [ft]	Z [ft]	Rigid Floor
1	0.00	0.00	0.00	0
2	36.00	0.00	0.00	0
3	40.00	0.00	0.00	0
4	80.00	0.00	0.00	0
5	86.00	0.00	0.00	0
6	114.00	0.00	0.00	0
7	120.00	0.00	0.00	0
8	160.00	0.00	0.00	0
9	166.00	0.00	0.00	0
10	200.00	0.00	0.00	0

Restraints

Node	TX	TY	TZ	RX	RY	RZ
1	1	1	1	0	0	0
3	0	1	1	0	0	0
4	0	1	1	0	0	0
7	0	1	1	0	0	0
8	0	1	1	0	0	0
10	0	1	1	0	0	0

Members

Member	NJ	NK	Description	Section	Material	d0 [in]	dL [in]	lg factor
1	1	2		W 18X35	A36	0.00	0.00	0.00
2	2	3		W 21X44	A36	0.00	0.00	0.00
3	3	4		W 21X44	A36	0.00	0.00	0.00
4	4	5		W 21X44	A36	0.00	0.00	0.00
5	5	6		W 18X35	A36	0.00	0.00	0.00
6	6	7		W 21X44	A36	0.00	0.00	0.00
7	7	8		W 21X44	A36	0.00	0.00	0.00
8	8	9		W 21X44	A36	0.00	0.00	0.00
9	9	10		W 18X35	A36	0.00	0.00	0.00

Hinges

	Node-J				Node-K						
Member	M33	M22	V3	V2	M33	M22	V3	V2	TOR	AXL	Axial rigidity
1	0	0	0	0	1	0	0	0	0	0	Full
5	1	0	0	0	1	0	0	0	0	0	Full
9	1	0	0	0	0	0	0	0	0	0	Full

Current Date: 1/31/2021 6:20 AM
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Load data

GLOSSARY

Comb : Indicates if load condition is a load combination

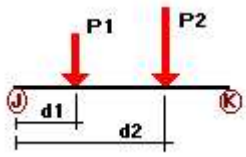
Load Conditions

Condition	Description	Comb.	Category
DL	Dead Load	No	DL
SL1	SOLAR LOAD	No	DL
D1	0.5DL	Yes	

Load on nodes

Condition	Node	FX [Kip]	FY [Kip]	FZ [Kip]	MX [Kip*ft]	MY [Kip*ft]	MZ [Kip*ft]
DL	3	0.00	-7.11	0.00	0.00	0.00	0.00
	4	0.00	-7.11	0.00	0.00	0.00	0.00
	7	0.00	-7.11	0.00	0.00	0.00	0.00
	8	0.00	-7.11	0.00	0.00	0.00	0.00
SL1	3	0.00	-7.11	0.00	0.00	0.00	0.00
	4	0.00	-7.11	0.00	0.00	0.00	0.00
	7	0.00	-7.11	0.00	0.00	0.00	0.00
	8	0.00	-7.11	0.00	0.00	0.00	0.00

Concentrated forces on members



Condition	Member	Dir1	Value1 [Kip]	Dist1 [ft]	%
DL	1	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	3	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No

		Y	-7.11	33.333	No
	5	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
	7	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	9	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
SL1	1	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	3	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	5	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
	7	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	9	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No

Self weight multipliers for load conditions

Condition	Description	Comb.	Self weight multiplier MultX	MultY	MultZ
DL	Dead Load	No	0.00	0.00	0.00
SL1	SOLAR LOAD	No	0.00	0.00	0.00
D1	0.5DL	Yes	0.00	0.00	0.00

Earthquake (Dynamic analysis only)

Condition	a/g	Ang. [Deg]	Damp. [%]
DL	0.00	0.00	0.00
SL1	0.00	0.00	0.00
D1	0.00	0.00	0.00

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List of materials

Note.- Only the graphically selected members and shells are listed

Members:

Profile	Material	Uweight [Kip/ft]	Length [ft]	Weight [Kip]
W 18X35	A36	3.51E-02	98.000	3.440
W 21X44	A36	4.43E-02	102.000	4.519
Total weight [Kip]				7.959

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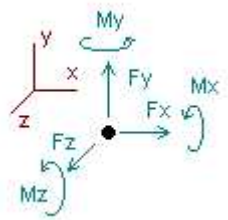
Analysis result

Reactions



Direction of positive forces and moments

Node	Forces [Kip] FX	FY	FZ	Moments [Kip*ft] MX	MY	MZ
Condition **D2=0.5DL+0.18SL1**						
1	0.00000	10.74400	0.00000	0.00000	0.00000	0.00000
3	0.00000	29.88175	0.00000	0.00000	0.00000	0.00000
4	0.00000	29.47885	0.00000	0.00000	0.00000	0.00000
7	0.00000	28.68885	0.00000	0.00000	0.00000	0.00000
8	0.00000	31.46175	0.00000	0.00000	0.00000	0.00000
10	0.00000	9.95400	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	140.20920	0.00000	0.00000	0.00000	0.00000

Maximum forces at members

Condition : **D2=0.5DL+0.18SL1**

	Axial [Kip]	Shear V2 [Kip]	Shear V3 [Kip]	Torsion [Kip*ft]	M22 [Kip*ft]	M33 [Kip*ft]
MEMBER **1**						
Max	0.00	10.74	0.00	0.00	0.00	117.97
Min	0.00	-13.43	0.00	0.00	0.00	0.00
MEMBER **2**						
Max	0.00	-13.43	0.00	0.00	0.00	0.00
Min	0.00	-13.43	0.00	0.00	0.00	-53.72
MEMBER **3**						
Max	0.00	11.62	0.00	0.00	0.00	81.92
Min	0.00	-12.56	0.00	0.00	0.00	-72.52
MEMBER **4**						
Max	0.00	12.09	0.00	0.00	0.00	0.00
Min	0.00	12.09	0.00	0.00	0.00	-72.52
MEMBER **5**						
Max	0.00	12.09	0.00	0.00	0.00	72.52
Min	0.00	-12.09	0.00	0.00	0.00	0.00
MEMBER **6**						
Max	0.00	-12.09	0.00	0.00	0.00	0.00
Min	0.00	-12.09	0.00	0.00	0.00	-72.52
MEMBER **7**						
Max	0.00	11.77	0.00	0.00	0.00	66.12

Min	0.00	-12.41	0.00	0.00	0.00	-85.32
MEMBER **8**						
Max	0.00	14.22	0.00	0.00	0.00	0.00
Min	0.00	14.22	0.00	0.00	0.00	-85.32
MEMBER **9**						
Max	0.00	14.22	0.00	0.00	0.00	102.26
Min	0.00	-9.95	0.00	0.00	0.00	0.00

STEEL MEMBER DESIGN (AISC 360)

In accordance with AISC360 15th Edition published 2016 using the ASD method

Tedds calculation version 4.4.05

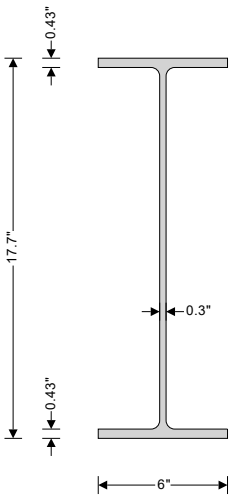
Safety factors

Shear	Ω_v = **1.67**
Flexure	Ω_b = **1.67**
Tensile yielding	$\Omega_{t,y}$ = **1.67**
Tensile rupture	$\Omega_{t,r}$ = **2.00**
Compression	Ω_c = **1.67**

Design section 1

Section details

Section type	W 18x35 (AISC 15th Edn (v15.0))
ASTM steel designation	A36
Steel yield stress	F_y = **36** ksi
Steel tensile stress	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi



W 18x35 (AISC 15th Edn (v15.0))
Section depth, d, 17.7 in
Section breadth, b_f, 6 in
Weight of section, Weight, 35 lbf/ft
Flange thickness, t_f, 0.425 in
Web thickness, t_w, 0.3 in
Area of section, A, 10.3 in^2
Radius of gyration about x-axis, r_x, 7.04 in
Radius of gyration about y-axis, r_y, 1.22 in
Elastic section modulus about x-axis, S_x, 57.6 in^3
Elastic section modulus about y-axis, S_y, 5.12 in^3
Plastic section modulus about x-axis, Z_x, 66.5 in^3
Plastic section modulus about y-axis, Z_y, 8.06 in^3
Second moment of area about x-axis, I_x, 510 in^4
Second moment of area about y-axis, I_y, 15.3 in^4

Analysis results

Required flexural strength - Major axis $M_{r,x}$ = **117** kips_ft

Restraint spacing

Major axis lateral restraint	L_x = **36** ft
Minor axis lateral restraint	L_y = **6** ft
Torsional restraint	L_z = **36** ft

Classification of sections for local buckling - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	b_f / (2 * t_f) = **7.06**	
Limiting ratio for compact section	λ_{pff} = 0.38 * √[E / F_y] = **10.79**	
Limiting ratio for non-compact section	λ_{rff} = 1.0 * √[E / F_y] = **28.38**	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 * k) / t_w$ = **53.49**

Limiting ratio for compact section $\lambda_{pwf} = 3.76 * \sqrt{[E / F_y]}$ = **106.72**

Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 * \sqrt{[E / F_y]}$ = **161.78** Compact

Section is compact in flexure

Design of members for flexure - Chapter F

Required flexural strength $M_{r,x}$ = **117** kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{n,yld,x} = M_{p,x} = F_y * Z_x$ = **199.5** kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length L_b = **6** ft

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 * r_y * \sqrt{(E / F_y)}$ = **5.079** ft

Distance between flange centroids h_o = **17.3** in

c = **1**

r_{ts} = **1.51** in

Limiting unbraced length for inelastic LTB - eq F2-6 $L_r = 1.95 * r_{ts} * E / (0.7 * F_y) * \sqrt{((J * c / (S_x * h_o)) + \sqrt{((J * c / (S_x * h_o))^2 + 6.76 * (0.7 * F_y / E)^2)}}$ = **15.004** ft

LTB modification factor C_b = **1.000**

Nominal flexural strength for lateral-torsional buckling - eq F2-2

$M_{n,ltb,x} = \min(C_b * (M_{p,x} - (M_{p,x} - 0.7 * F_y * S_x) * (L_b - L_p) / (L_r - L_p)), M_{p,x})$ = **192.2** kips_ft

Allowable flexural strength - F1

Nominal flexural strength $M_{n,x} = \min(M_{n,yld,x}, M_{n,ltb,x})$ = **192.2** kips_ft

Allowable flexural strength $M_{c,x} = M_{n,x} / \Omega_b$ = **115.1** kips_ft

$M_{r,x} / M_{c,x}$ = **1.017**

FAIL - Required flexural strength exceeds allowable flexural strength

Grey Fox Consulting, Inc. 57 Cooper Avenue Cherry Hill, NJ 08002	Project 320 Fairfield Road, Fairfield New Jersey				Job Ref.	
	Section Ext Cant Beam W21x44				Sheet no./rev. 1	
	Calc. by RA	Date 1/31/2021	Chk'd by	Date	App'd by	Date

STEEL MEMBER DESIGN (AISC 360)

In accordance with AISC360 15th Edition published 2016 using the ASD method

Tedds calculation version 4.4.05

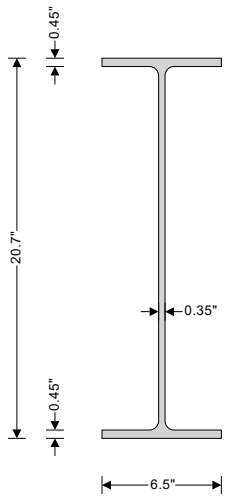
Safety factors

Shear	Ω_v = **1.67**
Flexure	Ω_b = **1.67**
Tensile yielding	$\Omega_{t,y}$ = **1.67**
Tensile rupture	$\Omega_{t,r}$ = **2.00**
Compression	Ω_c = **1.67**

Design section 1

Section details

Section type	W 21x44 (AISC 15th Edn (v15.0))
ASTM steel designation	A36
Steel yield stress	F_y = **36** ksi
Steel tensile stress	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi



W 21x44 (AISC 15th Edn (v15.0))
Section depth, d, 20.7 in
Section breadth, b_f, 6.5 in
Weight of section, Weight, 44 lbf/ft
Flange thickness, t_f, 0.45 in
Web thickness, t_w, 0.35 in
Area of section, A, 13 in^2
Radius of gyration about x-axis, r_x, 8.06 in
Radius of gyration about y-axis, r_y, 1.26 in
Elastic section modulus about x-axis, S_x, 81.6 in^3
Elastic section modulus about y-axis, S_y, 6.37 in^3
Plastic section modulus about x-axis, Z_x, 95.4 in^3
Plastic section modulus about y-axis, Z_y, 10.2 in^3
Second moment of area about x-axis, I_x, 843 in^4
Second moment of area about y-axis, I_y, 20.7 in^4

Analysis results

Required flexural strength - Major axis $M_{r,x}$ = **85** kips_ft

Restraint spacing

Major axis lateral restraint	L_x = **40** ft
Minor axis lateral restraint	L_y = **6** ft
Torsional restraint	L_z = **40** ft

Classification of sections for local buckling - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	b_f / (2 * t_f) = **7.22**	
Limiting ratio for compact section	λ_{pff} = 0.38 * √[E / F_y] = **10.79**	
Limiting ratio for non-compact section	λ_{rff} = 1.0 * √[E / F_y] = **28.38**	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 * k) / t_w$ = **53.71**

Limiting ratio for compact section $\lambda_{pwf} = 3.76 * \sqrt{[E / F_y]}$ = **106.72**

Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 * \sqrt{[E / F_y]}$ = **161.78** Compact

Section is compact in flexure

Design of members for flexure - Chapter F

Required flexural strength $M_{r,x}$ = **85** kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{n,yld,x} = M_{p,x} = F_y * Z_x$ = **286.2** kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length L_b = **6** ft

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 * r_y * \sqrt{(E / F_y)}$ = **5.245** ft

Distance between flange centroids h_o = **20.3** in

c = **1**

r_{ts} = **1.6** in

Limiting unbraced length for inelastic LTB - eq F2-6 $L_r = 1.95 * r_{ts} * E / (0.7 * F_y) * \sqrt{((J * c / (S_x * h_o)) + \sqrt{((J * c / (S_x * h_o))^2 + 6.76 * (0.7 * F_y / E)^2)}}$ = **15.752** ft

LTB modification factor C_b = **1.000**

Nominal flexural strength for lateral-torsional buckling - eq F2-2

$M_{n,ltb,x} = \min(C_b * (M_{p,x} - (M_{p,x} - 0.7 * F_y * S_x) * (L_b - L_p) / (L_r - L_p)), M_{p,x})$ = **277.9** kips_ft

Allowable flexural strength - F1

Nominal flexural strength $M_{n,x} = \min(M_{n,yld,x}, M_{n,ltb,x})$ = **277.9** kips_ft

Allowable flexural strength $M_{c,x} = M_{n,x} / \Omega_b$ = **166.4** kips_ft

$M_{r,x} / M_{c,x}$ = **0.511**

PASS - Allowable flexural strength exceeds required flexural strength

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Geometry data

GLOSSARY

Cb22, Cb33	: Moment gradient coefficients
Cm22, Cm33	: Coefficients applied to bending term in interaction formula
d0	: Tapered member section depth at J end of member
DJX	: Rigid end offset distance measured from J node in axis X
DJY	: Rigid end offset distance measured from J node in axis Y
DJZ	: Rigid end offset distance measured from J node in axis Z
DKX	: Rigid end offset distance measured from K node in axis X
DKY	: Rigid end offset distance measured from K node in axis Y
DKZ	: Rigid end offset distance measured from K node in axis Z
dL	: Tapered member section depth at K end of member
Ig factor	: Inertia reduction factor (Effective Inertia/Gross Inertia) for reinforced concrete members
K22	: Effective length factor about axis 2
K33	: Effective length factor about axis 3
L22	: Member length for calculation of axial capacity
L33	: Member length for calculation of axial capacity
LB pos	: Lateral unbraced length of the compression flange in the positive side of local axis 2
LB neg	: Lateral unbraced length of the compression flange in the negative side of local axis 2
RX	: Rotation about X
RY	: Rotation about Y
RZ	: Rotation about Z
TO	: 1 = Tension only member 0 = Normal member
TX	: Translation in X
TY	: Translation in Y
TZ	: Translation in Z

Nodes

Node	X [ft]	Y [ft]	Z [ft]	Rigid Floor
1	0.00	0.00	0.00	0
2	36.00	0.00	0.00	0
3	40.00	0.00	0.00	0
4	80.00	0.00	0.00	0
5	86.00	0.00	0.00	0
6	114.00	0.00	0.00	0
7	120.00	0.00	0.00	0
8	160.00	0.00	0.00	0
9	166.00	0.00	0.00	0
10	200.00	0.00	0.00	0

Restraints

Node	TX	TY	TZ	RX	RY	RZ
1	1	1	1	0	0	0
3	0	1	1	0	0	0
4	0	1	1	0	0	0
7	0	1	1	0	0	0
8	0	1	1	0	0	0
10	0	1	1	0	0	0

Members

Member	NJ	NK	Description	Section	Material	d0 [in]	dL [in]	lg factor
1	1	2		W 21X55	A36	0.00	0.00	0.00
2	2	3		W 21X44	A36	0.00	0.00	0.00
3	3	4		W 21X44	A36	0.00	0.00	0.00
4	4	5		W 21X44	A36	0.00	0.00	0.00
5	5	6		W 21X55	A36	0.00	0.00	0.00
6	6	7		W 21X44	A36	0.00	0.00	0.00
7	7	8		W 21X44	A36	0.00	0.00	0.00
8	8	9		W 21X44	A36	0.00	0.00	0.00
9	9	10		W 21X55	A36	0.00	0.00	0.00

Hinges

	Node-J				Node-K						
Member	M33	M22	V3	V2	M33	M22	V3	V2	TOR	AXL	Axial rigidity
1	0	0	0	0	1	0	0	0	0	0	Full
5	1	0	0	0	1	0	0	0	0	0	Full
9	1	0	0	0	0	0	0	0	0	0	Full

Current Date: 1/31/2021 6:27 AM
Units system: English
File name: S:\Projects\20-039 Summit Ridge NJ Roof Evaluation\320 Fairfield Rd\CALCS\INTERIOR CANT BEAM.retx

Load data

GLOSSARY

Comb : Indicates if load condition is a load combination

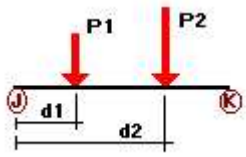
Load Conditions

Condition	Description	Comb.	Category
DL	Dead Load	No	DL
SL1	SOLAR LOAD	No	DL
D3	DL+0.29SL1	Yes	

Load on nodes

Condition	Node	FX [Kip]	FY [Kip]	FZ [Kip]	MX [Kip*ft]	MY [Kip*ft]	MZ [Kip*ft]
DL	3	0.00	-7.11	0.00	0.00	0.00	0.00
	4	0.00	-7.11	0.00	0.00	0.00	0.00
	7	0.00	-7.11	0.00	0.00	0.00	0.00
	8	0.00	-7.11	0.00	0.00	0.00	0.00
SL1	3	0.00	-7.11	0.00	0.00	0.00	0.00
	4	0.00	-7.11	0.00	0.00	0.00	0.00
	7	0.00	-7.11	0.00	0.00	0.00	0.00
	8	0.00	-7.11	0.00	0.00	0.00	0.00

Concentrated forces on members



Condition	Member	Dir1	Value1 [Kip]	Dist1 [ft]	%
DL	1	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	3	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No

		Y	-7.11	33.333	No
	5	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
	7	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	9	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
SL1	1	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	3	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	5	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No
	7	Y	-7.11	6.667	No
		Y	-7.11	13.333	No
		Y	-7.11	20.00	No
		Y	-7.11	26.667	No
		Y	-7.11	33.333	No
	9	Y	-7.11	0.667	No
		Y	-7.11	7.333	No
		Y	-7.11	14.00	No
		Y	-7.11	20.667	No
		Y	-7.11	27.333	No

Self weight multipliers for load conditions

Condition	Description	Comb.	Self weight multiplier MultX	MultY	MultZ
DL	Dead Load	No	0.00	0.00	0.00
SL1	SOLAR LOAD	No	0.00	0.00	0.00
D3	DL+0.29SL1	Yes	0.00	0.00	0.00

Earthquake (Dynamic analysis only)

Condition	a/g	Ang. [Deg]	Damp. [%]
DL	0.00	0.00	0.00
SL1	0.00	0.00	0.00
D3	0.00	0.00	0.00

Current Date: 1/31/2021 6:28 AM
Units system: English
File name: S:\Projects\20-039 Summit Ridge NJ Roof Evaluation\320 Fairfield Rd\CALCS\INTERIOR CANT BEAM.retx

List of materials

Note.- Only the graphically selected members and shells are listed

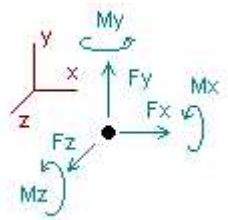
Members:

Profile	Material	Uweight [Kip/ft]	Length [ft]	Weight [Kip]
W 21X44	A36	4.43E-02	102.000	4.519
W 21X55	A36	5.52E-02	98.000	5.411
Total weight [Kip]				9.930

Current Date: 1/31/2021 6:29 AM
Units system: English
File name: S:\Projects\20-039 Summit Ridge NJ Roof Evaluation\320 Fairfield Rd\CALCS\INTERIOR CANT BEAM.retx

Analysis result

Reactions



Direction of positive forces and moments

Node	Forces [Kip] FX	FY	FZ	Moments [Kip*ft] MX	MY	MZ
Condition **D3=DL+0.29SL1**						
1	0.00000	20.38200	0.00000	0.00000	0.00000	0.00000
3	0.00000	56.68744	0.00000	0.00000	0.00000	0.00000
4	0.00000	55.92311	0.00000	0.00000	0.00000	0.00000
7	0.00000	54.42444	0.00000	0.00000	0.00000	0.00000
8	0.00000	59.68479	0.00000	0.00000	0.00000	0.00000
10	0.00000	18.88332	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	265.98510	0.00000	0.00000	0.00000	0.00000

Maximum forces at members

Condition : **D3=DL+0.29SL1**

	Axial [Kip]	Shear V2 [Kip]	Shear V3 [Kip]	Torsion [Kip*ft]	M22 [Kip*ft]	M33 [Kip*ft]
MEMBER **1**						
Max	0.00	20.38	0.00	0.00	0.00	223.79
Min	0.00	-25.48	0.00	0.00	0.00	0.00
MEMBER **2**						
Max	0.00	-25.48	0.00	0.00	0.00	0.00
Min	0.00	-25.48	0.00	0.00	0.00	-101.91
MEMBER **3**						
Max	0.00	22.04	0.00	0.00	0.00	155.41
Min	0.00	-23.82	0.00	0.00	0.00	-137.58
MEMBER **4**						
Max	0.00	22.93	0.00	0.00	0.00	0.00
Min	0.00	22.93	0.00	0.00	0.00	-137.58
MEMBER **5**						
Max	0.00	22.93	0.00	0.00	0.00	137.58
Min	0.00	-22.93	0.00	0.00	0.00	0.00
MEMBER **6**						
Max	0.00	-22.93	0.00	0.00	0.00	0.00
Min	0.00	-22.93	0.00	0.00	0.00	-137.58
MEMBER **7**						
Max	0.00	22.32	0.00	0.00	0.00	125.44

Min	0.00	-23.54	0.00	0.00	0.00	-161.86
MEMBER **8**						
Max	0.00	26.98	0.00	0.00	0.00	0.00
Min	0.00	26.98	0.00	0.00	0.00	-161.86
MEMBER **9**						
Max	0.00	26.98	0.00	0.00	0.00	193.99
Min	0.00	-18.88	0.00	0.00	0.00	0.00

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STEEL MEMBER DESIGN (AISC 360)

In accordance with AISC360 15th Edition published 2016 using the ASD method

Tedds calculation version 4.4.05

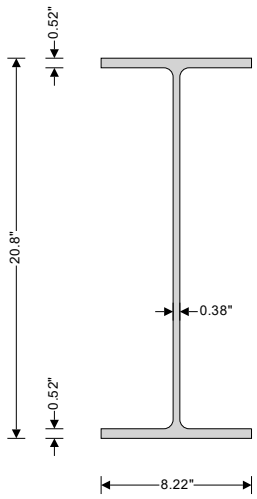
Safety factors

Shear	Ω_v = **1.67**
Flexure	Ω_b = **1.67**
Tensile yielding	$\Omega_{t,y}$ = **1.67**
Tensile rupture	$\Omega_{t,r}$ = **2.00**
Compression	Ω_c = **1.67**

Design section 1

Section details

Section type	W 21x55 (AISC 15th Edn (v15.0))
ASTM steel designation	A36
Steel yield stress	F_y = **36** ksi
Steel tensile stress	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi



W 21x55 (AISC 15th Edn (v15.0))
Section depth, d, 20.8 in
Section breadth, b_f, 8.22 in
Weight of section, Weight, 55 lbf/ft
Flange thickness, t_f, 0.522 in
Web thickness, t_w, 0.375 in
Area of section, A, 16.2 in^2
Radius of gyration about x-axis, r_x, 8.4 in
Radius of gyration about y-axis, r_y, 1.73 in
Elastic section modulus about x-axis, S_x, 110 in^3
Elastic section modulus about y-axis, S_y, 11.8 in^3
Plastic section modulus about x-axis, Z_x, 126 in^3
Plastic section modulus about y-axis, Z_y, 18.4 in^3
Second moment of area about x-axis, I_x, 1140 in^4
Second moment of area about y-axis, I_y, 48.4 in^4

Analysis results

Required flexural strength - Major axis $M_{r,x}$ = **236** kips_ft

Restraint spacing

Major axis lateral restraint	L_x = **36** ft
Minor axis lateral restraint	L_y = **6** ft
Torsional restraint	L_z = **36** ft

Classification of sections for local buckling - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 * t_f)$ = **7.87**	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 * \sqrt{[E / F_y]}$ = **10.79**	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 * \sqrt{[E / F_y]}$ = **28.38**	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 * k) / t_w$ = **50.03**

Limiting ratio for compact section $\lambda_{pwf} = 3.76 * \sqrt{[E / F_y]}$ = **106.72**

Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 * \sqrt{[E / F_y]}$ = **161.78** Compact

Section is compact in flexure

Design of members for flexure - Chapter F

Required flexural strength $M_{r,x}$ = **236** kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{n,yld,x} = M_{p,x} = F_y * Z_x$ = **378** kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length L_b = **6** ft

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 * r_y * \sqrt{(E / F_y)}$ = **7.202** ft

Distance between flange centroids h_o = **20.3** in

c = **1**

r_{ts} = **2.11** in

Limiting unbraced length for inelastic LTB - eq F2-6 $L_r = 1.95 * r_{ts} * E / (0.7 * F_y) * \sqrt{((J * c / (S_x * h_o)) + \sqrt{((J * c / (S_x * h_o))^2 + 6.76 * (0.7 * F_y / E)^2)}}$ = **21.182** ft

L_b <= L_p - Lateral-torsional buckling does not apply

Allowable flexural strength - F1

Nominal flexural strength $M_{n,x} = M_{n,yld,x}$ = **378** kips_ft

Allowable flexural strength $M_{c,x} = M_{n,x} / \Omega_b$ = **226.3** kips_ft

$M_{r,x} / M_{c,x}$ = **1.043**

FAIL - Required flexural strength exceeds allowable flexural strength

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STEEL MEMBER DESIGN (AISC 360)

In accordance with AISC360 15th Edition published 2016 using the ASD method

Tedds calculation version 4.4.05

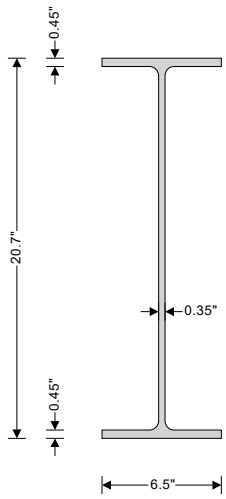
Safety factors

Shear	Ω_v = **1.67**
Flexure	Ω_b = **1.67**
Tensile yielding	$\Omega_{t,y}$ = **1.67**
Tensile rupture	$\Omega_{t,r}$ = **2.00**
Compression	Ω_c = **1.67**

Design section 1

Section details

Section type	W 21x44 (AISC 15th Edn (v15.0))
ASTM steel designation	A36
Steel yield stress	F_y = **36** ksi
Steel tensile stress	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi



W 21x44 (AISC 15th Edn (v15.0))
Section depth, d, 20.7 in
Section breadth, b_f, 6.5 in
Weight of section, Weight, 44 lbf/ft
Flange thickness, t_f, 0.45 in
Web thickness, t_w, 0.35 in
Area of section, A, 13 in^2
Radius of gyration about x-axis, r_x, 8.06 in
Radius of gyration about y-axis, r_y, 1.26 in
Elastic section modulus about x-axis, S_x, 81.6 in^3
Elastic section modulus about y-axis, S_y, 6.37 in^3
Plastic section modulus about x-axis, Z_x, 95.4 in^3
Plastic section modulus about y-axis, Z_y, 10.2 in^3
Second moment of area about x-axis, I_x, 843 in^4
Second moment of area about y-axis, I_y, 20.7 in^4

Analysis results

Required flexural strength - Major axis $M_{r,x}$ = **171** kips_ft

Restraint spacing

Major axis lateral restraint	L_x = **40** ft
Minor axis lateral restraint	L_y = **6** ft
Torsional restraint	L_z = **40** ft

Classification of sections for local buckling - Section B4

Classification of flanges in flexure - Table B4.1b (case 10)

Width to thickness ratio	$b_f / (2 * t_f)$ = **7.22**	
Limiting ratio for compact section	$\lambda_{pff} = 0.38 * \sqrt{[E / F_y]}$ = **10.79**	
Limiting ratio for non-compact section	$\lambda_{rff} = 1.0 * \sqrt{[E / F_y]}$ = **28.38**	Compact

Classification of web in flexure - Table B4.1b (case 15)

Width to thickness ratio $(d - 2 * k) / t_w$ = **53.71**

Limiting ratio for compact section $\lambda_{pwf} = 3.76 * \sqrt{[E / F_y]}$ = **106.72**

Limiting ratio for non-compact section $\lambda_{rwf} = 5.70 * \sqrt{[E / F_y]}$ = **161.78** Compact

Section is compact in flexure

Design of members for flexure - Chapter F

Required flexural strength $M_{r,x}$ = **171** kips_ft

Yielding - Section F2.1

Nominal flexural strength for yielding - eq F2-1 $M_{n,yld,x} = M_{p,x} = F_y * Z_x$ = **286.2** kips_ft

Lateral-torsional buckling - Section F2.2

Unbraced length L_b = **6** ft

Limiting unbraced length for yielding - eq F2-5 $L_p = 1.76 * r_y * \sqrt{(E / F_y)}$ = **5.245** ft

Distance between flange centroids h_o = **20.3** in

c = **1**

r_{ts} = **1.6** in

Limiting unbraced length for inelastic LTB - eq F2-6 $L_r = 1.95 * r_{ts} * E / (0.7 * F_y) * \sqrt{((J * c / (S_x * h_o)) + \sqrt{((J * c / (S_x * h_o))^2 + 6.76 * (0.7 * F_y / E)^2)}}$ = **15.752** ft

LTB modification factor C_b = **1.000**

Nominal flexural strength for lateral-torsional buckling - eq F2-2

$M_{n,ltb,x} = \min(C_b * (M_{p,x} - (M_{p,x} - 0.7 * F_y * S_x) * (L_b - L_p) / (L_r - L_p)), M_{p,x})$ = **277.9** kips_ft

Allowable flexural strength - F1

Nominal flexural strength $M_{n,x} = \min(M_{n,yld,x}, M_{n,ltb,x})$ = **277.9** kips_ft

Allowable flexural strength $M_{c,x} = M_{n,x} / \Omega_b$ = **166.4** kips_ft

$M_{r,x} / M_{c,x}$ = **1.027**

FAIL - Required flexural strength exceeds allowable flexural strength

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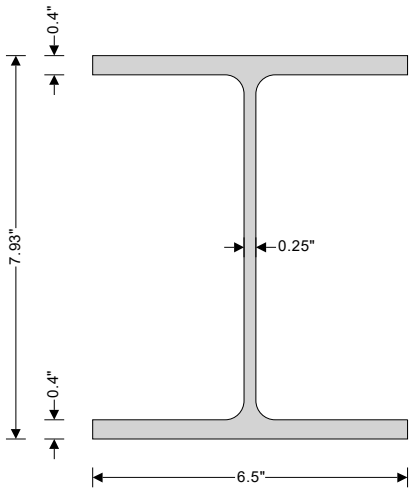
STEEL COLUMN DESIGN

In accordance with AISC360-16 and the ASD method

Tedds calculation version 1.0.10



Column and loading details

Column details

Column section	**W 8x24**

Design loading

Required axial strength	P_r = **32** kips (Compression)
Maximum moment about x axis	M_x = **0.0** kips_ft
Maximum moment about y axis	M_y = **0.0** kips_ft
Maximum shear force parallel to y axis	V_{ry} = **0.0** kips
Maximum shear force parallel to x axis	V_{rx} = **0.0** kips

Material details

Steel grade	**A36**
Yield strength	F_y = **36** ksi
Ultimate strength	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi
Shear modulus of elasticity	G = **11200** ksi

Unbraced lengths

For buckling about x axis	L_x = **264** in
For buckling about y axis	L_y = **264** in
For torsional buckling	L_z = **264** in

Effective length factors

For buckling about x axis	K_x = **1.00**
For buckling about y axis	K_y = **1.00**
For torsional buckling	K_z = **1.00**

Effective unbraced lengths

For buckling about x axis	$L_{cx} = L_x \times K_x$ = **264** in

For buckling about y axis $L_{cy} = L_y \times K_y =$ **264** in

For torsional buckling $L_{cz} = L_z \times K_z =$ **264** in

Section classification

Section classification for local buckling (cl. B4)

Critical flange width $b = b_f / 2 =$ **3.250** in

Width to thickness ratio of flange $\lambda_f = b / t_f =$ **8.125**

Depth between root radii $h = d - 2 \times k =$ **6.342** in

Width to thickness ratio of web $\lambda_w = h / t_w =$ **25.886**

Compression

Limit for nonslender flange $\lambda_{rf_c} = 0.56 \times \sqrt{(E / F_y)} =$ **15.894**

The flange is nonslender in compression

Limit for nonslender web $\lambda_{rw_c} = 1.49 \times \sqrt{(E / F_y)} =$ **42.290**

The web is nonslender in compression

The section is nonslender in compression

Slenderness

Member slenderness

Slenderness ratio about x axis $SR_x = L_{cx} / r_x =$ **77.2**

Slenderness ratio about y axis $SR_y = L_{cy} / r_y =$ **164.0**

Compressive strength

Flexural buckling about x axis (cl. E3)

Elastic critical buckling stress $F_{ex} = \pi^2 * E / (SR_x)^2 =$ **48** ksi

Flexural buckling stress $F_{crx} = (0.658^{F_y / F_{ex}}) * F_y =$ **26.3** ksi

Nominal compressive strength for flexural buckling $P_{nx} = F_{crx} * A =$ **186.3** kips

Flexural buckling about y axis (cl. E3)

Elastic critical buckling stress $F_{ey} = \pi^2 * E / (SR_y)^2 =$ **10.6** ksi

Flexural buckling stress $F_{cry} = 0.877 * F_{ey} =$ **9.3** ksi

Nominal compressive strength for flexural buckling $P_{ny} = F_{cry} * A =$ **66.1** kips

Torsional and torsional-flexural buckling of members with slender elements (cl. E7)

Flexural-torsional elastic buckling stress $F_{et} = (\pi^2 * E * C_w / (L_{cz})^2 + G * J) / (I_x + I_y) =$ **48.9** ksi

Flexural-torsional buckling stress $F_{crt} = 0.877 * F_{et} =$ **42.9** ksi

Nominal compressive strength for torsional and flexural-torsional buckling

$P_{nt} = F_{crt} * A =$ **303.6** kips

Allowable compressive strength (cl. E1)

Safety factor for compression $\Omega_c =$ **1.67**

Allowable compressive strength $P_c = \min(P_{nx}, P_{ny}, P_{nt}) / \Omega_c =$ **39.6** kips

PASS - The allowable compressive strength exceeds the required compressive strength

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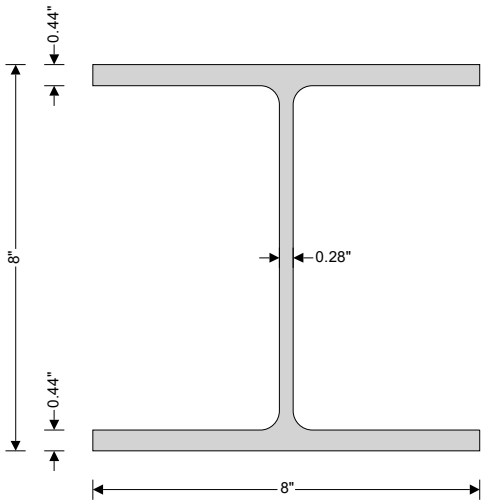
STEEL COLUMN DESIGN

In accordance with AISC360-16 and the ASD method

Tedds calculation version 1.0.10



Column and loading details

Column details

Column section	**W 8x31**

Design loading

Required axial strength	P_r = **60** kips (Compression)
Maximum moment about x axis	M_x = **0.0** kips_ft
Maximum moment about y axis	M_y = **0.0** kips_ft
Maximum shear force parallel to y axis	V_{ry} = **0.0** kips
Maximum shear force parallel to x axis	V_{rx} = **0.0** kips

Material details

Steel grade	**A36**
Yield strength	F_y = **36** ksi
Ultimate strength	F_u = **58** ksi
Modulus of elasticity	E = **29000** ksi
Shear modulus of elasticity	G = **11200** ksi

Unbraced lengths

For buckling about x axis	L_x = **264** in
For buckling about y axis	L_y = **264** in
For torsional buckling	L_z = **264** in

Effective length factors

For buckling about x axis	K_x = **1.00**
For buckling about y axis	K_y = **1.00**
For torsional buckling	K_z = **1.00**

Effective unbraced lengths

For buckling about x axis	$L_{cx} = L_x \times K_x$ = **264** in

For buckling about y axis $L_{cy} = L_y \times K_y =$ **264** in

For torsional buckling $L_{cz} = L_z \times K_z =$ **264** in

Section classification

Section classification for local buckling (cl. B4)

Critical flange width $b = b_f / 2 =$ **4.000** in

Width to thickness ratio of flange $\lambda_f = b / t_f =$ **9.195**

Depth between root radii $h = d - 2 \times k =$ **6.342** in

Width to thickness ratio of web $\lambda_w = h / t_w =$ **22.253**

Compression

Limit for nonslender flange $\lambda_{rf_c} = 0.56 \times \sqrt{(E / F_y)} =$ **15.894**

The flange is nonslender in compression

Limit for nonslender web $\lambda_{rw_c} = 1.49 \times \sqrt{(E / F_y)} =$ **42.290**

The web is nonslender in compression

The section is nonslender in compression

Slenderness

Member slenderness

Slenderness ratio about x axis $SR_x = L_{cx} / r_x =$ **76.1**

Slenderness ratio about y axis $SR_y = L_{cy} / r_y =$ **130.7**

Compressive strength

Flexural buckling about x axis (cl. E3)

Elastic critical buckling stress $F_{ex} = \pi^2 * E / (SR_x)^2 =$ **49.4** ksi

Flexural buckling stress $F_{crx} = (0.658^{F_y / F_{ex}}) * F_y =$ **26.5** ksi

Nominal compressive strength for flexural buckling $P_{nx} = F_{crx} * A =$ **242.3** kips

Flexural buckling about y axis (cl. E3)

Elastic critical buckling stress $F_{ey} = \pi^2 * E / (SR_y)^2 =$ **16.8** ksi

Flexural buckling stress $F_{cry} = (0.658^{F_y / F_{ey}}) * F_y =$ **14.6** ksi

Nominal compressive strength for flexural buckling $P_{ny} = F_{cry} * A =$ **133.7** kips

Torsional and torsional-flexural buckling of members with slender elements (cl. E7)

Flexural-torsional elastic buckling stress $F_{et} = (\pi^2 * E * C_w / (L_{cz})^2 + G * J) / (I_x + I_y) =$ **55.6** ksi

Flexural-torsional buckling stress $F_{crt} = (0.658^{F_y / F_{et}}) * F_y =$ **27.5** ksi

Nominal compressive strength for torsional and flexural-torsional buckling

$P_{nt} = F_{crt} * A =$ **250.7** kips

Allowable compressive strength (cl. E1)

Safety factor for compression $\Omega_c =$ **1.67**

Allowable compressive strength $P_c = \min(P_{nx}, P_{ny}, P_{nt}) / \Omega_c =$ **80.1** kips

PASS - The allowable compressive strength exceeds the required compressive strength