Take Heart School

Migori, Kenya

Written By:
Quentin Porter

Advised By:
Kevin Dong

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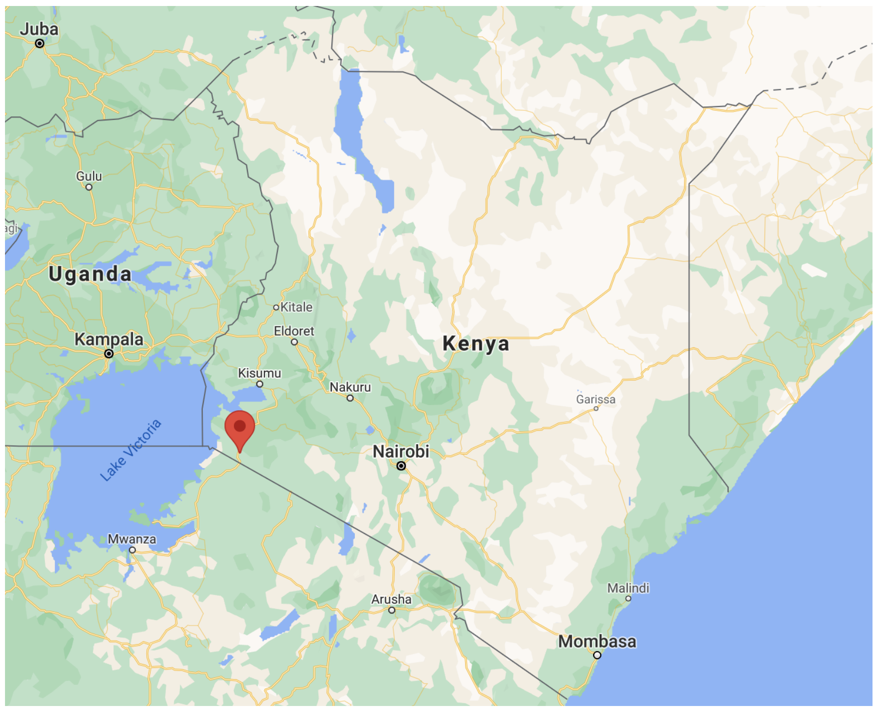
ABSTRACT:

Journeyman International, also known as JI, is a non-profit organization that groups together design and construction students with organizations looking to build humanitarian projects around the world. This pairing is beneficial for both the organization because they get free design and construction expertise, as well as for the students who get real-world experience. The Take Heart School is a planned school and grounds for the region of Migori Kenya. Take Heart Africa is a fair trade store with all profits going to help the impoverished communities of Kenya. The three-acre site will have a school with eight classrooms, offices, a library, a cafeteria, and housing for students and visitors. It is located near a small village which it is intended to serve. The design team included Janelle Tatari, a Cal Poly Architecture student, who completed the architectural work for the twelve buildings. Spencer Mishky, a Cal Poly Construction Management student, did the construction development work. David Corona, a Cal Poly Architectural Engineering, designed the structural system for the eight classroom school building. As well as myself who designed the structural system for the library and office building. Throughout this process, I was advised by ARCE professor Kevin Dong. The project was completed over the course of the 2020/2021 school year with the majority of the architectural design being completed in the fall and winter, and the structural and construction design being completed in the spring. This report will focus on the research, assumptions, structural design process, and lessons learned from the design experience.

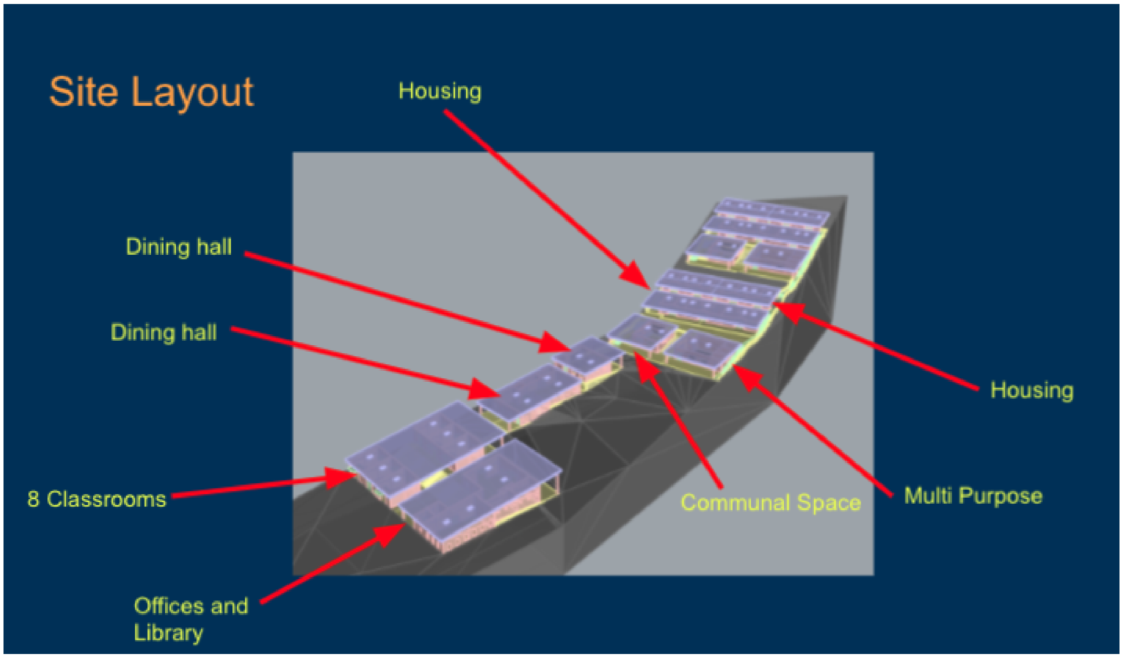
PROJECT DESCRIPTION:

As stated before the project is located in rural Kenya, within the Migori region. The site is a three-acre sloped site, with a road that leads to the property line, but no driveway running through the property. The surrounding landscape consists of mostly short brush and grasslands, as well as rural farms. Walking distance from the site is a village, whose people the project is



meant to serve. The project itself will consist of twelve buildings. There will be four dormitory-style buildings. These will be used to house visitors and guest lecturers, displaced women, and their children, and young adults aged 18-22 because the Kenyan government no longer provides free housing to people of that age range. There will be four communal/multi-purpose spaces. These will be used as places for guest presentations and events, as well as space for the residents to relax and gather. There will be a cafeteria that will serve the residents as well as the students from the local village who are attending school. The school building will have eight classrooms, and next door there will be a library building with facility

offices attached. The clients came provided two design requirements. They wanted to maximize the views out to the west, as well as provide outdoor spaces for people on-site to gather and use.



DESIGN PROCESS:

Because of the location of the site, many design assumptions were made beginning with the site. The site was assumed a risk category II and site class of D because a soils report was not provided. In order to get an Sds, a location other than Mogori Kenya had to be assumed. The location of the California capital was used, as it is likely a similar seismic region. Using this information, and info conducted by another firm the site was assigned an Sds of 0.51.

Take Heart School

1315 10th St room b-27, Sacramento, CA 95814, USA

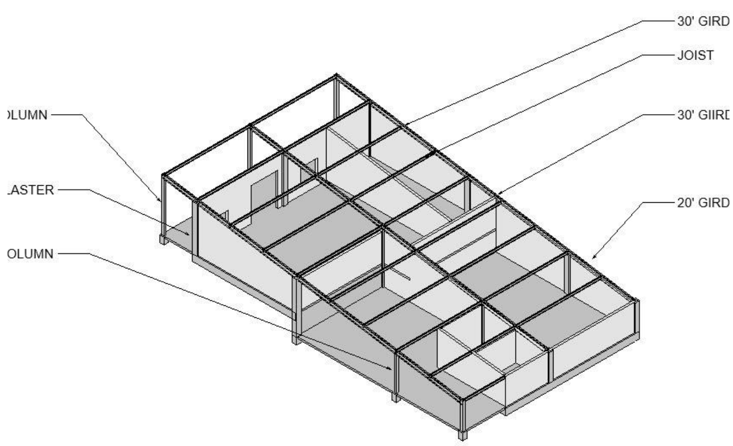
Latitude, Longitude: 38.5765882, -121.4932368

Date	5/12/2021, 5:53:39 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Default (See Section 11.4.3)

Type	Value	Description
S_S	0.568	MCE_R ground motion. (for 0.2 second period)
S_1	0.253	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.764	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	0.51	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

A 5 PSF dead load, and a 15 PSF live load, were assumed for the vertical loading. A 20 PSF wind load on the building was also assumed. Some design thought had to be made regarding the materiality of the building. After speaking with an architect from Kenya, we determined that the availability of construction materials is limited. For the gravity system, the architect suggested that we use steel decking as the main roofing material, steel wide flange for the joist/girder system, and CMU pilasters and steel columns to transfer the roof load into the ground. In the lateral direction, reinforced masonry shear walls were used because there is skilled labor available in that trade, and both CMU and No. 4 rebar is available. We were not able to determine the most common CMU sizes in Kenya, so we opted to use the standard 8”x8”x16” block.

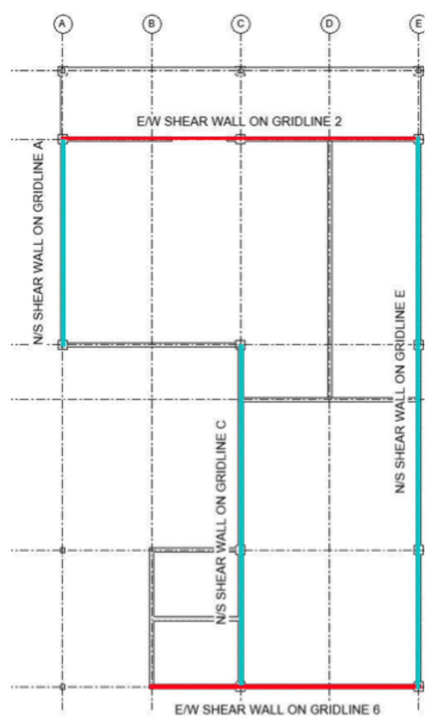
The gravity design was fairly straightforward, although there were some considerations made about the forty-foot girder, that required some extra design consideration. The decking was sized as twenty gauge deep VERCOR deck. This is a fairly standard deck in the U.S., and it was assumed that this or a similar deck can be found and purchased in Kenya. The joists were spaced at ten feet on center and sized to be W8x10's. These framed into girders that were split up into different length pieces. The first being a twenty-foot girder, which a single joist point load in the center. This was sized to be a W12x14. The second span was thirty feet with two point loads applied at ten feet and twenty feet across. This was sized to be a W12x26. The architect designed



the building to have a ten-foot cantilever, that provides shade outside of the building. In order to have it cantilever, we needed to use a forty-foot girder. This length however would be hard to transport along dirt roads and lift once on site. Because of these challenges, I decided to offer two design options for the remaining forty-foot length. The first being a forty-foot girder that would be able to support the cantilever. This was sized at W12x40. The other option is a thirty-foot girder, and then a ten-foot girder with a column at the end instead of a cantilever. By providing these two options the contractor and owner can make a decision on what they would like to use. The columns were placed on a grid, and along wall lines, as to not inhibit open space. The CMU pilasters are 16"x16" with 4 N.o. 4 rebar vertically. The steel columns however

required a few more design considerations. Here in the United States, most columns would be sized as HSS squares, however, the availability of materials is limited in Kenya, and so I designed the columns twice, once using the HSS and once using lower grade 36ksi pipe. The low-grade pipes are easier to find in locations with scarce materials and seemed like a good choice as a substitute for the HSS. Understanding that this was a school, and would have young kids playing about, I wanted to ensure that the columns would not deflect if students were climbing them. To do this the columns were designed with a 500 lb lateral force applied at the center. Two-column heights were designed. With the ten-foot column being sized at HSS 4x4x1/8 or 3' STD pipe, and the sixteen-foot column being sized at HSS 4x4x3/16 or 4' STD pipe.

The lateral design was more straightforward. The building was designed to have two reinforced masonry shear walls in the east-west direction, and three in the north-south. Once the



lateral forces were determined, I focused on the thirteen-foot shear wall running in the east-west

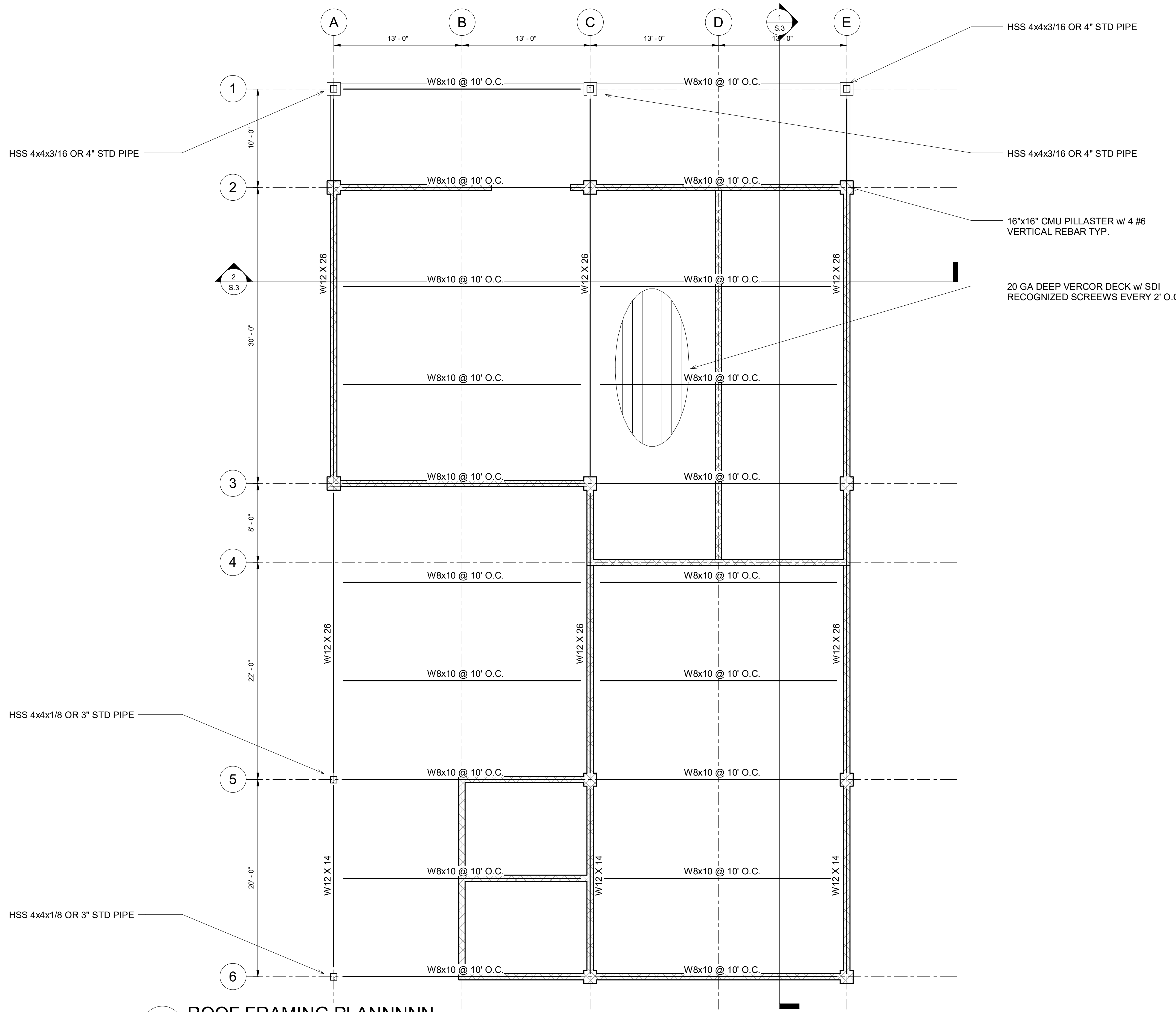
direction. The wall proved to be of interest because it had three openings, one door, and two windows. The wall was checked for both in-plane and out of plain loading. And it was determined that N.o. 4’s at 32in on center each way would suffice as the standard spacing of rebar. It is important to note that if this building was being built in the US, the spacing of 32in on center would not be permitted, and would need to be brought down to 24in. Because the out-of-plane loading is larger around the openings, the rebar must be spaced at 16in on center when framing openings. The calculations were preliminary, and the next steps would be to start developing the connections needed for construction.

LESSONS LEARNED:

I had three main takeaways from this project. The first being the importance of communication and professional relationships. Before beginning this project I had a friendship and working relationship with the Construction Management student on the team Spencer Mishky. Throughout the process, my communication with him was much easier than the communication I had with Janelle Tatari, the Architect. When I had a question for Spencer, I would just drop him a text or give him a call. I typically had the question answered within a few hours. When I had a question for Janelle I would have to schedule a zoom call with her, and typically get it answered within two days. Communication is key to getting a project done well and in a timely manner. As I begin work in August I will be sure to foster all of my professional relationships, as well as work hard to communicate clearly and effectively with all people working on the project.

I also learned that the client does not always know what they want. The three primary requirements the clients wanted were eight classrooms, being able to see the view to the west, and being able to utilize outdoor space. This is very little to go on, and I learned that it is our job as design professionals to ask the correct questions of the client to help them understand what they want and need.

I finally learned that designing here in the United States we have a luxury of goods. I can size almost anything out of my design manuals and know that it can be ordered and delivered to the site. That is just not the case in other countries. The design of buildings in many countries is limited by the materials present. This was a new challenge for me to design with, but one that I found offered interesting problems that were a joy to solve.



1 ROOF FRAMING PLANNNNN

SCALE: 3/16" = 1'-0"

Take Heart School Porject

Journeyman International

Quinn Porter
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ARCE

STAMP:

PRINTING DATE

REVISION DATE

DRAWING TITLE

ROOF FRAMING PLAN

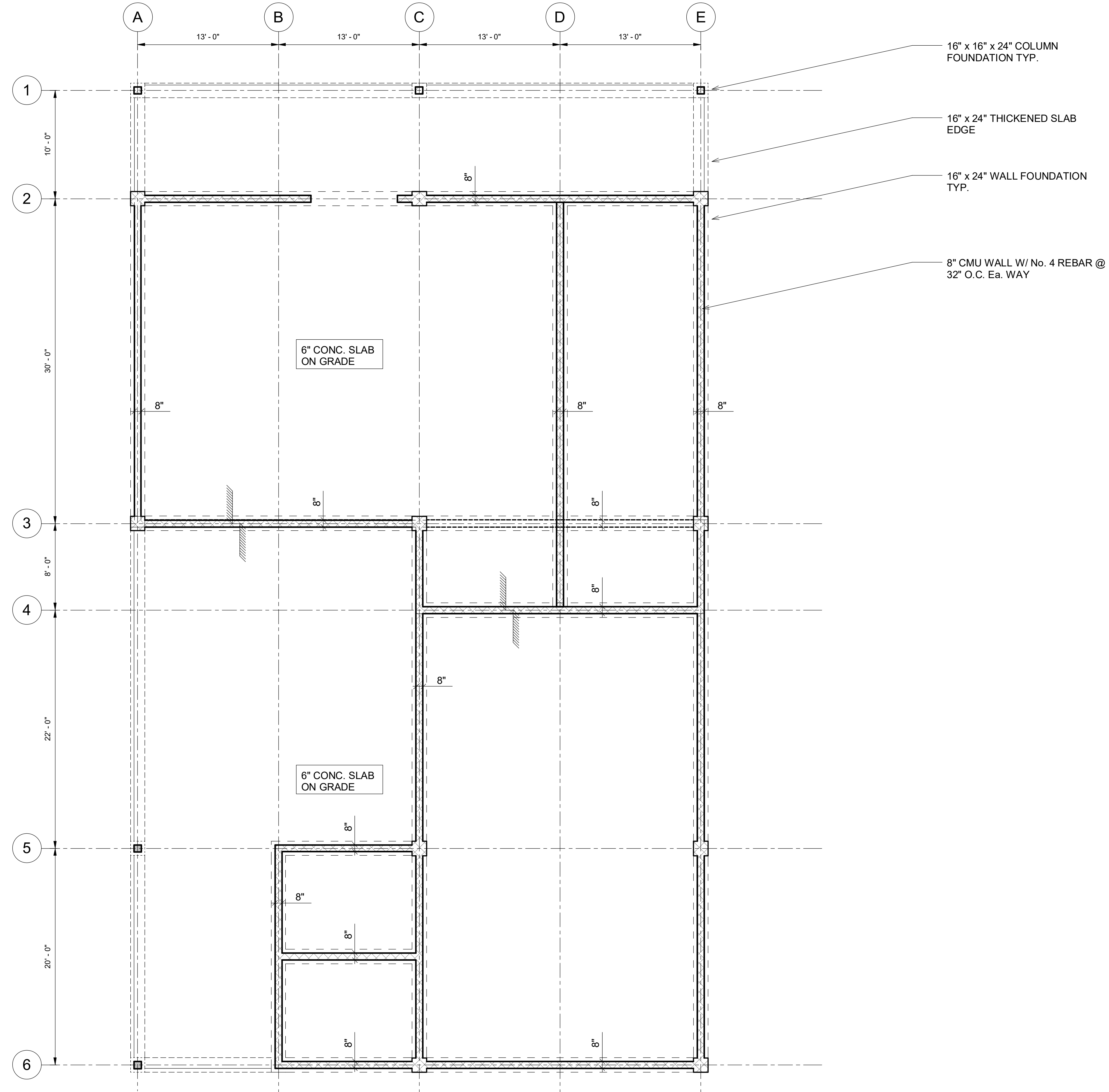
SHEET NO.

S.1

SCALE: 3/16" = 1'-0"

DRAWN BY: QP

SUBMITTAL DATE: 6/9/2021 4:23:08 PM



1 FOUNDATION PLAN

SCALE: 3/16" = 1'-0"

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FOUNDATION PLAN

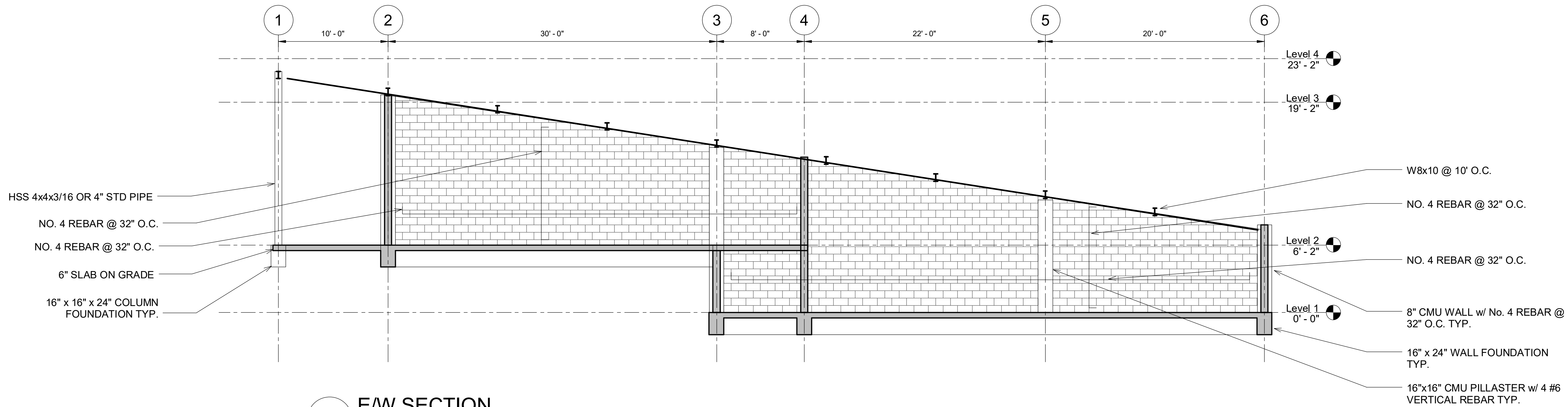
SHEET NO.

S.2

SCALE: 3/16" = 1'-0"

DRAWN BY: QP

SUBMITTAL DATE: 6/9/2021 4:23:09 PM



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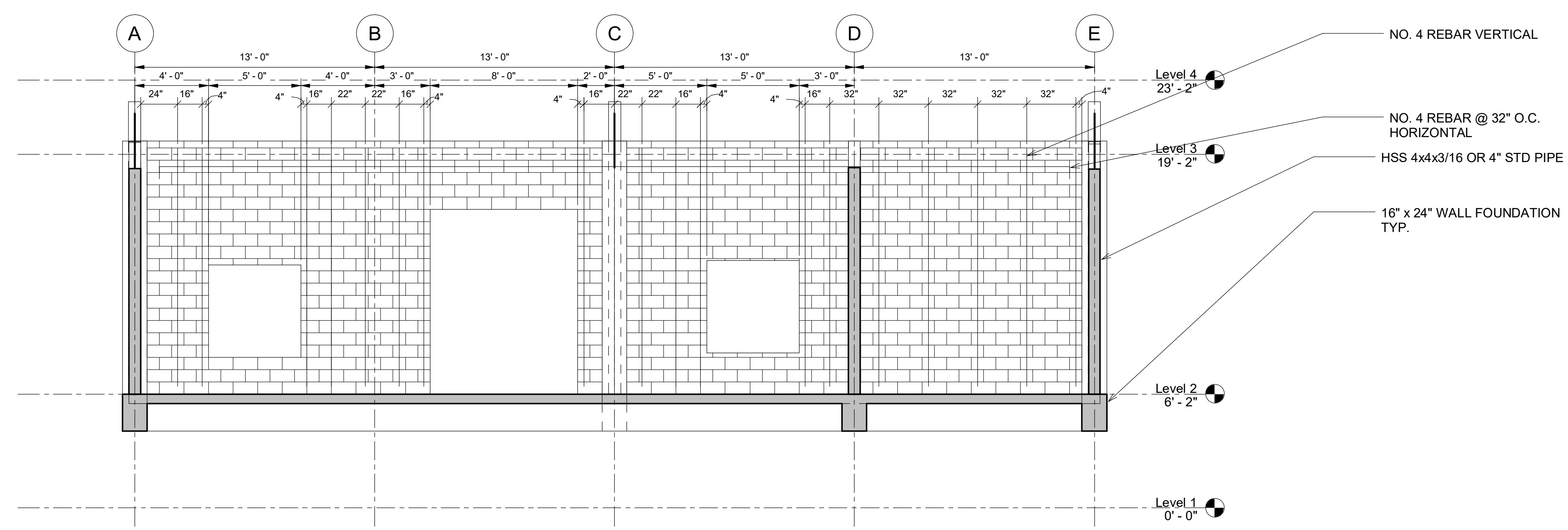
NO SCALE



2 N/S SECTION

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DRAWING TITLE

SECTIONS

SHEET NO.

S.3

SCALE:	DRAWN BY:
As indicated	Author

SUBMITTAL DATE:

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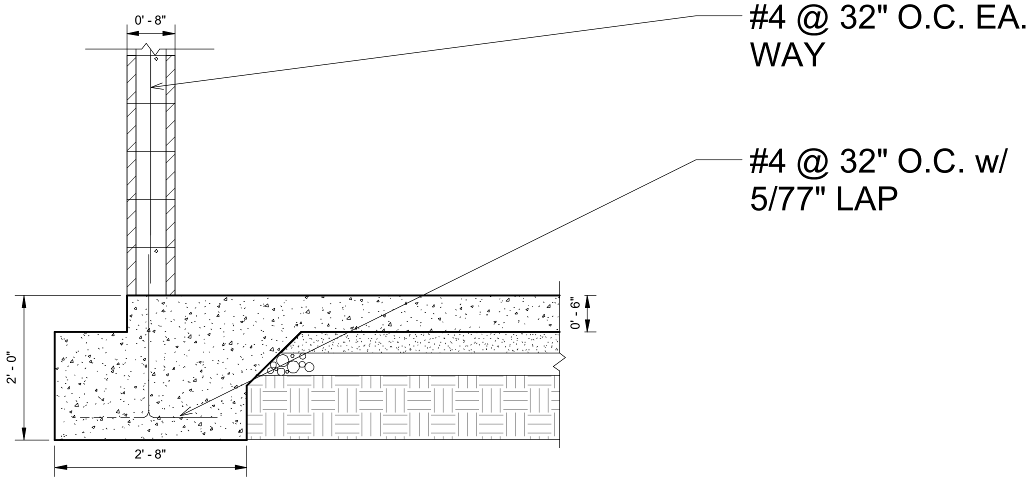

1 FOUNDATION DETAIL

NO SCALE

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DRAWING TITLE

DETAILS

SHEET NO.

S.4

SCALE:	DRAWN BY:
3/4" = 1'-0"	Author

SUBMITTAL DATE:

6/9/2021 4:23:09 PM

Topic: Gravity Loading/Deck
Date: 4/26/21
Name: Quinn Porter

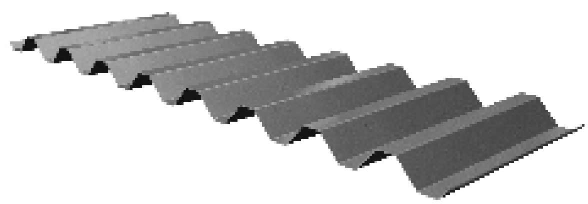
Roof Loading:
This will likely be a bare bones roof, with no fire proofing, and very light MEP.
We will use 5 PSF for Dead Load in case lighting, or solar is added.

Dead Load: 5PSF
Live Load: 15PSF

Total Load: 20PSF

Metal Roof Deck Selection:

Deep VERCOR™



Allowable Uniform Loads (psf)

SPAN	DECK GAGE	CRITERIA	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"
TRIPLE	26	Stress	300	252	193	153	124	102	86	73	63	55	48	43	38	34	31
		L/360	229	144	97	68	49	37	29	23	18	15	12	10	8	7	6
		L/240	♦♦♦	216	145	102	74	56	43	34	27	22	18	15	13	11	9
		L/180	♦♦♦	♦♦♦	♦♦♦	136	99	74	57	45	36	29	24	20	17	14	12
	24	Stress	300	300	259	204	166	137	115	98	84	74	65	57	51	46	41
		L/360	296	187	125	88	64	48	37	29	23	19	16	13	11	9	8
		L/240	♦♦♦	280	187	132	96	72	56	44	35	28	23	20	16	14	12
		L/180	♦♦♦	♦♦♦	250	176	128	96	74	58	47	38	31	26	22	19	16
	22	Stress	300	300	300	253	205	170	143	121	105	91	80	71	63	57	51
		L/360	♦♦♦	231	155	109	79	59	46	36	29	23	19	16	14	12	10
		L/240	♦♦♦	♦♦♦	232	163	119	89	69	54	43	35	29	24	20	17	15
		L/180	♦♦♦	♦♦♦	♦♦♦	217	158	119	92	72	58	47	39	32	27	23	20
	20	Stress	300	300	300	300	245	202	170	145	125	109	96	85	76	68	61
		L/360	♦♦♦	275	184	129	94	71	55	43	34	28	23	19	16	14	12
		L/240	♦♦♦	♦♦♦	276	194	142	106	82	64	52	42	35	29	24	21	18
		L/180	♦♦♦	♦♦♦	♦♦♦	259	189	142	109	86	69	56	46	38	32	28	24

Use 20 Gage Deep VERCOR Deck spanning 10 ft

VERCO Catalog Page 148

Topic: Int Joist
Date: 6/9/21
Name: Quinn Porter

Design Int Joist

DL = 5PSF $W = [1.2(5PSF) + 1.6(15PSF)]10' = 300PLF$
LL = 15PSF $\omega = [5PSF + 15PSF]10' = 200PLF$

$M_U = \frac{WL^2}{8} = \frac{300PLF(26')^2}{8} = 25.35k' = M_U$

$V_U = \frac{WL}{2} = \frac{300PLF(26')}{2} = 3.9k = V_U$

$L_b = 0 \quad \Phi_b = .9$

$Z_{xreq} = \frac{M_U}{\Phi_b f_y} = \frac{25.35k'}{.9(50ksi)} = 6.76in^3 = Z_{xreq}$

$\frac{L}{240} = \frac{5\omega l^4}{384EI} \Rightarrow I = \frac{1200\,\omega l^3}{384EI}$

$I_{req} = \frac{3.125(.2)(26)^3(12^3)}{29 \times 10^6} = 6.54in^4 = I_{req}$

Choose W 8x10

$I_x = 30.8in^4 > 6.54in^4 = I_{req}$ ✓

$\phi_b M_{px} = 32.9k' > 25.35k' = M_U$ ✓

$\phi_v V_{nx} = 40.2k > 3.9k = V_U$ ✓

$Z_x = 8.87in^3 > 6.76in^3 = Z_{xreq}$ ✓

USE W 8x10 Joists

Topic: Int 20' Girder
Date: 6/9/21
Name: Quinn Porter

Design Int 20' Girder

DL = 5 PSF $P = [1.2(5) + 1.6(15)]\,10'(26') = 7.8k$

LL = 15 PSF $P_1 = (5+15)\,10'(26') = 5.2k$

$Mu = \frac{P\ell}{4} = \frac{7.8k(20')}{4} = \underline{39k' = Mu}$

$Vu = P/2 = 7.8k/2 = \underline{3.9k = Vu}$

$Lb = 0 \quad \Phi b = .9$

$Z_{x\,req} = \frac{Mu}{\phi b F y} = \frac{39k'(12)}{.9(50ksi)} = \underline{10.4 in^4 = Z_{x\,req}}$

$\frac{L}{240} = \frac{P\ell^3}{48EI} \Rightarrow \frac{5PL^2}{E} = I$

$I_{req} = \frac{5(5200)(20')(12^2)}{29000 \times 10^6} = \underline{51.64 in^4 = I_{req}}$

Choose: W 12x14

$I_x = 88.6 in^4 > 51.64 in^4 = I_{req}$ ✓

$\phi_b M_{px} = 65.3k' > 39k' = Mu$ ✓

$\phi_v V_{nx} = 64.3k > 3.9k = Vu$ ✓

$Z_x = 17.4 in^3 > 10.4 in^3$ ✓

<u>USE W 12x14 for 20' span</u>

Topic: Int 30' Girder
Date: 6/9/21
Name: QP

Design Int 30' Span

DL = 5 PSF $\quad P = [1.2(5) + 1.6(15)](10')(26') = 7.8\,k$

LL = 15 PSF $\quad P_1 = (5+15)(10')(26') = 5.2\,k$

$M_u = P(a) = 7.8k(10') = \underline{78\,k' = M_u}$

$V_u = P = \underline{7.8k = V_u}$

$L_b = 0 \quad \Phi_b = .9$

$Z_{x\,req} = \frac{M_u}{\Phi_b f_y} = \frac{78k'(12)}{.9(50)} = \underline{20.8\,in^3 = Z_{x\,req}}$

$\frac{L}{240} = \frac{Pa}{24EI}(3l^2 - 4a^2) \Rightarrow I = \frac{10Pa}{El}(3l^2 - 4a^2)$

$I_{req} = \frac{10(5200)(10')(12^2)}{29 \times 10^6 (30')}(3(30)^2 - 4(10^2)) = \underline{198\,in^4}$

Choose: W12x26

$I_x = 204\,in^4 > 198\,in^4 = I_{x\,req}$ ✓

$\phi_b M_{px} = 140k' > 78k' = M_u$ ✓

$\phi_v V_{nx} = 84.2k > 7.8k = V_u$ ✓

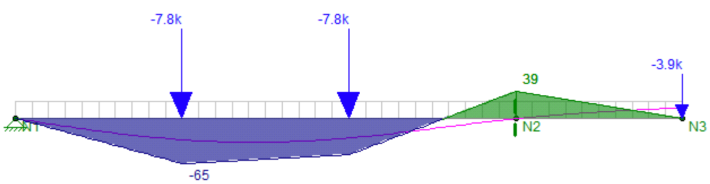
$Z_x = 37.2\,in^3 > 20.8\,in^3 = Z_{x\,req}$ ✓

USE W12x26 FOR 30' SPAN

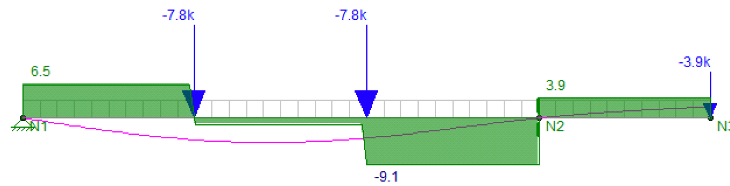
Topic: 40' INT GIRDER
Date: 6/8/21
Name: Quinn Porter

Design of Int 40' Girder

DL = 5PSF
LL = 15PSF
P1 = [1.2*5PSF+1.6*15PSF]*10'*26' = 7.8K
P2 = [1.2*5PSF+1.6*15PSF]*5'*26' = 3.9K



Mu = 65K'



Vu = 9.1K

Per IBC TABLE 1604.3
Deltau = L/180
Per footnote I for cantilever L shall be taken as twice the length of the cantilever
Deltau = 20'*12in/ft/180 = 1.33"

Lb = 0
Phib = .9
Zxreq = Mu/(Phib*Fy) = 65K'*12in/ft/(.9*50ksi) = 17.33 in^3

Using RISA to check Deflection CHOOSE: W12x40

Deltamax = 1.286" < 1.33" = Deltau CHECK
PhibMpx = 214K' > 65K' = Mu CHECK
PhivVnx = 105K > 9.1K = Vu CHECK
Zx = 57in^3 > 17.33in^3 = Zxreq CHECK

	L...	Member Label	S...	x [in]	y [in]	(n) L/y' ...
1	1	M1	1	0	0	NC
2			2	0	-.954	377
3			3	0	-1.281	281
4			4	0	-.821	438
5			5	0	0	NC
6	1	M2	1	0	0	NC
7			2	0	.205	585
8			3	0	.366	328
9			4	0	.497	241
10			5	0	.613	195

USE W12 x 40 FOR 40' GIRDER W/ CANTILEVER

Topic: 16' Column
Date: 5/26/21
Name: Quinn Porter

* Size for unexpected lateral loads by adding 500# horizontally at center

$AT = 5' \times 26' = 130SF$

$DL\ Joist = 26'(10PLF) = 260\#$

$DL\ Girder = 5'(40PLF) = 200\#$

$DL = 6PSF(130SF) + 260\# + 200\# = 1.24k$

$LL = 15PSF(130SF) = 1.95k$

$P_u = 1.2D + 1.6L = 1.2(1.24) + 1.6(1.95) = 4.6k = P_u$

$k_y L_y = 1.0(16') = 16'$

$P = .5k$

$$\frac{L}{360} = \frac{PL^3}{48EI} \qquad = \frac{7.5PL^2}{E}$$

$$I_{req} = \frac{7.5(500)(16^2)(12^2)}{26\times10^6} = 5.32\ in^4$$

Choose HSS 4x4x3/16

$I_x = 6.21\ in^4 > 5.32\ in^4 = I_{req}$ ✓

$\phi_c P_n = 38k > 4.6k = P_u$ ✓

Choose 4' STD PIPE

$I_x = 6.82\ in^4 > 5.32\ in^4 = I_{req}$ ✓

$\phi_c P_n = 40.8k > 4.6k = P_u$ ✓

Topic: 16' Column Cont
Date: 6/8/21
Name: Quinn Porter

Check Both Shapes w/ Eccentricity

HSS 4 x 4 x 3/16

$P = P_u = 4.6k$ $\quad \frac{P}{\phi_c P_n} = \frac{4.6k}{38k} = .121 < .2$ USE H1-2b

$\phi_c P_n = 38k$

$M_u = \frac{5''}{12}(P_u) = \frac{5''}{12}(4.6k) = 1.91k'$

$M_p = \phi Z F_y = .9(3.67 in^3)(50ksi) = 165.15k''$
$= 13.76k'$

$\frac{P}{2P_y} + \frac{M_{pc}}{M_p}$

$\frac{4.6k}{2(38k)} + \frac{1.91k'}{13.76k'} = .2 < 1.0$ ✓

Pipe No. 4 Std

$\frac{P}{\phi_c P_n} = \frac{4.6k}{40.8k} = .11 < .2$ Use H1-2b

$M_p = \phi Z F_y = .9(4.05 in^3)(35ksi) = 127.6k''$
$= 10.6k'$

$\frac{P}{2P_y} + \frac{M_{pc}}{M_p} = \frac{4.6}{2(40.8)} + \frac{1.91k'}{10.6k'} = .237 < 1$ ✓

USE EITHER HSS 4x4x3/16 OR 4' STDPIPE FOR 16' COLUMN

Topic: 10' COLUMN
Date: 6/8/21
Name: Quinn Porter

* Size for unexpected lateral loads by adding 500# horizontally at center

$A_T = 25'(13') = 325\ SF$

Joist Load: $(5' + 5' + 5'/2)(10\ PLF) = 125\#$

Girder Load: $15'(40\ PLF) + 10'(14\ PLF) = 740\#$

$DL = 6\ PSF$

$DL = 6\ PSF(325\ SF) + 125\# + 740\# = 2.82k$

$LL = 15\ PSF(325\ SF) = 4.875k$

$P_u = 1.2D + 1.6L = 1.2(2.82) + 1.6(4.875) = \underline{11.2k = P_u}$

$k_y L_y = 1.0(10') = 10'$

$P = .5k$

$I_{req} = \frac{7.5PL^3}{E} = \frac{7.5(500)(10)^3(12)^3}{26\times10^6} = 2.1 in^4$

Choose $\underline{HSS\ 4\times4\times1/8}$ □

$I_x = 4.4 in^4 > 2.1 in^4$ ✓

$\phi_c P_n = 52.2k > 11.2k = P_u$ ✓

Choose $\underline{3'\ STD\ PIPE}$ ○

$I_x = 2.85 in^4 > 2.1 in^4 = I_{req}$ ✓

$\phi_c P_n = 38.1k > 11.2k = P_u$ ✓

Topic: 10' Cont
Date: 6/8/21
Name: Quinn Porter

Check Both Shapes For Eccentricity

HSS 4x4x1/8

$P = P_u = 11.2k$ $\quad \frac{P}{\phi_c P_n} = \frac{11.2}{522} = .21 > .2$

$\phi_c P_n = 522k$

USE H1-2a

$M_u = \frac{5''}{12}(P_u) = \frac{5''}{12}(11.2k) = 4.66k'$

$M_p = \phi Z F_y = .9(2.56in^3)(50ksi) = 115k''$
$= 9.6k'$

$\frac{P}{2P_y} + \frac{M_{pc}}{M_p}\left(\frac{8}{9}\right) \leq 1$

$\frac{11.2k}{2(522)} + \frac{4.66k'}{9.6k'}\left(\frac{8}{9}\right) = .539 < 1$ ✓

3" STD PIPE

$\frac{P}{\phi_c P_n} = \frac{11.2k}{38.1k} = .294 > .2$ USE H1-2a

$M_p = \phi Z F_y = .9(2.19in^3)(35ksi) = 69k''$
$= 5.75k'$

$\frac{P}{P_y} + \frac{M_{pc}}{M_p}\left(\frac{8}{9}\right)$

$\frac{11.2k}{38.1k} + \frac{4.66k'}{5.75k'}\left(\frac{8}{9}\right) = 1 \leq 1$ ✓

USE EITHER HSS 4x4x1/8 OR 3" STD PIPE FOR 10' COLUMN

Topic: Site Information
Date: 5/12/21
Name: Quinn Porter

Site Information

Take Heart School

Print

1315 10th St room b-27, Sacramento, CA 95814, USA
Latitude, Longitude: 38.5765882, -121.4932368

Date	5/12/2021, 5:53:39 PM
Design Code Reference Document	ASCE7-16
Risk Category	II
Site Class	D - Default (See Section 11.4.3)

Type	Value	Description
S_S	0.568	MCE_R ground motion. (for 0.2 second period)
S_1	0.253	MCE_R ground motion. (for 1.0s period)
S_{MS}	0.764	Site-modified spectral acceleration value
S_{M1}	null -See Section 11.4.8	Site-modified spectral acceleration value
S_{DS}	0.51	Numeric seismic design value at 0.2 second SA
S_{D1}	null -See Section 11.4.8	Numeric seismic design value at 1.0 second SA

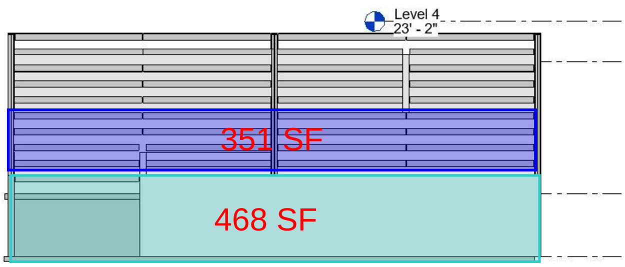
Topic: Lateral Load Takeoffs
Date: 5/13/21
Name: Quinn Porter

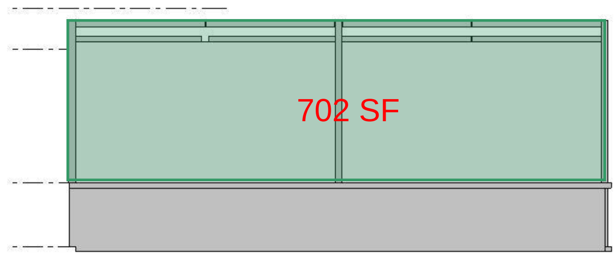
Wind

B/C limited access to site information, assume 20 PSF Wind Load

Estimating Base Shear Wind E/W Direction:

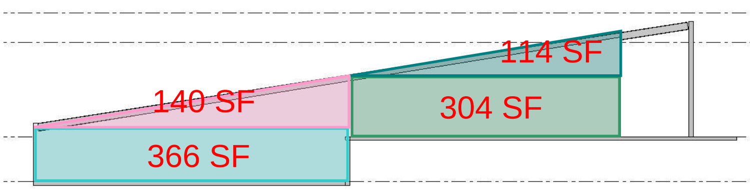
A = 819SF = 351SF+468SF > 702SF
Ve = 829SF * 20PSF = 16.38K

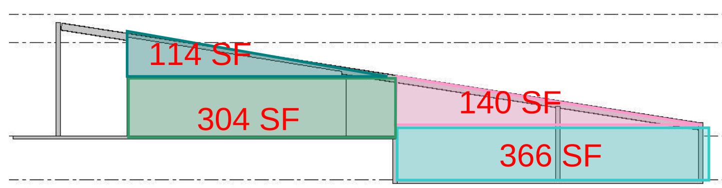




Estimating Base Shear Wind N/S Direction:

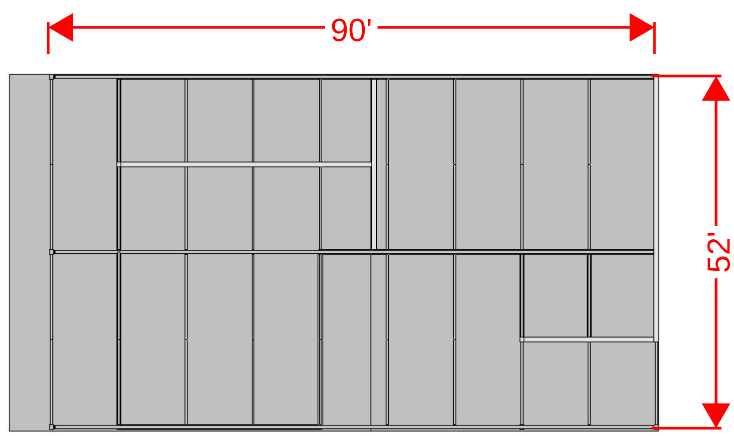
A = 924SF = 114SF + 304SF + 366SF +140SF
Ve = 924SF * 20PSF = 18.48K



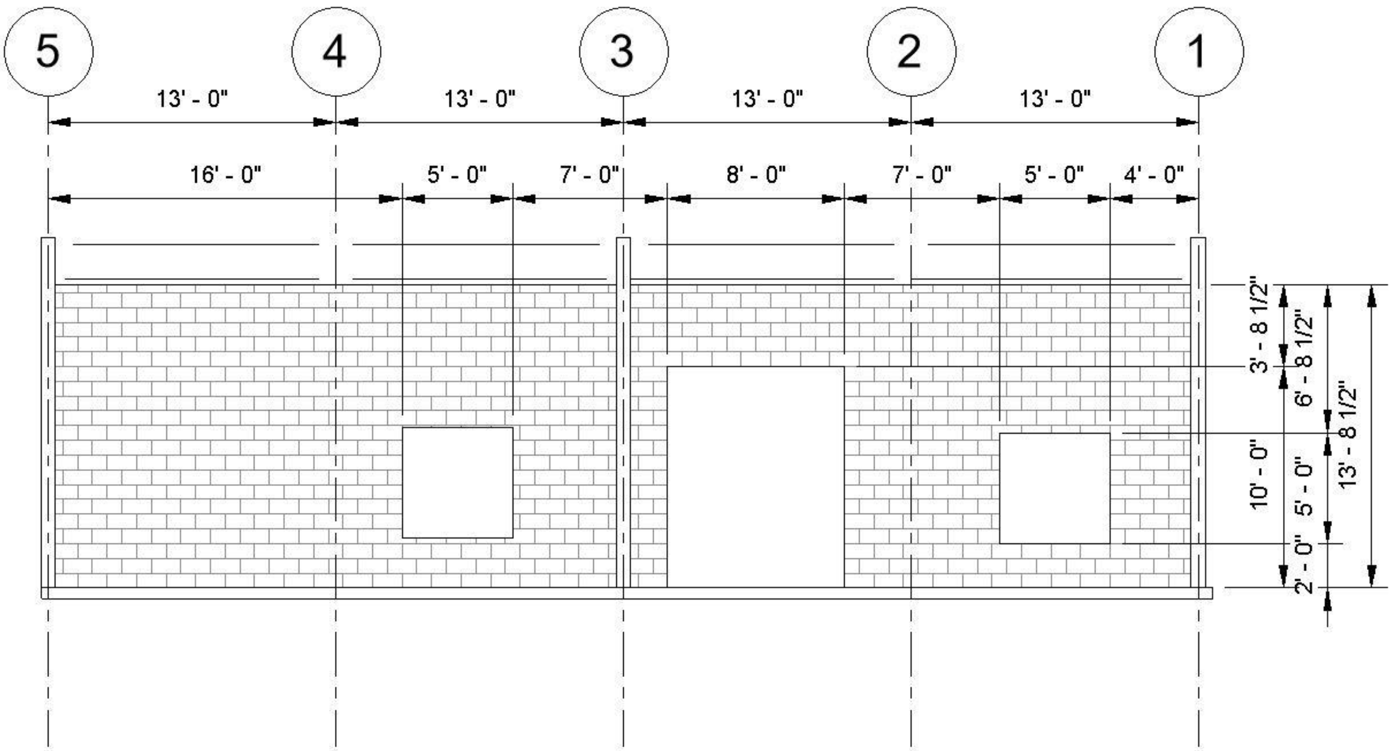


Estimating Seismic Base Shear

SDS = .51
R = 2
I = 1
Wdeck = 4680sf*(2psf) = 4K
WGirders = 40'*22PLF + 20'*26PLF + 140'*34PLF + 70'*43PLF = 9.17K
Wjoists = 468'*26PLF = 12.17K
Wwalls = [13.66'*51.33+2*10'*80'+10.5'*38'+12'*50'+9'*20'+8'*39'+10.33'*13'+8'*26'+8'*26']*78PSF = 339K
Weight = 4K+9.17K+12.17K + 339 = 364.4K
V = =364.34K*(.51)/(2/1) = 93K



Topic: Masonry Wall Design
Date: 6/8/21
Name: Quinn Porter



DESIGN BEARING WALL OUT OF PLANE

WIND LOADING:
Wwall = 20PSF

SEISMIC LOADING:
Wwall = .4*Sds*I*weightwall
Wwall = .4*.51*1*78 = 16PSF

DESIGN MOMENT:
Mu = WL^2/8 = 20PSF(13.66^2)/8 = .467Kft/ft

DESIGN AXIAL LOAD:
Pu = 13.66' / 2 * 1' * 78PSF = .532K/ft

Area Trial = .001bh = .001*(12")*(7.625") =.0915in^2/ft

Try No 4 @ 32* O.C.

Try No 4 @ 32* O.C.

PhiMp = Phi*(C)*(h/2-a/2)
Pu = (0.9-0.2*Sds)Pd
Pu = (0.9-0.2*.51)*(.532K/ft) = 424#/ft
C = AsFy + P
0.8*2*a*12 = 0.2/2.66in^2 * 60 - .424K
=> a = .213"
PhiMp = 0.9*0.8*2*.213*12*(7.63/2-.213/2)
PhiMp = 13.65K-in = 1.14Kft/ft > .467Kft/ft CHECK

USE No.4 @ 32" O.C.

Topic: Masonry Wall Design CONT
Date: 6/8/21
Name: Quinn Porter

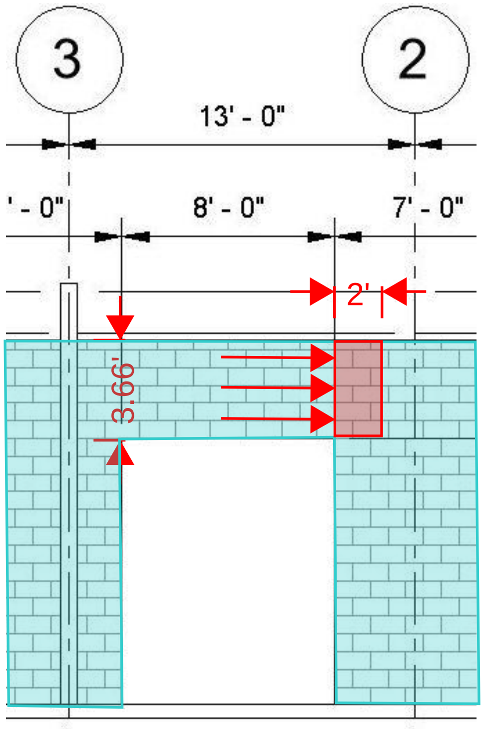
DESIGN BEARING WALL OUT OF PLANE CONT.

CHECK CRACKING:
Mcr = Sxfr
fr = 163PSI - fully grouted joints - TMS 9.1.9.2
Mcr = bt^2/6*fr = (4*12*7.63^2/6) * ((163/1000)/12) = 6.31k-ft
Service Moment = W = .6 * 6.31Kft/ft = 3.79Kft/ft
Mcr = 3.79Kft/ft > .28Kft/ft = Service Moment CHECK

CHECK DEFLECTION:
Du = 5Muh^2/(48EmI)
Du = 5*.467Kft/ft*13.66^2/(48*900*1.5*245) = .000027"
Dallow = .007h TMS Eq 9-32
Dallow = .007 *13.66*12 = 1.15"
Dallow = 1.15" > .000027" = Du CHECK

Topic: Wall Out of Plane
Date: 6/8/21
Name: Quinn Porter

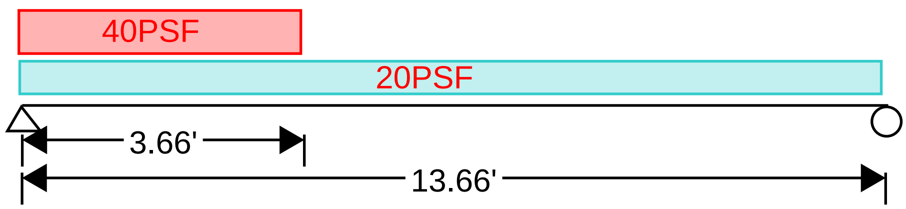
DESIGN BEARING WALL OUT OF PLANE @ DOOR



WIND LOADING:
Wwall = 20PSF

SEISMIC LOADING:
Wwall = .4*Sds*I*weightwall
Wwall = .4*.51*1*78 = 16PSF

DESIGN MOMENT:
At Door we will have extra load for 2 ft on either side of door b/c of surface area of header
AddedLoad = 20PSF*4'/2' = 40PSF



Mu = .611 Kft

DESIGN AXIAL LOAD:
Pu = [(13.66' / 2 * 1') + 4'*3.66'/2] * 78PSF = 1.1K/ft

Area Trial = .001bh = .001*(12")*(7.625")
=.0915in^2/ft

Try No 4 @ 18* O.C.

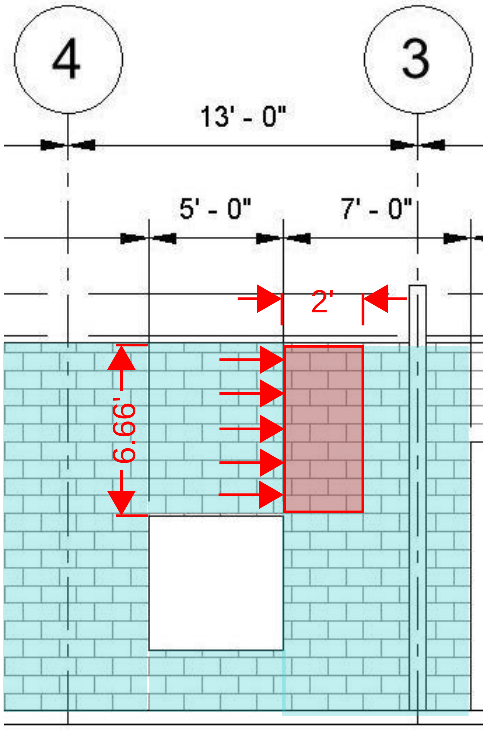
PhiMp = Phi*(C)*(h/2-a/2)
Pu = (0.9-0.2*Sds)Pd
Pu = (0.9-0.2*.51)*(1.1K/ft) = 878#/ft
C = AsFy + P
0.8*2*a*12 = .15in^2 * 60 - .878K
=> a = .423"
PhiMp = 0.9*0.8*2*.423*12*(7.63/2-.423/2)
PhiMp = 26.3K-in = 2.19Kft/ft > .611Kft/ft CHECK

No. 4 @ 18 work, **USE #4 @16** to match spacing of cells

CHECK CRACKING:
Mcr = Sxfr
fr = 163PSI - fully grouted joints - TMS 9.1.9.2
Mcr = 245 / (7.625/2) * ((163/1000)/12) = .436k-ft
Service Moment = W = .6 * .611Kft/ft = 3.66Kft/ft
Mcr = .436Kft/ft > .3.66Kft/ft = Service Moment CHECK

CHECK DEFLECTION:
Du = 5Muh^2/(48EmI)
Du = 5*.611Kft/ft*13.66^2/(48*900*1.5*245) = .000036"
Dallow = .007h TMS Eq 9-32
Dallow = .007 *13.66*12 = 1.15"
Dallow = 1.15" > .000036" = Du CHECK

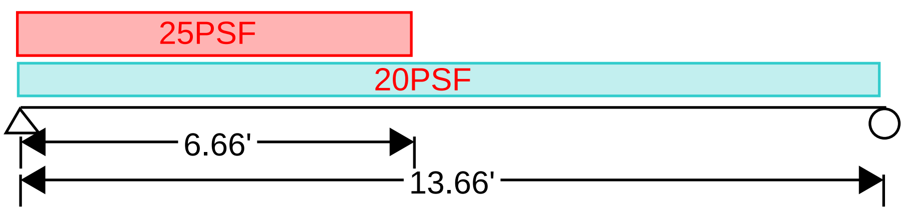
DESIGN BEARING WALL OUT OF PLANE @ DOOR



WIND LOADING:
Wwall = 20PSF

SEISMIC LOADING:
Wwall = .4*Sds*I*weightwall
Wwall = .4*.51*1*78 = 16PSF

DESIGN MOMENT:
At Door we will have extra load for 2 ft on either side of door b/c of surface area of header
AddedLoad = 20PSF*2.5'/2' = 25PSF



Mu = .763 Kft

DESIGN AXIAL LOAD:
Pu = [(13.66' / 2 * 1') + 2.5'*6.66'/2] * 78PSF = 1.2K/ft

Area Trial = .001bh = .001*(12")*(7.625")
=.0915in^2/ft

Try No 4 @ 18* O.C.

PhiMp = Phi*(C)*(h/2-a/2)
Pu = (0.9-0.2*Sds)Pd
Pu = (0.9-0.2*.51)*(1.2K/ft) = 958#/ft
C = AsFy + P
0.8*2*a*12 = .15in^2 * 60 - .958K
=> a = .419"
PhiMp = 0.9*0.8*2*.419*12*(7.63/2-.419/2)
PhiMp = 26.1K-in = 2.19Kft/ft > .611Kft/ft CHECK

CHECK CRACKING:
Mcr = Sxfr
fr = 163PSI - fully grouted joints - TMS 9.1.9.2
Mcr = 245 / (7.625/2) * ((163/1000)/12) = .436k-ft
Service Moment = W = .6 * .763Kft/ft = .458Kft/ft
Mcr = .436Kft/ft < .4.58Kft/ft = Service Moment
We must account for cracking

CHECK DEFLECTION:
Du = 5Muh^2/(48EmI)+5*(Mu-Mcr)^2/(48EmI)
Du = 5*.763Kft/ft*13.66^2/(48*900*1.5*245)
+ 5*(.763Kft/ft-.436Kft/ft)*13.66^2/(48*900*1.5*245)
= .000467"
Dallow = .007h TMS Eq 9-32
Dallow = .007 *13.66*12 = 1.15"
Dallow = 1.15" > .000467" = Du CHECK

4 @ 18" O.C. work, **use #4 @16" O.C.** to match cell spacing

Topic: Story Forces
Date: 6/8/21
Name: Quinn Porter

DETERMINATION STORY FORCES

PROJECT NAME: Take Heart
PROJECT NAME: Senior Project
PROJECT LOCATION: Kenya

Mapped Spectral Accelerations (%g)	
Site Class D	
Ss =	0.568
S1 =	0.253

Site Coefficients (%g)		
Design Site Class	Fa	Fv
	Table 11.4-1	Table 11.4-2
D - Default	1.2	1.50

Adjusted Maximum Considered EQ (MCE) Spectral Response Acceleration Parameters (ASCE 7-16 / 11.4.4)

SMS = Fa*Ss =	0.6816
SM1 = Fv*S1 =	0.3795

Design Spectral Acceleration Parameters (ASCE 7-16 / 11.4.5)

SDS = 2/3*SMS =	0.4544
SD1 = 2/3*SM1 =	0.2530

Design Coefficients and Factors for Seismic Force-Resisting System (ASCE 7-16 / 12.2)

Response Modification Coefficient, R	5
System Overstrength Factor, Ω_0	2.5
Deflection Amplification Factor, C_d	1.75
System Limitations (ft)	NP

Importance Factor (ASCE 7-16 / 1.5.2)

Nature of Occupancy per Table 16041.5:
Buildings and other structures except those listed in Risk Categories I, III and IV

Occupancy Category:	II
Importance Factor, I:	1.0

Seismic Design Category (ASCE 7-16 / 11.6)

Design Category based on S1:	N/A	S1 < 0.75
Design Category based on SDS:	D	*T 11.6-1*
Design Category based on SD1:	D	*T 11.6-2*
Design Seismic Design Category:	**D**	

Period Determination (ASCE 7-16 / 12.8.2)

Structure Type:

Ct =	0.02		*T12.8-2*
x =	0.75		*T12.8-2*
h_n =	11	ft	ht. above the base
T=Ta=Ct*(hn)^x =	0.12080	sec	*EQN 12.8-7*
TL =	12		*FIG 22-14*

Seismic Response Coefficient

ρ =	1	*SECT 12.3.4.2 (SDC* *removal of one wall results in only 25% reduction in strength
Cs = SDS/(R/I) =	**0.091**	*EQN 12.8-2*
For T<=TL: Cs, max = SD1/(T*R/I) =	0.419	*EQN 12.8-3*
For T>TL : Cs, max = SD1*TL/(T2 *R/I) =	N/A	*EQN 12.8-4*
Cs,min = 0.044*SDS*I >= 0.01	0.020	*EQN 12.8-5*
For S1>=0.6g: Cs min = 0.5*S1/(R/I) =	0.025	*EQN 12.8-6*
V = ρ*Cs*W =	**0.091 * W**	STRENGTH

Topic: Story Forces CONT.
Date: 6/8/21
Name: Quinn Porter

DETERMINATION STORY FORCES CONT.

Building Weight

Item	Weight (K) *See Calculation Packedt for determination of values
Decking	4
Girders	9.17
Joists	12.17
Walls	339
∑	**364.34**

Story Forces and Diaphram Forces

		N/S & E/W			Cvx	Fx = Cvx*V	Fx	ΣFx	Ax (coeff.)	**Cs**
Level	Wx (kips)	ΣWx (kips)	hx (ft)	Wx*hx^k	Wx*hx^k/Σ(wx*hx^k)	Coefficient * W	(kips)	(kips)	Fx/Wx (%g)	**0.091**
Roof	364.34	364.34	11	4007.74	1	0.091*W	33.15494	33	**0.091**	
∑	364.34			4007.74	1	0.091*W	**33.15494**			

1' STRIP E/W wt x Ax

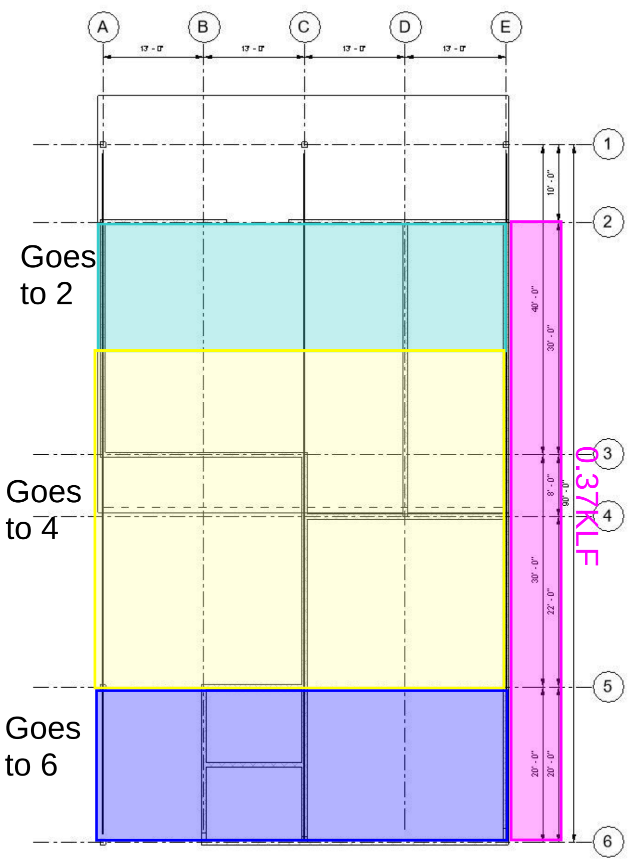
Weight (k)	Ax	Wt x Ax	Total / 1' strip (Kip/ft)
364.34	0.091	33.15494	**0.368388222**

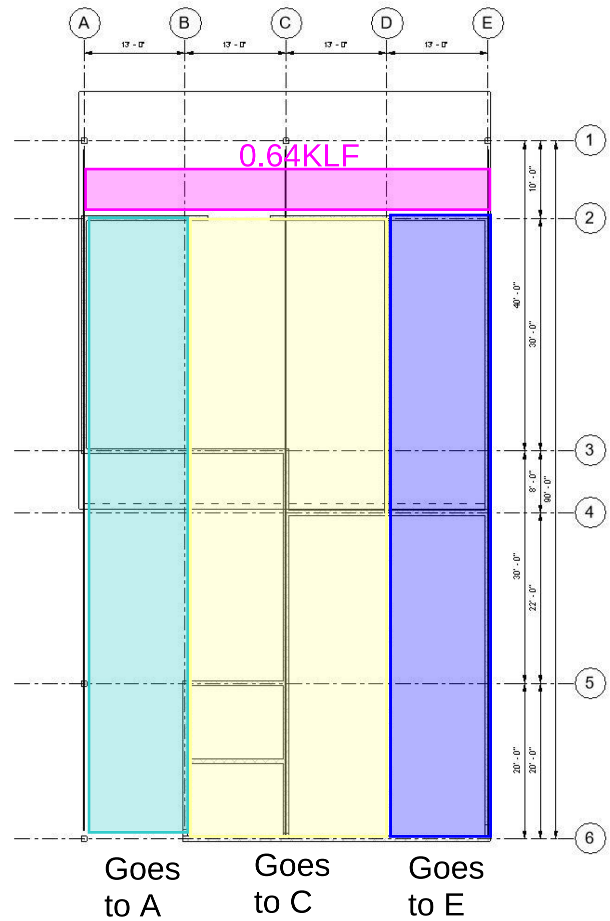
1' STRIP N/S wt x Ax

Weight (k)	Ax	Wt x Ax	Total / 1' strip (Kip/ft)
364.34	0.091	33.15494	**0.637595**

Topic: Story Force Distribution
Date: 6/8/21
Name: Quinn Porter

DISTRIBUTION OF STORY FORCES TO WALL LINES





SHEAR ON WALL 2:
20' * 0.37KLF / 52' = 142PLF

SHEAR ON WALL 4:
55' * 0.37KLF / 26' = 783PLF

SHEAR ON WALL 6:
25' * 0.37KLF / 39' = 237PLF

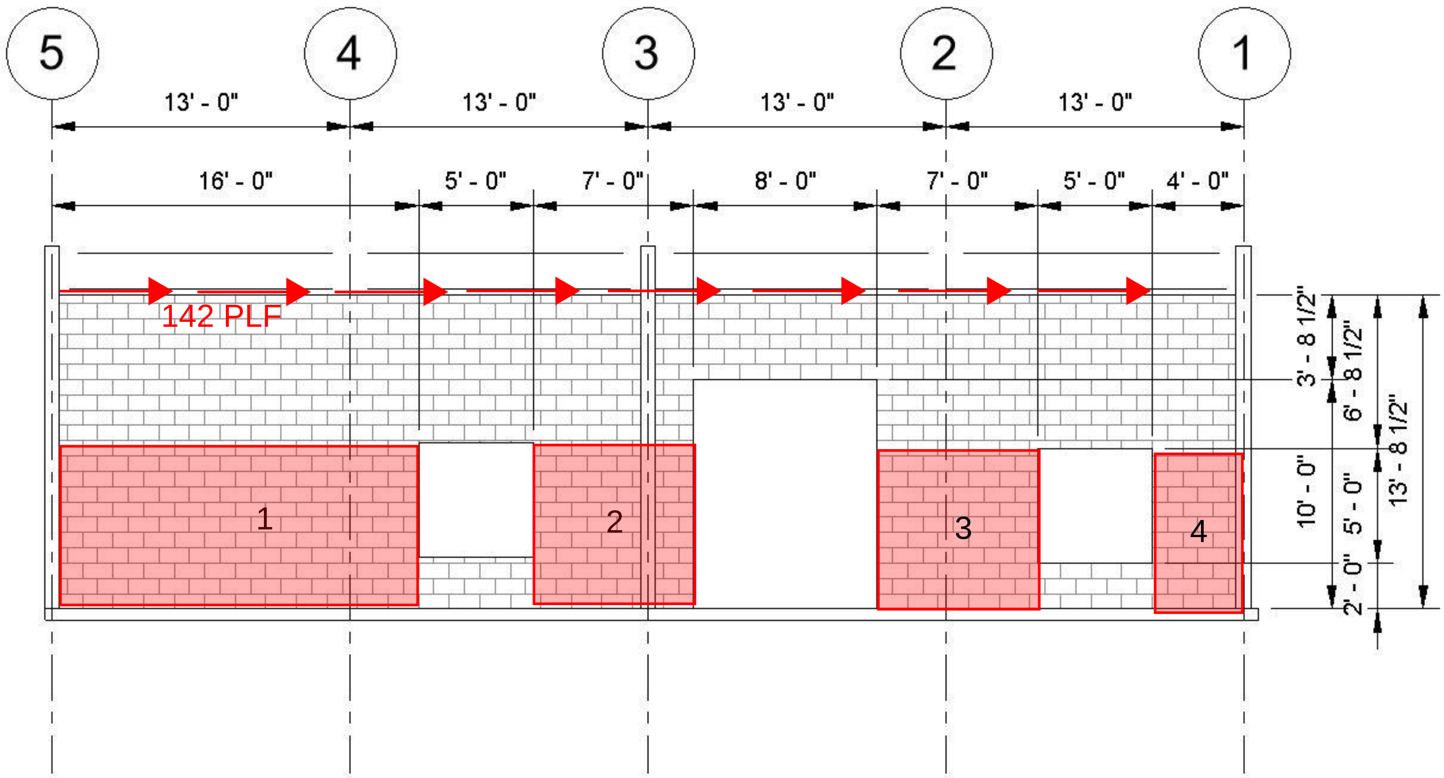
SHEAR ON WALL A:
13' * 0.64KLF / 30' = 277PLF

SHEAR ON WALL C:
26' * 0.64KLF / 50' = 333PLF

SHEAR ON WALL 6:
13' * 0.64KLF / 90' = 92PLF

Topic: In Plane Shear Design
Date: 6/8/21
Name: Quinn Porter

CHECK IN PLANE SHEAR



R = 1/(E*t)((H/L)^3+3*(H/L))

R1 = 1/(E*t)*((7'/16')^3+3*(7'/16')) = .716
R2 = 1/(E*t)*((7'/7')^3+3*(7'/7')) = .25
R3 = 1/(E*t)*((7'/7')^3+3*(7'/7')) = .25
R4 = 1/(E*t)*((7'/4')^3+3*(7'/4')) = .094

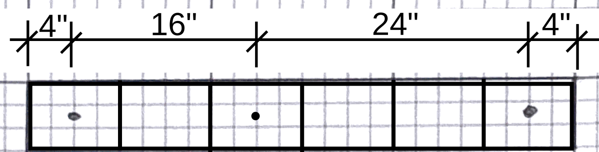
R1+R2+R3+R4 = .77

We will check pier 4

V' = .094 / .77 * 142PLF * 52' = .9K

Topic: Inplane Shear Wall
Date: 5/26/21
Name: QP

Check In Plane Pier 4



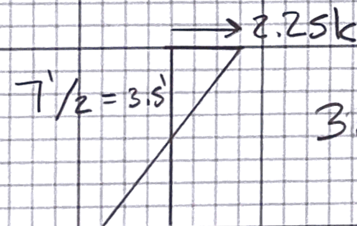
$$a = \frac{A_s f_y}{.8 f'_m b} = \frac{3(.2)(60\text{ksi})}{.8(2.5\text{ksi})(7.625")} = 2.36"$$

$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$

$$= 3(.2\text{in}^2)(60\text{ksi})\left(\frac{2}{3}(48") - \frac{2.36"}{2}\right)$$

$$= 1110 \text{ k-in} = 92.46 \text{ kft}$$

$$\Rightarrow \phi M_n = 83.2 \text{ k}'$$



$$3.5'(2.25\text{k}) = 7.875 \text{ k-ft} = M_u$$

$$\phi M_n = 83.2\text{k}' > 8\text{k}' = M_u \checkmark$$

Topic: In Plane Shear Wall Cont
Date: 5/26/21
Name: QP

Check Shear

$V_u = 1.25\left(\frac{\phi M_n}{M_u}\right)V' = 1.25\left(\frac{83.2k'}{8k'}\right)2.25k$

$V_u = 29.25k$

$V_{nmax} = 4A_n\sqrt{f'_m}$

$= 4(7.63''(48'') - 3(.2))\sqrt{2500}$

$= 70.54k$

$V_{nmax} = 70.54k > 29.25k = V_u$ ✓

$\phi V_{nm} = .8(2.25)(A_n)\sqrt{f'_m}$

$= .8(2.25)(7.63''(48'') - 3(.2in^2))\sqrt{2500}$

$= 32.9k$

$\phi V_{nm} = 32.9k > 29.25k = V_u$ ✓

Topic: Foundation Design
Date: 5/28/21
Name: QP

FOUNDATION DESIGN

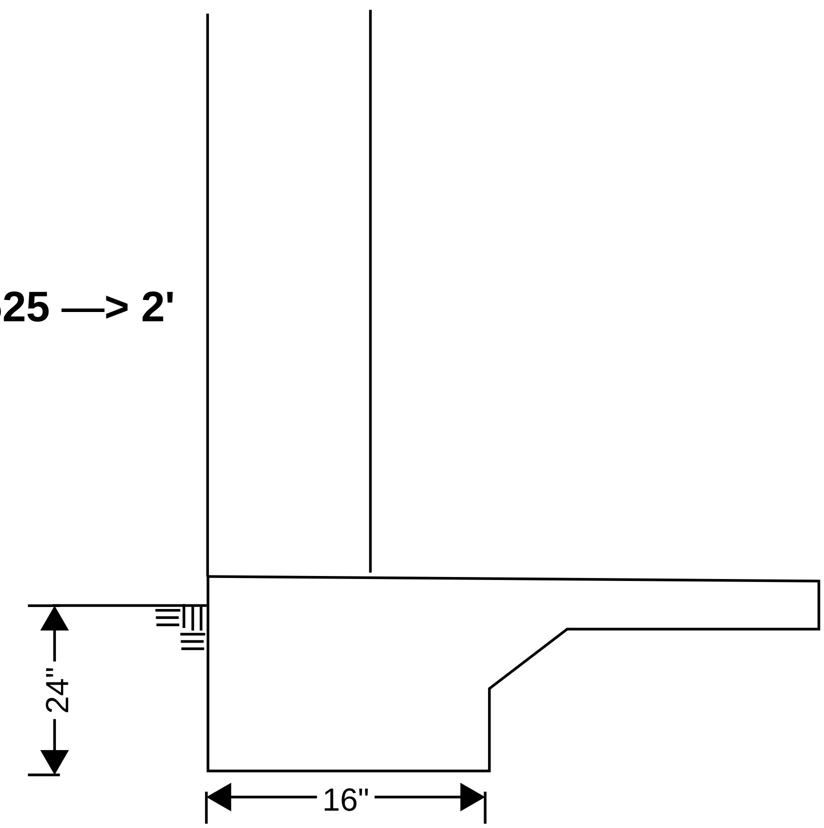
tions 1809.9.1 and 1809.9.2, and the provisions of Chapter 21.

Exception: Where a specific design is not provided, masonry-unit footings supporting walls of light-frame construction shall be permitted to be designed in accordance with Table 1809.7.

1809.9.1 Dimensions. Masonry-unit footings shall be laid in Type M or S mortar complying with Section 2103.2.1 and the depth shall be not less than twice the projection beyond the wall, pier or column. The width shall be not less than 8 inches (203 mm) wider than the wall supported thereon.

1809.9.2 Offsets. The maximum offset of each course in brick foundation walls stepped up from the footings shall be $1\frac{1}{2}$ inches (38 mm) where laid in single courses, and 3 inches (76 mm) where laid in double courses.

Width = 7.625+8 = 15.625 —> 1'-4"
Depth = 2*(15.625-(7.625/2)) = 23.625 —> 2'



Topic: Diaphragm Design
Date: 6/8/21
Name: Quinn Porter

DIAPHRAGM DESIGN

N/S Direction
VE = VF = 1/2*0.64*52FT/90FT = 185PLF
.7VE = 0.7*185PLF = 129PLF

E/W Direction
VE = VF = 1/2*0.37*90FT/52FT = 320PLF
.7VE = 0.7*320PLF = 224PLF

Shear in E/W will govern B/C larger load with shorter distribution length
Shear along gridline 2 = 11340#/52' = 218PLF
Shear along gridline 6 = 8820#/39' = 226PLF

Choose SDI Screws
673#/2'O.C. = 336.5PLF > 226PLF CHECK

USE SDI RECOGNIZED SCREWS EVERY 2' O.C.

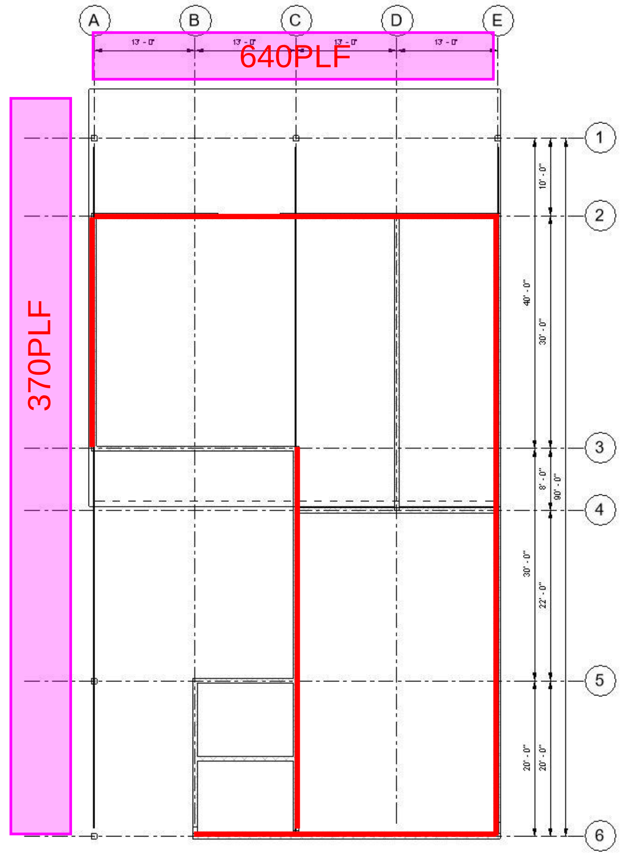


Table 4: Allowable Shear Strength (lbs/connection) for Arc Spot Welds. Arc Seam Welds, Hilti Fasteners, Pneutek Fasteners and SDI Recognized Screws for Verco Deck Panel Support Connections

Deck Gage	Profile	BMT	ARC SPOT WELD	ARC SEAM WELD	HILTI X-ENDK22 or X-HSN 24	HILTI X-ENP-19	PNEUTEK SDK61	PNEUTEK SDK63	PNEUTEK K64	PNEUTEK K66	SDI RECOGNIZED SCREWS
		(in.)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
22	B & N	0.0299	783	1231	603	650	618	691	694	736	561
20	B & N	0.0359	1091	1491	720	775	733	791	886	903	673
18	B & N	0.0478	1850	2017	947	1020	951	967	1204	1253	896
16	B & N	0.0598	2309	2564	1169	1259	1158	1125	1474	1630	1121

Topic: Pilaster Design
Date: 6/8/21
Name: Quinn Porter

TA = 26' × (15' + 20') = 920 SF

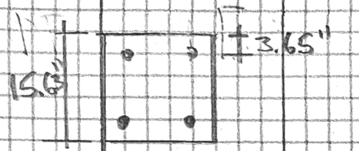
DL Joist = 26'(10 PLF) = 260#

DL Girder = 35'(40 PLF) = 1400#

DL = 6 PSF (920 SF) + 260# + 1400# = 7.18k

LL = 15 PSF (920 SF) = 13.8k

$P_u = 1.2(7.18k) + 1.6(13.8) = 30.696k \approx \underline{31k}$



$f'_m = 2ksi$

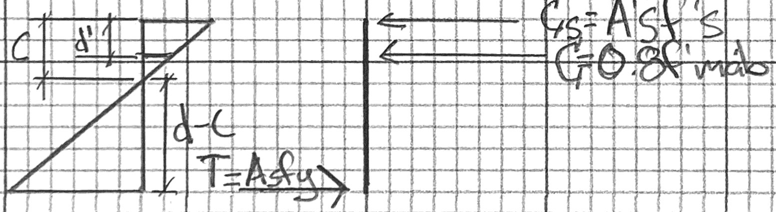
$A_s = .44 in^2$

Try 4 #6

$\phi P_n = .9(.8)[f'_m(A_n - A_s) + f_y A_s]$

$\phi P_n = .9(.8)(2ksi(15.63^2 - 4(.44 in^2)) + 60ksi(4(.44)))$

$\phi P_n = 425k > 31k = P_u$ ✓



$\Sigma F_x = A_s f_y - A'_s f'_c - .8 f'_m a b = 0$

$0 = .88(60) - .88[.0025 \frac{c - 3.625}{c} 29000] - 0.8(2)[.8c(15.63) - 4(.44)]$

$\Rightarrow c = 3.2 in$

Topic: Pilaster Design CONT
Date: 6/8/21
Name: Quinn Porter

$\phi M_n = .9\left[.88(60)(12-3.2)\right] + .88\left[.0025\,\frac{3.2-3.625}{3.2}(29000)\right]3.2$
$+ .8(2)\left[.8(3.2)(15.63)\left(3.625 - \frac{3.2}{2}\right)\right]$

$\phi M_n = 418.176 - 2.7115 + 27.2087$

$\phi M_n = 442.67\ \text{k-in} = \boxed{36.89\,k' = \phi M_n}$

$P_b = f_y A_s + \varepsilon_m\left[\frac{d'-c}{c}\right]\varepsilon_s A_s - .64 f'_m b c$

$= 60(.88)_{(1)} + .0025\left[\frac{3.625-3.2}{3.2}\right]_{(2)} 29000(.88) - .64(2)(15.63)(3.2)_{(3)}$

$= 52.8 + 8.47 - 64.02$

$P_b = 19.69k$

$\phi P_b = 17.72k$

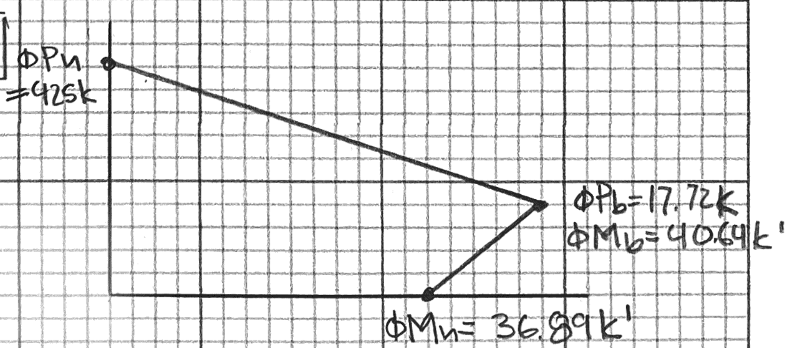
$M_b = (1)\left[12 - \frac{15.63}{2}\right] + (2)\left[\frac{15.63}{2} - \frac{a}{2}\right] + (3)\left[\frac{15.63}{2} - d'\right]$

$M_b = 52.8\left[12 - \frac{15.63}{2}\right] + 8.47\left[\frac{15.63}{2} - \frac{3.2}{2}\right]$
$+ 64.02\left[\frac{15.63}{2} - 3.625\right]$

$M_b = 220.968 + 52.64 + 268.24$

$M_b = 541.85k'' = 45.15k'$

$\boxed{\phi M_b = 40.64k'}$



Take Heart School

Migori, Kenya

By: Quinn Porter
Advisor: Kevin Dong

The Team

Quinn Porter

ARCE

Spencer Mishky

CAL POLY
SAN LUIS OBISPO
Construction Mangement

Janelle Tatari

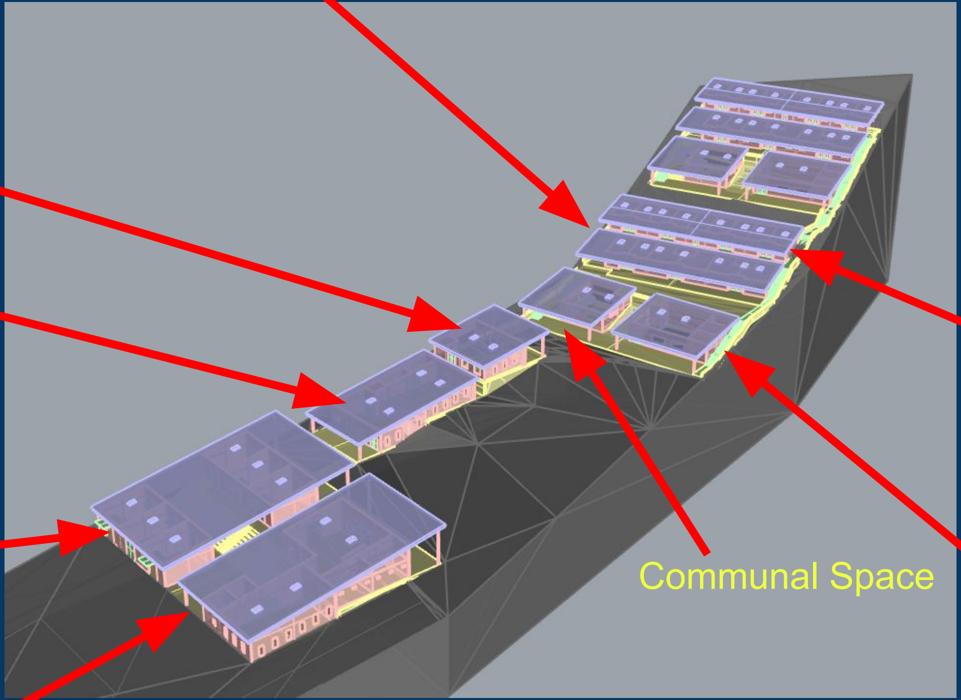
DISCERE FACIENDO
CAL POLY
Architecture

Scope

- 3 acre sloped site, surrounded by agriculture and empty land
- Located near a small rural village
- Buildings:
  - School with 8 classrooms
  - Housing
  - Cafeteria
  - Program space

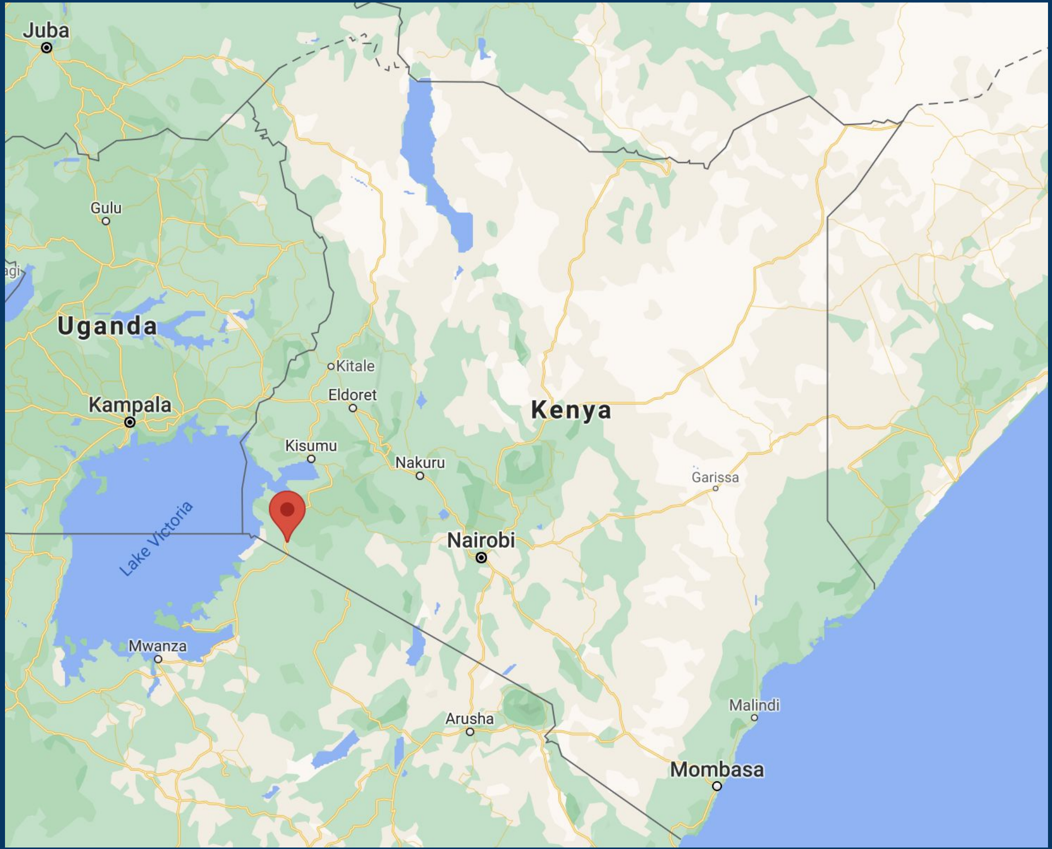
- Design Considerations:
  - Maximise View out to the west
  - Maximise use of shaded outdoor space

Site Layout


Housing
Dining hall
Dining hall
Housing
8 Classrooms
Communal Space
Multi Purpose
Offices and
Library

Assumptions

- Site Assumptions
- Loading
- Materials



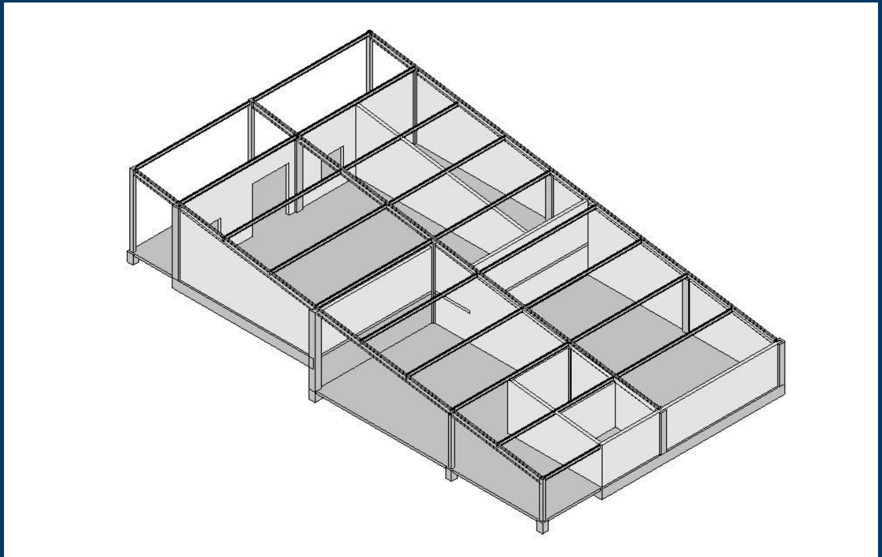
Specifications

Roof/Gravity System

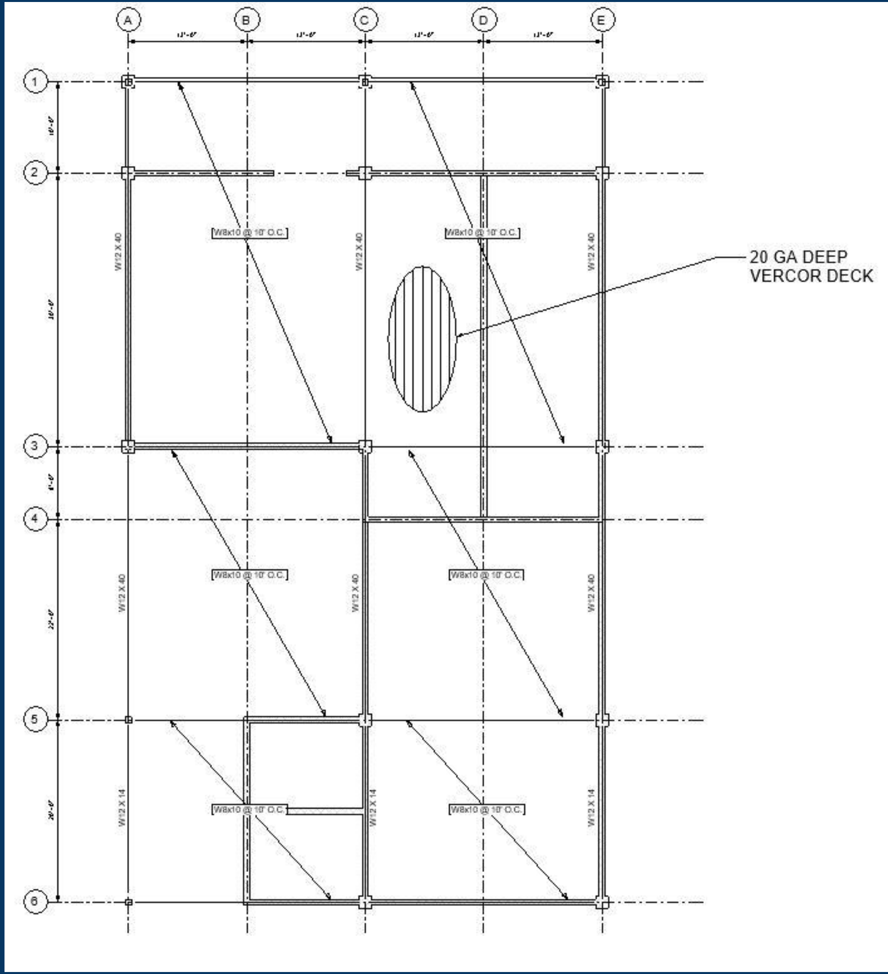
- Steel Decking
- Steel wide flange beams/girder
- Steel columns & Masonry pilasters

Lateral System

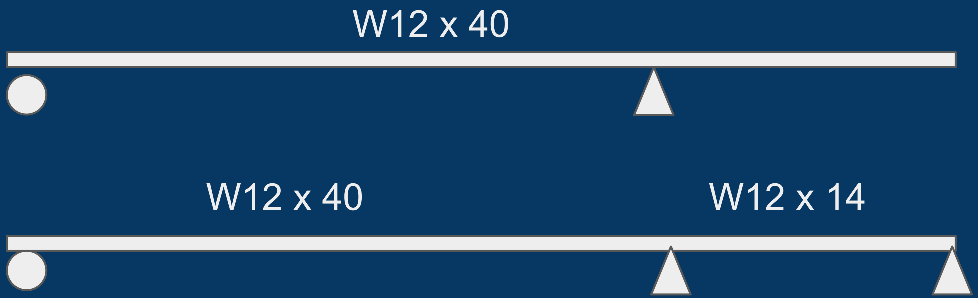
- Reinforced masonry shear walls
- Used standard CMU

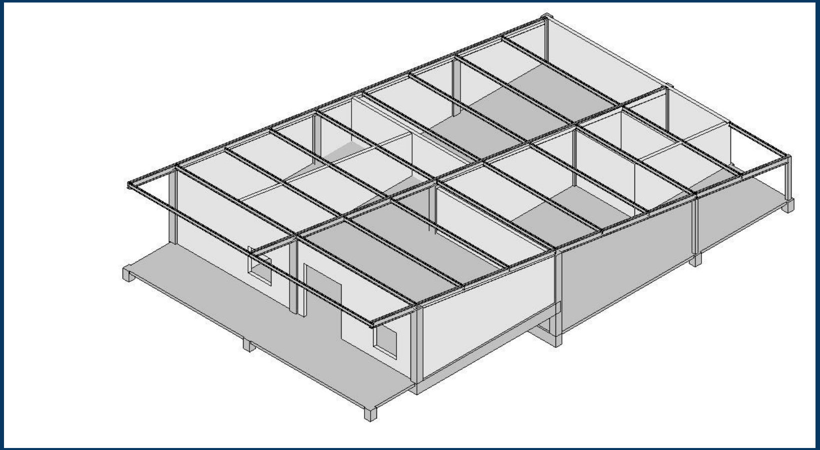


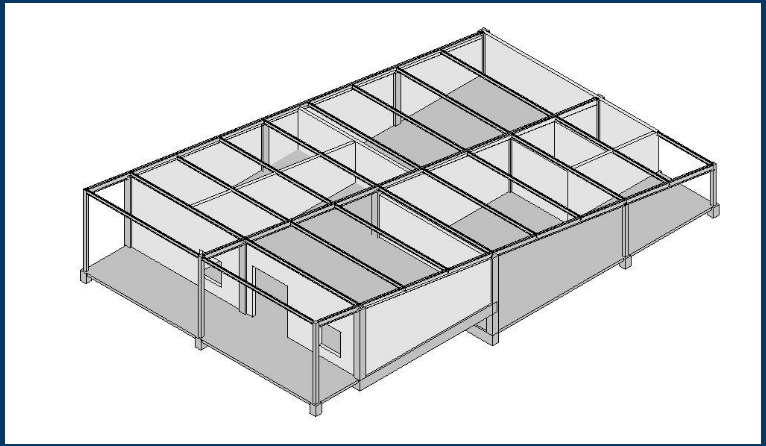
Gravity Design



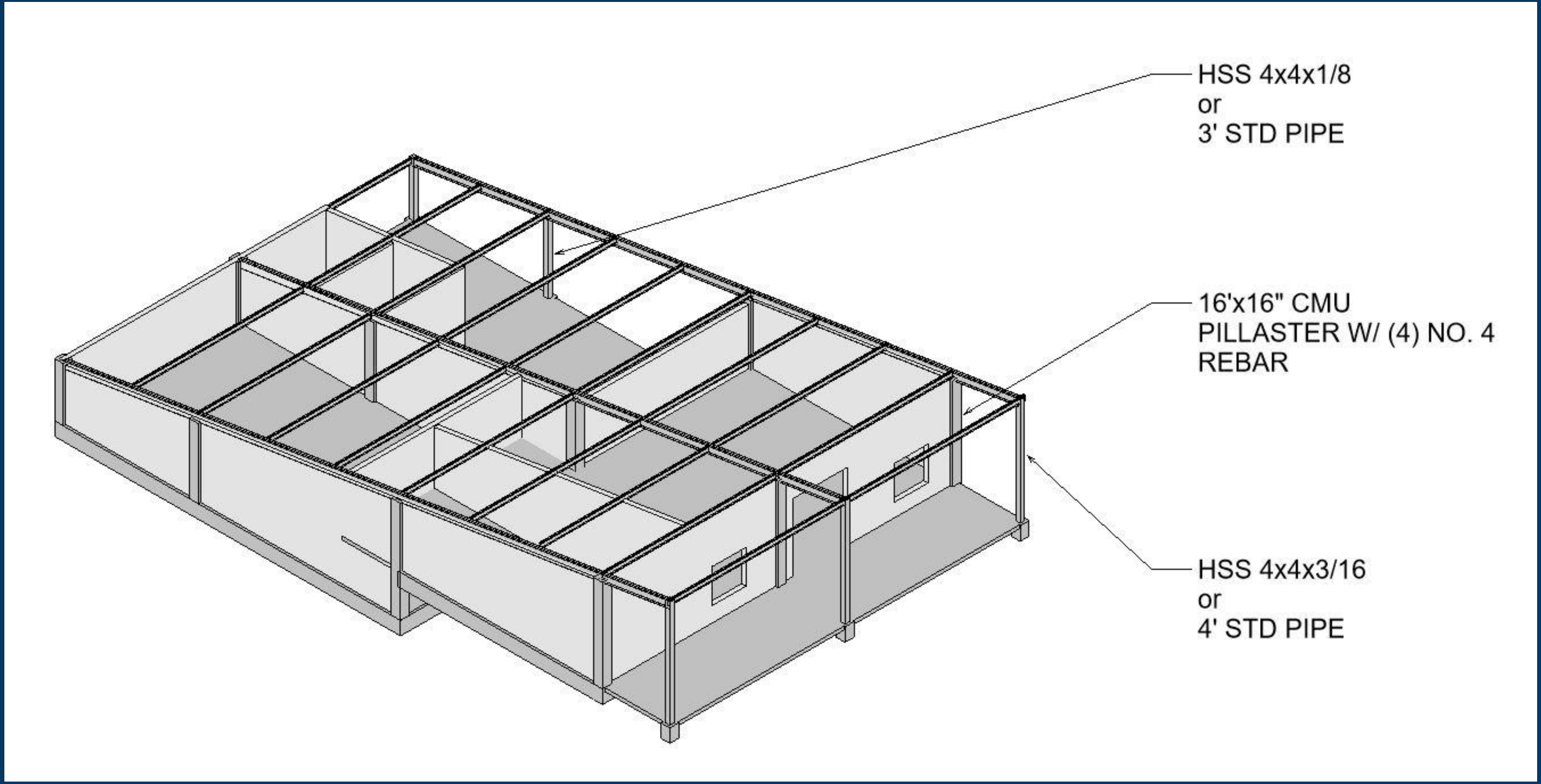
Roof Design Considerations







Gravity Design Continued

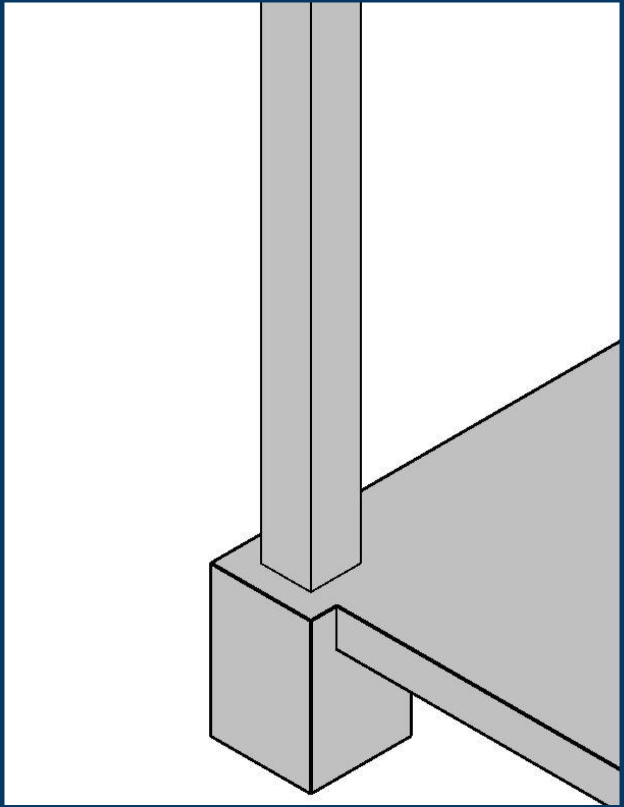


Column Design Considerations

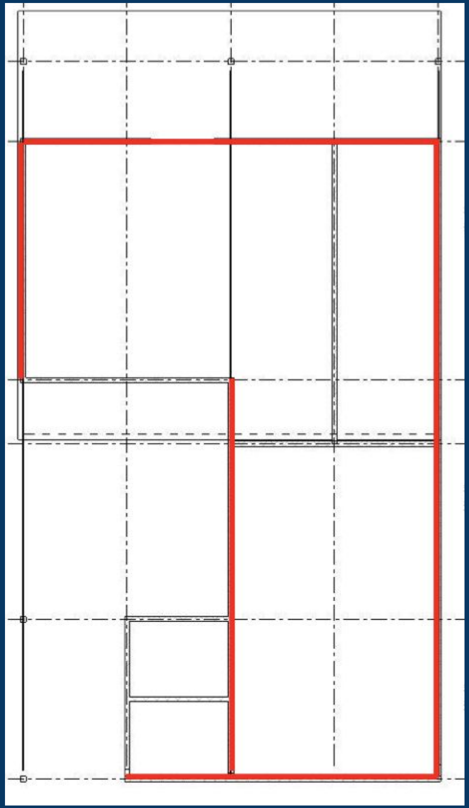
Concerned about available materials

Two Options for 10ft Column
- HSS 4x4x1/8
- 3’ STD. PIPE

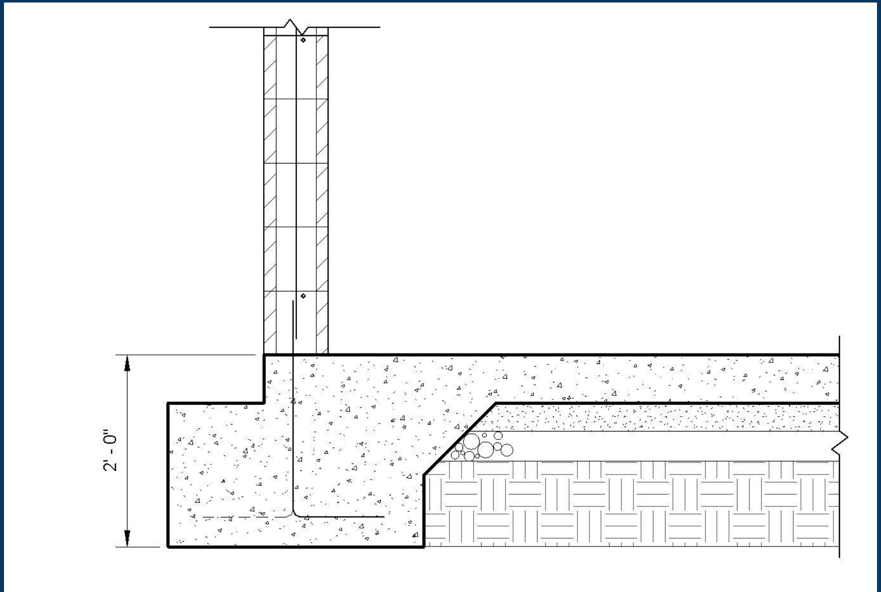
Two Options for 16ft Column
- HSS 4x4x3/16
- 4’ STD. PIPE

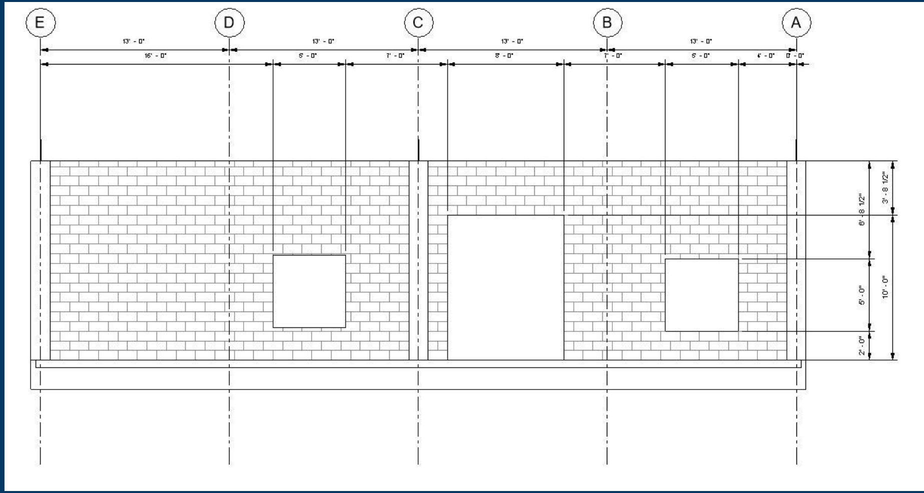


Lateral Design



Lateral Design Cont.





Lessons Learned

- The importance of communication and relationships
- The client does not always know what they want
- The luxury of materials/construction techniques we have here in the US

Next Steps

- Send Plans to Architect and Engineer in Kenya
- Client has gone rogue and hired their own architect
- Plans may merge, but the outlook for this project to be built in any way that resembles our design is pretty low

Questions