

CHIEDZA STEWARDSHIP CENTER

ZIMBABWE



CAL POLY

Written By:

ROBERT GARLAND

Advised By:

JAMES MWANGI

TABLE OF CONTENTS

ABSTRACT	2
INTRODUCTION.....	3
PROJECT DESCRIPTION	4
DELIVERABLES	6
CHALLENGES	7
IMPACT	8
CONCLUSION	10
PERSONAL REFLECTIONS	11
APPENDIX A - STRUCTURAL CALCULATIONS	A1
APPENDIX B - STRUCTURAL DRAWINGS	B1
APPENDIX C - PROJECT PRESENTATION SLIDES	C1

ABSTRACT

Journeyman International (JI) is a non-profit organization that supports humanitarian projects in countries all around the world by pairing design professionals and overseeing the design and construction of the projects. The Chiedza Stewardship Center is the first phase of a project supported by East African Power and Foundations for Farming. The project is planned to include 200 hectares of a solar farm, 50 homesteads, and a community center including a stewardship center. This project and this report focus on the structural design of the stewardship center. This stewardship center will allow Foundations for Farming to be able to teach local people zero tillage farming around the area of Lake Chivero in Zimbabwe. The design of the structure includes an office, meeting space, a large indoor classroom, and an outdoor classroom. The space is open and all under one single roof, while the outdoor classroom opens directly to agricultural training fields. The design team consisted of one architecture student and one architectural engineering student. This report will focus primarily on the structural design while covering background, research, impact, structural design calculations, and structural drawings for the Chiedza Stewardship Center.

INTRODUCTION

Journeyman International (JI) is a non-profit organization that focused on "building what matters most" all across the globe. They accomplish this by overseeing and mentoring architects and architectural engineers through the design and construction of humanitarian projects. This report focuses on the structural design process of the Chiedza Stewardship Center by an architectural engineering student, Robert Garland.



A large aspect of the design is the location of the project. The site is located in rural central Zimbabwe near Lake Chivero. There are a few existing structures already located on the site; this includes an old farmhouse and a few adjacent storage structures. None of these buildings will be considered in the final phase of the project. Although it may be rural, the location of the project is only around an hour from the capital, Harare. Because the capital is so close, acquiring steel shapes and reinforcing will not be an issue.

Also, because it was located in Zimbabwe, special considerations had to be examined. Many of their building practices are different from the design that is taught here in the US. For this reason, specifications became extremely important, especially involving the concrete and masonry detailing.

PROJECT DESCRIPTION

The design team for this project consisted of two California Polytechnic State University, San Luis Obispo (Cal Poly) students. Hannah Oitzman is a fifth-year architecture student and Robert Garland is a fourth-year architectural engineering student. The team's goal was to deliver a practical and safe structure that would be respectful to the local culture. In doing so, the team was careful to "help without hurting" by designing in a way that residents would take pride and ownership in the Chiedza Stewardship Center.

The location for this structure was chosen off of a site provided to the design team by East African Power and Foundations for Farming. This site came from a grant from the Zimbabwe government for more solar energy and agricultural training.

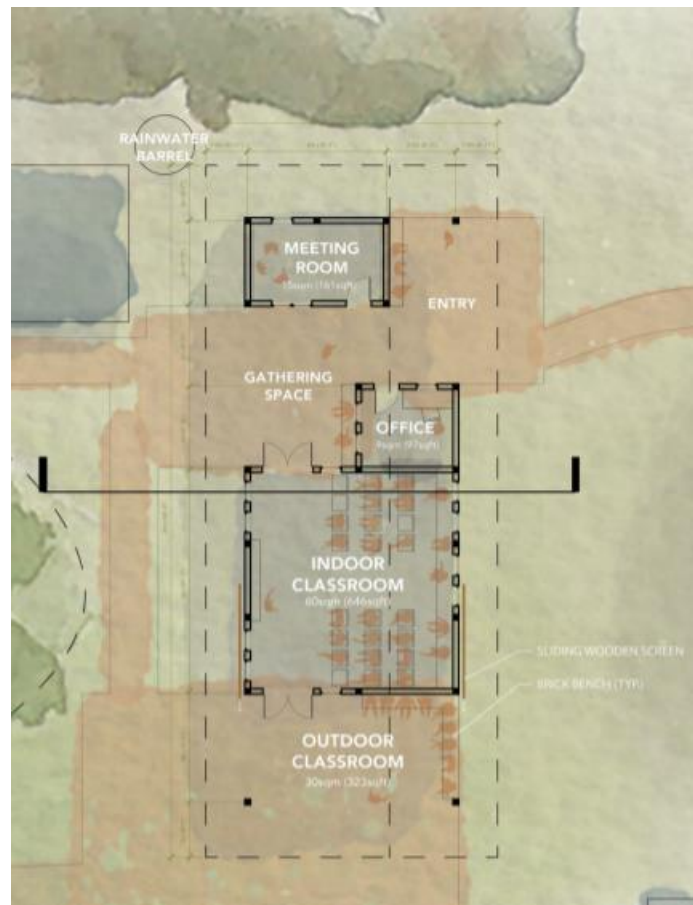


Image via Hannah Oitzman

On the site, Hannah Oitzman created a master plan for all phases of the project, and through this settled on a location near the center of the large site.

The proposed building has four main spaces: a meeting or conference room, an office space, a large indoor classroom, and an outdoor area designated to host lessons outdoors. The goal was to maximize the interior space of the classroom to make the space more flexible for larger class sizes or any future needs.

Through looking at local vernacular, it was decided that the structural system would be confined masonry with a steel-framed roof structure. The masonry to be used was chosen to be made by local people in a way that is already familiar with them, instead of buying and importing bricks from outside business. A clearstory window was added to improve air circulation and provide natural light to the indoor classroom. To



Rendering by Hannah Oitzman

keep the floor plan as flexible as possible, it was decided early on that there should be no structural elements along with the interior of the structure or where a wall did not already exist. The overall architectural vision was to be "open and clean" without too much intrusion of structural elements where it was avoidable.

DELIVERABLES

Structural calculations were provided for the Chiedza Stewardship Center in Appendix A and the corresponding structural drawings are compiled in Appendix B. These calculations and drawings are specific to this structure and must be reviewed by a local architect/engineer in Zimbabwe.

The design process began with calculating preliminary member sizes based on gravity design. A load take off was compiled with estimates based on local materials and construction practices. The American Concrete Institute (ACI) 318-04 codebook was used to help design the concrete members. The American Institute of Steel Construction (AISC) 15th Edition Steel Construction Manual was heavily used for the design of any structural steel members. Finally, the Design Guidelines for Confined Masonry Buildings by Ajay Chourasia was used for the design of the confined masonry portion of the structure.

For the slab on grade, a local building expert recommended the use of a 4-inch slab with #3 rebar at 12 inches on center each way.

Seismic forces were found to control lateral design over wind due to a high building weight from the masonry walls. The confined masonry was designed to accommodate for the total base shear 105 kips. The calculations for this can be found in Appendix A.

To be as clear as possible, the drawings and original design were created to favor metric units. However, throughout calculations for clarity among American designers, English units were used and then converted to metric.

CHALLENGES

Many challenges needed to be overcome to produce a complete and safe design. A large problem was understanding a building system that is not taught in the United States. Many of the codes used had no data on confined masonry and thus assumptions had to be made. Also, designers learned a completely new way of designing and sizing of members based on documentation written for a different continent.

Additionally, the construction process in Zimbabwe significantly differs from that in the United States. To design a successful structure, allowances for local building techniques had to be made while still maintaining safer detailing practices. To achieve such a design, the Cal Poly students relied heavily on faculty advisors and professors with knowledge of construction in African countries.

Another important challenge was the interdisciplinary collaboration that took place on this project. Throughout the design development, Hannah Oitzman and Robert Garland met weekly to create a design that met both party's goals.

Finally, this project was heavily impacted by the COVID-19 global pandemic. Without access to the tools and programs they were taught with, the design team had

to do much of the work either by hand or by using other methods of analysis. Due to this situation, no computer analysis was able to be conducted as the personal laptop owned by Robert Garland could not run such advanced programs. Also due to the COVID-19 situation, meetings with faculty advisors and other students were impacted and created for a very isolating design process.

IMPACT

The impact of this project will be felt worldwide. Journeyman International and Cal Poly created a space for student architects and engineers to grow their skills while impacting a small village in rural Zimbabwe.



Globally, this structure is the first in a phase for what may become its own village, it is nearly impossible to say how far-reaching this project may be. In the short run, it will create a space for local farmers to learn better ways of farming. This will spread to many of the existing local villages and in time the country as a whole.

Economically, the Chiedza Stewardship Center can drastically change the lives of those who attend the Foundations for Farming lessons. For many in Zimbabwe, farming is their only means of income. In this way, their very livelihood will be drastically altered due to the construction of this project. Also, materials were specifically chosen to be made or purchased locally. This will promote local economic growth and investment.

Culturally, it was incredibly important to the design team that the building produced would honor the local culture and not intrude upon their customs. As this structure will function as a community center (until a more specifically designed structure is constructed) this truly could be the most important building to the local culture. For this reason, many of the spaces were designed to function as more than their original intent. Outdoor seating and teaching spaces were added to further this commitment to local culture.

Socially, this structure was designed to create a community investment. By using local craftsmen and materials, it is more likely that this building will represent personal pride to many local people. Also, the building is a gathering space for many different

people of all backgrounds to meet and learn about farming, or to enjoy the outdoor or meeting spaces.

Environmentally, the structure uses local or semi-local materials. The locally made bricks are made from the very soil that the building will sit upon and the steel is less than an hour's drive away. Also, the building will be used to teach better environmental farming techniques that can be used all around the area.

CONCLUSION

This senior project was rewarding for the design team. It was extremely rewarding to not only design a structure that may one day be constructed but also to work on a project with humanitarian efforts in mind. Watching the building from start to finish was extremely rewarding, as the design ideas melded with structural reality.

The calculations and drawings will be submitted to Journeyman International who will advise and edit them before sending them to the clients, our partnering organizations. They will be reviewed and approved by a local architect and engineer before any construction begins. The goal remains to produce a safe and practical building that will help the local people without overstepping our bounds.

PERSONAL REFLECTION

I have learned so much through this senior project. I am grateful to Journeyman International and Cal Poly for the opportunity to be involved in such a rewarding project. I have never worked on a structure that may be constructed without higher-level engineers looking over my designs. It was incredibly rewarding feeling the weight that what I design may end up as part of a structure that impacts the lives of people I will most likely never meet.

As for interdisciplinary work, Hannah was a blessing. She was extremely communicative and upfront about design decisions. We met often to discuss different parts of the project and make small adjustments. The interdisciplinary aspects of the project were still difficult as Hannah and I differed on our personal goals of the project and at times had opposite preferences on matters, but we always came up with a solution and had the same overall goals. It was difficult to learn to tell an architect that their design may not be practical, but I am glad to have begun learning how to better communicate through this project.

I learned a lot about time management and having to plan in advance. I did not have a set time to meet with my faculty advisor, James Mwangi, every week, so much of the deadlines were created by myself. It was difficult to do this when motivation was low, but the more I got into the project, the more motivated I became.

The COVID-19 situation greatly impacted my ability to work on this project as my laptop could not support any analysis programs or BlueBeam. I had to do many of

the calculations and analysis by hand and rely on codebooks for this process. Also, it was difficult to not be able to ask my peers small questions like I would have been able to if I had been able to work on this design in the architectural engineering labs. However, through this adversity, I believe I became a better engineer and I am so glad that I had the support with Journeyman International and James Mwangi for this project.



APPENDIX A
STRUCTURAL CALCULATIONS

CHIEDZA STEWARDSHIP CENTER

ZIMBABAWE

Prepared by:

ROBERT GARLAND

June 14, 2020

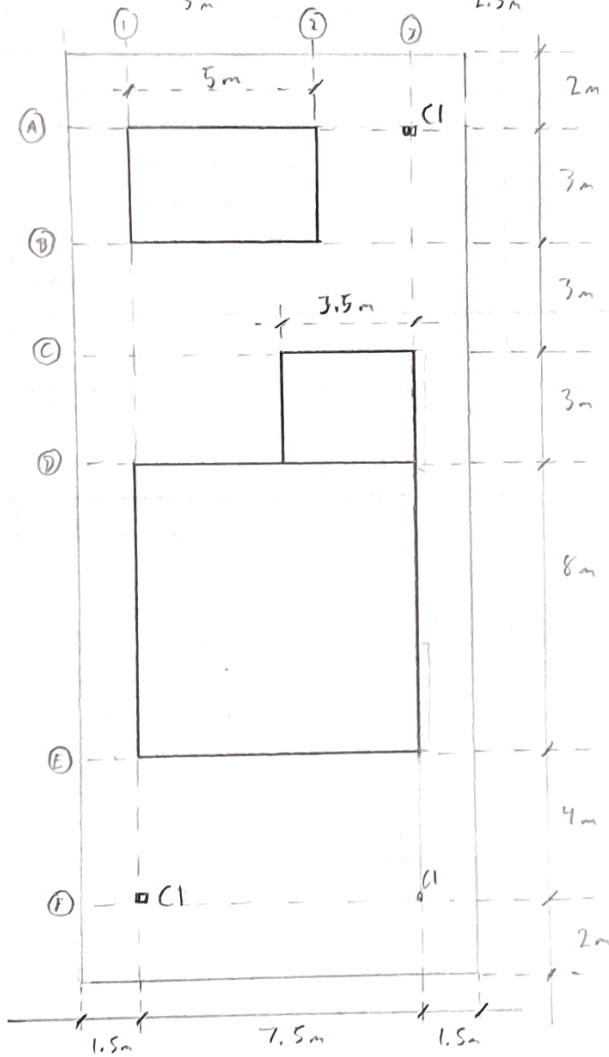
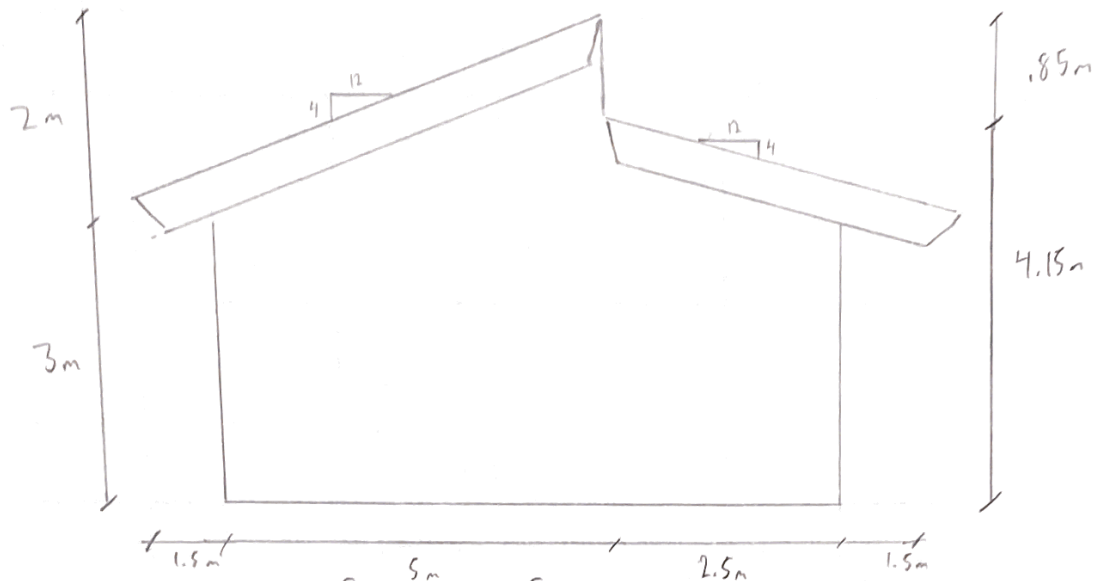
JOURNEYMAN INTERNATIONAL

ROOF	Purlins (psf)	Trusses (psf)	Columns (psf)	Foundations (psf)	Seismic	
IBR roofing	3.5	3.5	3.5	3.5	3.5	3.5
Insulation	2	2	2	2	2	2
Waterproofing	3	3	3	3	3	3
Ceiling	3	3	3	3	3	3
Misc	3.5	3.5	3.5	3.5	3.5	6.5
Purlins		5	5	5	5	5
Trusses			0	0	0	0
Columns				2	2	2
Shear Walls						0
Partions						0
Curtain Walls						0
	15	20	20	22	22	25

TABLE OF CONTENTS

LOAD TAKE OFF	0
KEY PLAN & ELEVATION	1
GRAVITY DESIGN	
INTERIOR PURLIN DESIGN	G 2
GIRDER DESIGN	G 4
TRANSFER GIRDER DESIGN	G 6
STEEL COLUMN DESIGN	G 8
LATERAL DESIGN	
LATERAL FORCE DISTRIBUTION	L 1
SHEAR WALL DESIGN	L 6
BOND BEAM DESIGN	L 8
TIE COLUMN DESIGN	L 9
COLLECTOR DESIGN	L 11
CHORD DESIGN	L 12
ROOF DIAPHRAM BRACE	L 13

KEY PLAN & ELEVATION



REF

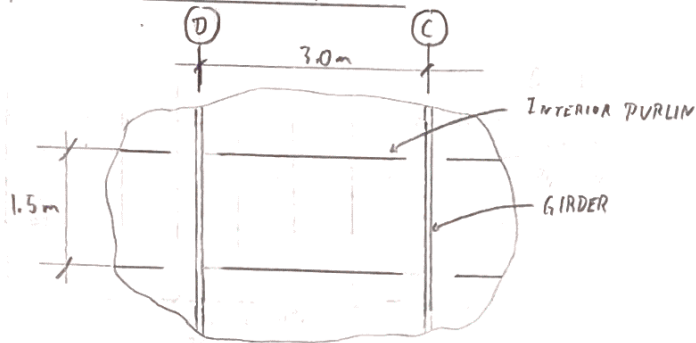
INTERIOR PURLIN DESIGN

USING IBR G550 .47mm*

PERMISSABLE FOR DISTANCE BETWEEN PURLINS TO BE 1.5m

$$1.5m < 1.95m^* \text{ max}$$

PLAN TYP FRAMING:

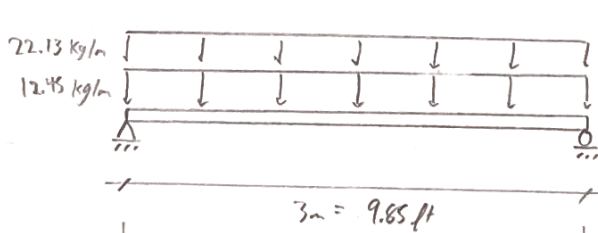


TRIBUTARY AREA:

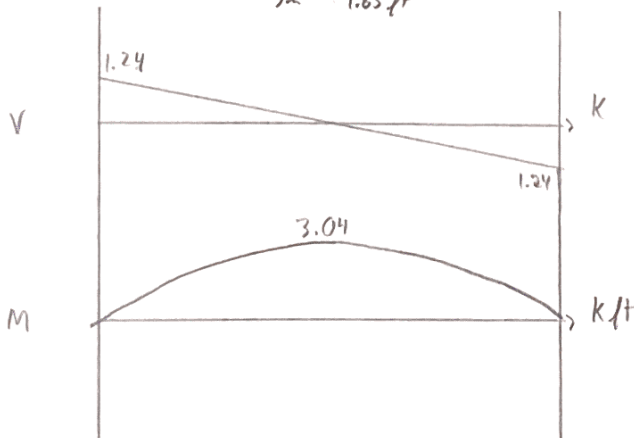
$$A_T = 1.5m \times 3m = 4.5m^2$$

$$4.5m^2 = 48.5ft^2$$

LOADING: 1.2D + 1.6L



	DEPTH	LOAD	FACTOR	SLOPE
160 lb/ft LIVE	= (5.0')	(20 psf)	(1.6)	
90 lb/ft DEAD	= (5.0')	(15 psf)	(1.2)	(1.05)



$$V_{max} = 1.24 k$$

$$M_{max} = 3.04 k/ft = 36.48 \text{ kin}$$

SHEAR:

$$\begin{aligned}
 V_n &= .6 F_y A_w C_v \\
 &= .6 (50 \text{ ksi}) (2 (3) (\frac{1}{4})) (1.0) \\
 &= 45 \text{ k} > 1.24 \text{ k}
 \end{aligned}$$

BENDING:

$$\phi M_n = \phi F_y Z$$

$$36.48 \text{ kin} = (.9) (50 \text{ ksi}) Z$$

$$Z \geq .811$$

USE 3x3 x 1/4

$$Z = 2.48 \text{ in}^3 \quad \text{OK}$$

DEFLECTION:

$$\Delta = \frac{5 w l^4}{384 EI}$$

$$= \frac{5 (.0133 \text{ k/in}) (120 \text{ in})^4}{384 (29000) (5.04)}$$

$$= .246''$$

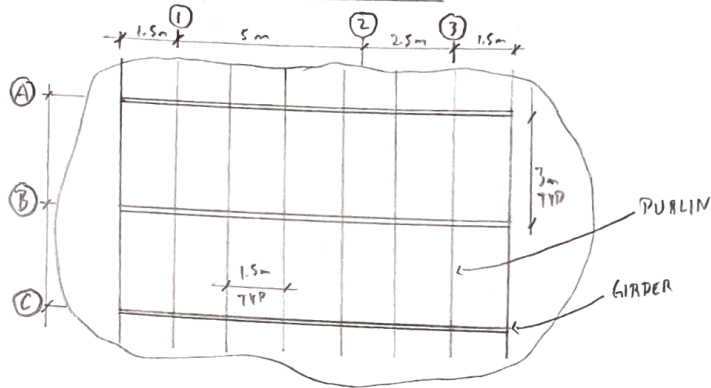
$$A_{allow} = \frac{L}{240} = \frac{120}{240} = .50''$$

$$.50'' > .246'' \quad \checkmark \text{ OK}$$

USE 3x3 x 1/4 HSS

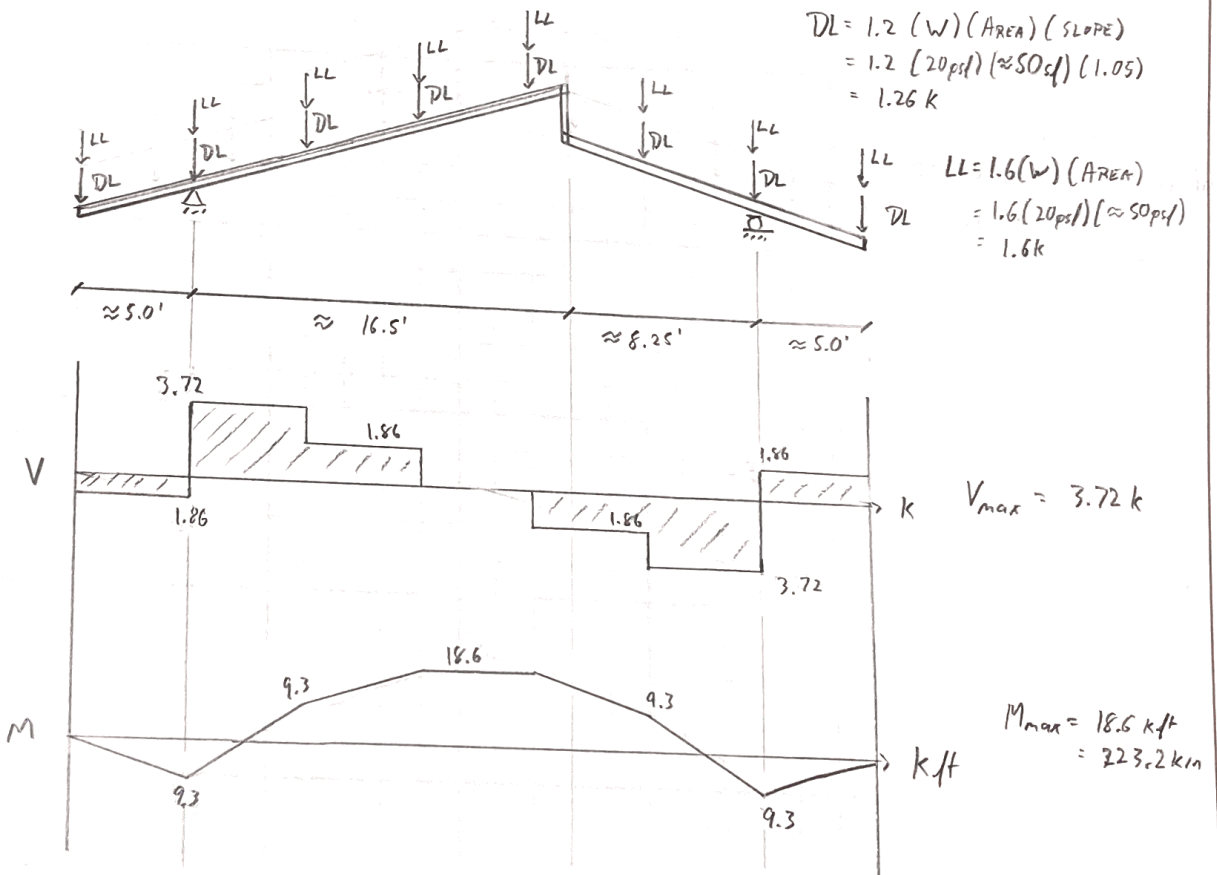
GIRDER DESIGN

TYP FRAMING PLAN



TRIBUTARY AREA: $A_T = 3m \times 10.5m = 31.5m^2 = 337ft^2$

LOADING: $1.2D + 1.6L$



HSS MEMBER:

BENDING:

$\phi M_n = \phi F_y Z$
 $223.2 k\cdot in \approx (.9) (50 ksi) Z$
 $Z \geq 4.96 in^3$

USE HSS $8 \times 4 \times 1/4 \Rightarrow Z = 13.3 in^3$

SHEAR:

$$\begin{aligned}
 V_n &= .6 F_y A_w C_v2 \\
 &= .6 (50 \text{ ksi}) (2(8)(\frac{1}{4})) (1.0) \\
 &= 120 \text{ k} > 3.72 \text{ k} \quad \checkmark
 \end{aligned}$$

DEFLECTION:

$$\begin{aligned}
 \text{ESTIMATE EDGE } \Delta &= \frac{P_x}{6EI} (2 \times l + 3x^2 - x^2) \\
 &= \frac{1.86}{6(29000)(42.5)} (2(59)(700) + 2(59^2)) \\
 &\approx .0106''
 \end{aligned}$$

$$\begin{aligned}
 \text{ESTIMATE MID } \Delta &= \frac{5 w l^4}{384 EI} \\
 &= \frac{5(0.16)(240^4)}{384(29000)(42.5)} \\
 &\approx .561 \text{ in}^2
 \end{aligned}$$

$$\Delta_{\text{allow}} = \frac{L}{240} = \frac{297}{240} = 1.24'' > .655'' \quad \checkmark \text{ OK}$$

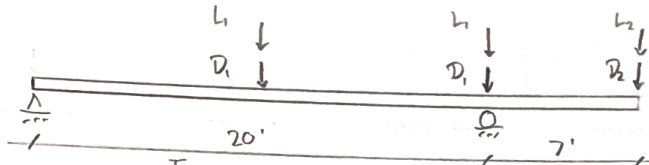
HSS 8x4 x 1/4

TRANSFER GIRDER DESIGN

OCCURS @ GRID 1 B/W D & B

GRID 3 B/W A & C ← WORST CASE

GRID 1 B/W F & E



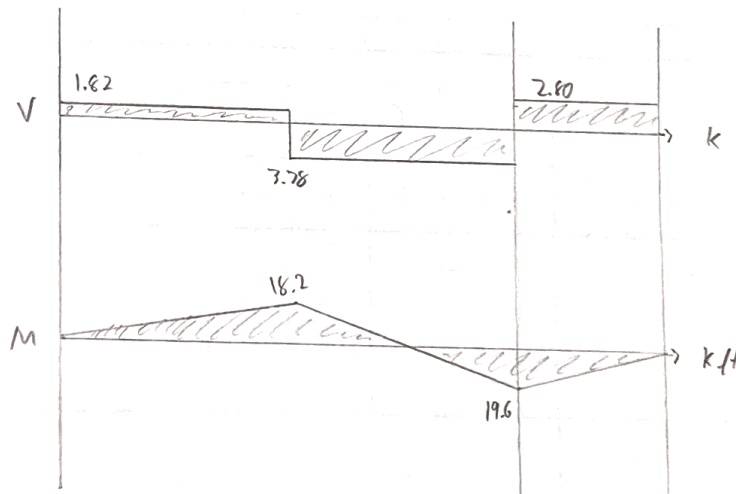
USING 1.2D + 1.6L: FROM INTERIOR GIRDER WORST CASE:

$$L_1 = 3.2 \text{ k}$$

$$D_1 = 2.4 \text{ k}$$

$$L_2 = 20 \text{ psf} \left(\frac{\text{AT}}{(3')(16')} \right) \left(\frac{\text{FACTOR}}{1.6} \right) = 1.6 \text{ k}$$

$$D_2 = 20 \text{ psf} \left(\frac{\text{AT}}{(3')(16')} \right) \left(\frac{\text{FACTOR}}{1.2} \right) \left(\frac{\text{SLOPE}}{1.05} \right) = 1.2 \text{ k}$$



$$V_{max} = 3.78 \text{ k}$$

$$M_{max} = 19.6 \text{ k-ft} = 235.2 \text{ kin}$$

BENDING:

$$\phi M_n = \phi F_y Z$$

$$235.2 \text{ kin} = (0.9)(50 \text{ ksi})(Z)$$

$$Z \geq 5.23$$

USE 8 x 4 x 1/4

$$Z = 13.3 \text{ in}^3 \quad \checkmark \text{ OK}$$

SHEAR:

$$\begin{aligned}
 V_n &= .6 F_y A_w C_v \\
 &= .6 (50 \text{ ksi}) \left(\frac{1}{4} (2(8)) (1.0) \right) \\
 &= 120 \text{ k} > 3.78 \text{ k}
 \end{aligned}$$

DEFLECTION:

$$\begin{aligned}
 \text{EDGE } \Delta &= \frac{P a^2}{3 E I} (l+a) \\
 &= \frac{(1.6)(84")^2}{3 (29000) (42.5)} (324") \\
 &= .989" < 1.35" \quad \checkmark \text{ OK}
 \end{aligned}$$

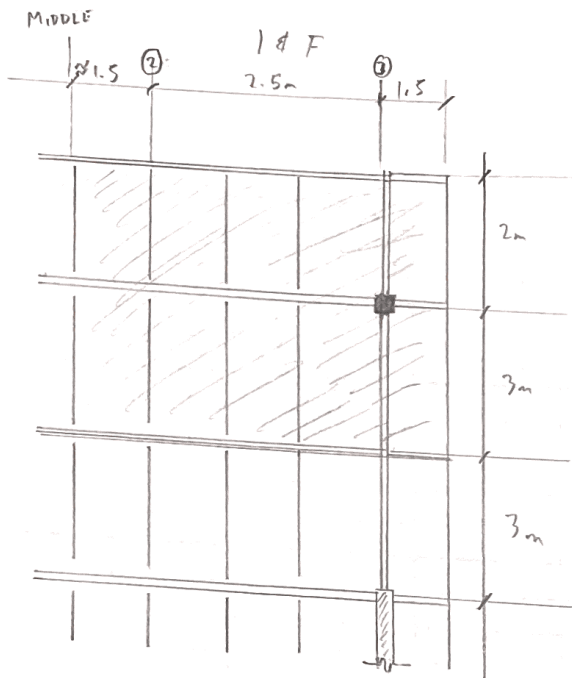
$$\Delta_{\text{allow}} = \frac{324}{240} = 1.35"$$

$$\begin{aligned}
 \text{INTERIOR } \Delta &= \frac{P a^3}{3 E I} \\
 &= \frac{(3.2)(240")^3}{48 (29000) (42.5)} \\
 &= .750" < 1.35" \quad \checkmark \text{ OK}
 \end{aligned}$$

VSE 8x4x1/4 HSS

STEEL COLUMN DESIGN

OCCURS @ 3 & A ← WORST CASE



$$\begin{aligned}
 A_T &\approx (5.5m)(5m) \\
 &\approx 27.5 m^2 \\
 &\approx 300 sf
 \end{aligned}$$

AXIAL LOADINGS:

$$1.2D + 1.6L$$

$$\begin{aligned}
 &1.2(20psf) + 1.6(20psf) \\
 &24psf + 32psf
 \end{aligned}$$

$$D = 24psf(300sf) = 7.2k$$

$$L = 32psf(300sf) = 9.6k$$



$$\begin{aligned}
 P_{max} &= 7.2k + 9.6k \\
 &= 16.8k
 \end{aligned}$$

AXIAL CAPACITY:

$$K = 1.0 \quad L = 10'$$

$$L_c = 10' = 120''$$

$$(E3) \quad \frac{L_c}{r} \leq 4.71 \sqrt{\frac{E}{F_y}}$$

$$\frac{120''}{1.52} \leq 4.71 \sqrt{\frac{29000}{50}}$$

$$78.95 \leq 113.43 \quad \text{USE (E3-3)}$$

$$(E3-4) \quad F_c = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2}$$
$$= \frac{\pi^2 (29000)}{\left(\frac{120}{1.52}\right)^2} = 45.93 \text{ ksi}$$

$$(E3-3) \quad F_{cr} = .877 F_c = .877 (45.93) = 40.27 \text{ ksi}$$

$$P_n = F_{cr} A_g = (40.27)(3.37) = 135.7 \text{ k}$$

$$\phi P_n = .9(500 \text{ k}) = 450 \text{ k} > 135.7 \text{ k} \quad \checkmark \text{ OK}$$

USE 4x4 x 1/4 HSS

LATERAL FORCE DISTRIBUTION: FLEXIBLE DIAPHRAGM

$$Q_e = V = C_s W$$

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I_c}\right)} = \frac{1.0}{\left(\frac{2}{1.0}\right)} = .5$$

R = DETAILED PLAIN MASONRY SHEAR WALL
= 2

$$I_c = 1.0$$

$$S_{DS} \approx 1.0$$

ASSUMPTION BASED ON LOCAL HAZARD MAPS COMPARED WITH
SEAC SEISMIC MAP TOOL

$$W_{\text{WALL}} = (150 \text{ pcf}) \left(\frac{\text{HEIGHT}}{2} \right) (\text{WIDTH}) (\text{TOTAL LENGTH})$$

$$W_{\text{WALL}} = 139 \text{ k}$$

$$W_{\text{ROOF}} = (25 \text{ pcf}) (2825 \text{ cf})$$

$$W_{\text{ROOF}} = 70.7 \text{ k}$$

$$W_{\text{TOTAL}} = W_{\text{WALL}} + W_{\text{ROOF}} = 139 \text{ k} + 70.7 \text{ k} \approx \underline{\underline{210 \text{ k}}}$$

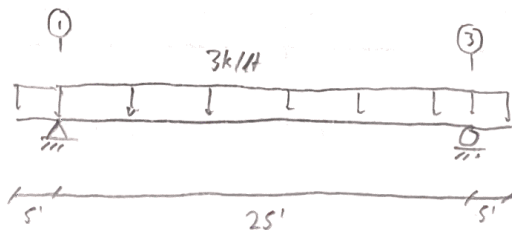
BASE SHEAR:

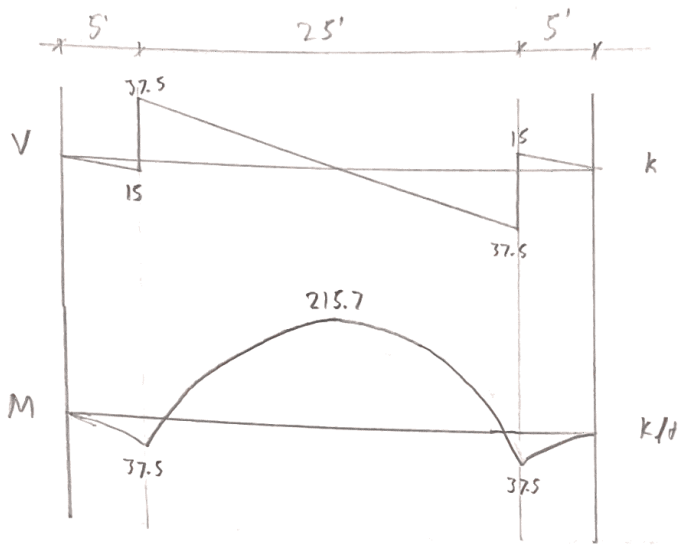
$$V = (.5)(210 \text{ k}) = \underline{\underline{105 \text{ k}}} = Q_e$$

N/S DIRECTION:

EVEN DIAPHRAGM:

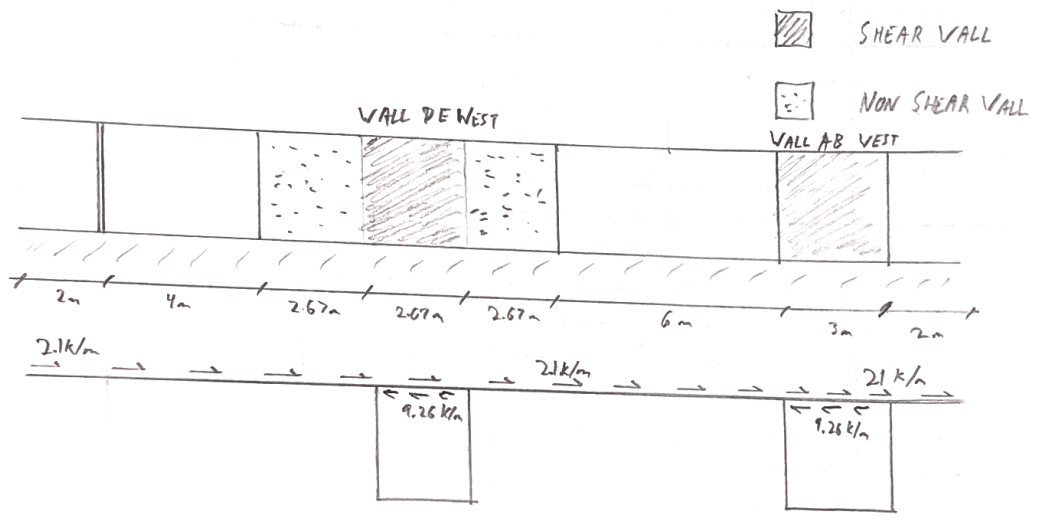
$$105 \text{ k} / 35' = 3 \text{ k/ft}$$



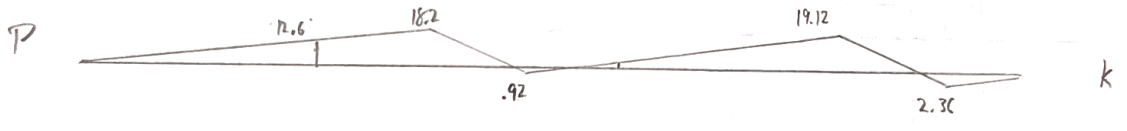


REACTION = 52.5k

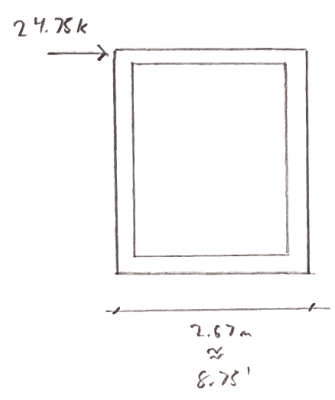
WEST WALL:



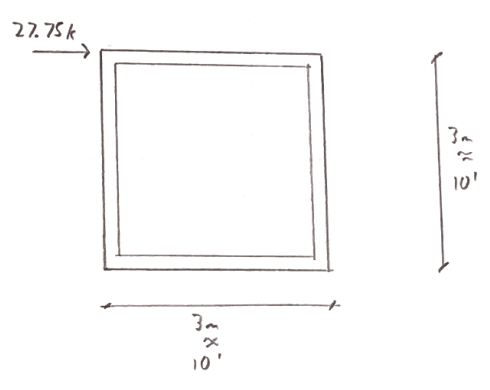
$\frac{52.5k}{25m} = 2.1k/m$
 $\frac{52.5k}{5.67m} = 9.26k/m$



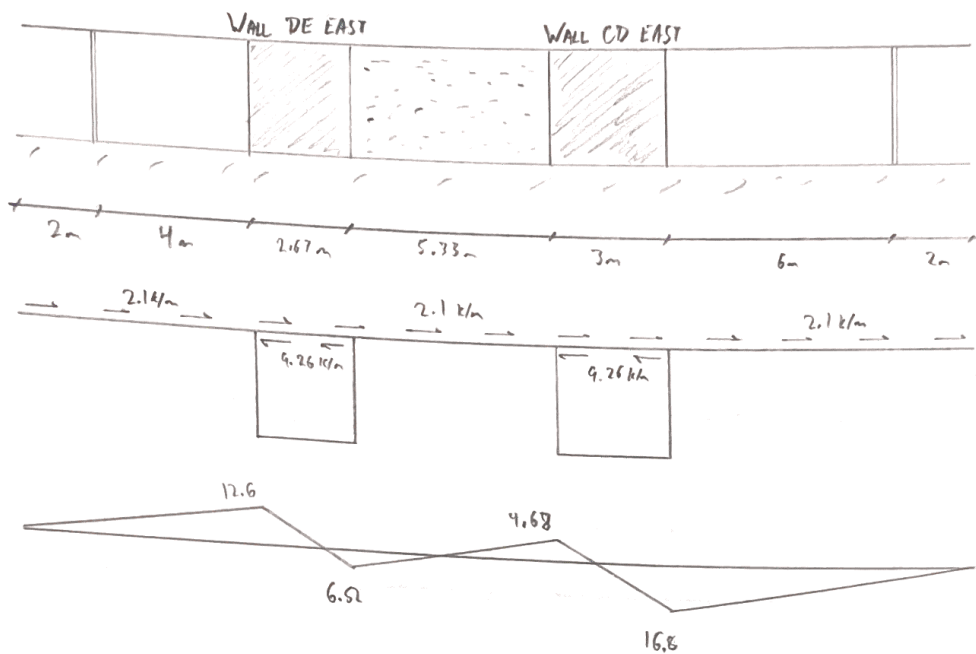
WALL DE WEST:



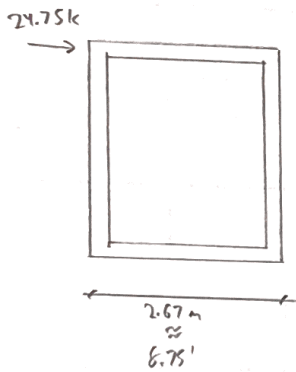
WALL AB WEST:



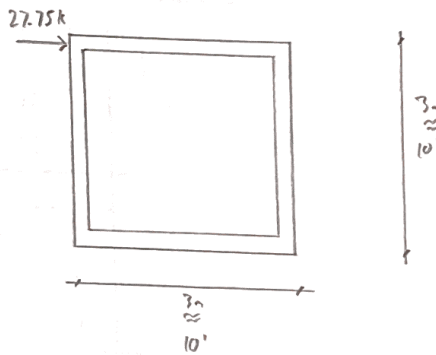
EAST WALL:



WALL DE EAST:



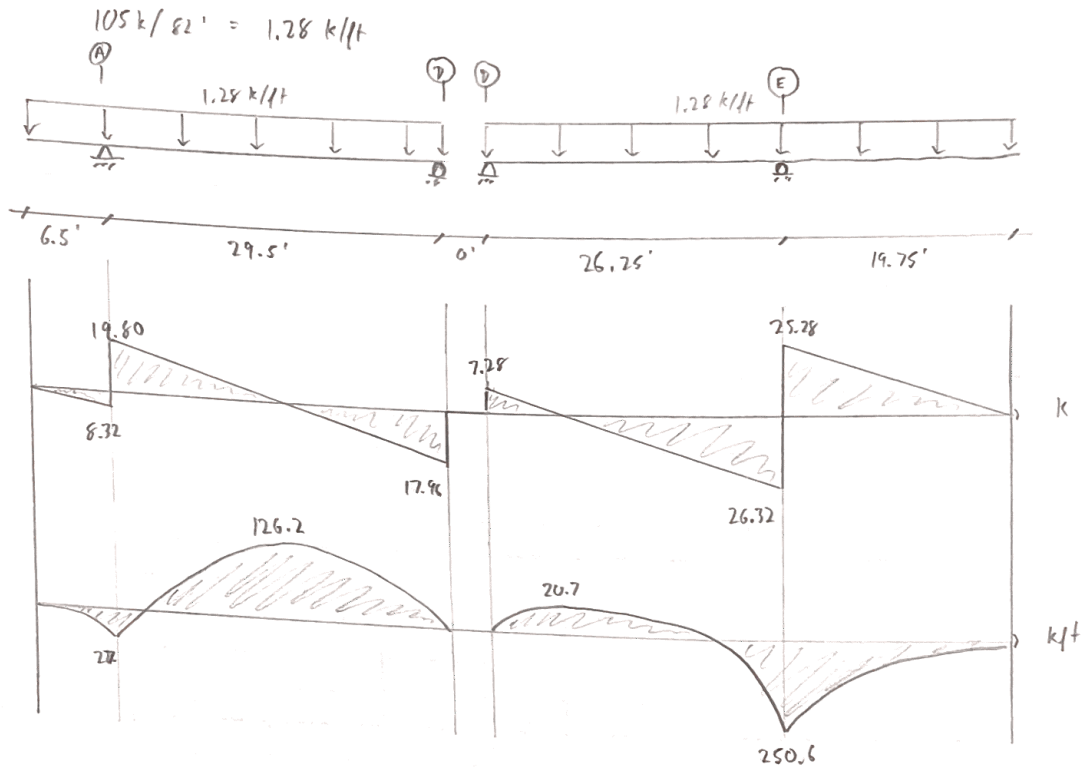
WALL CD EAST:



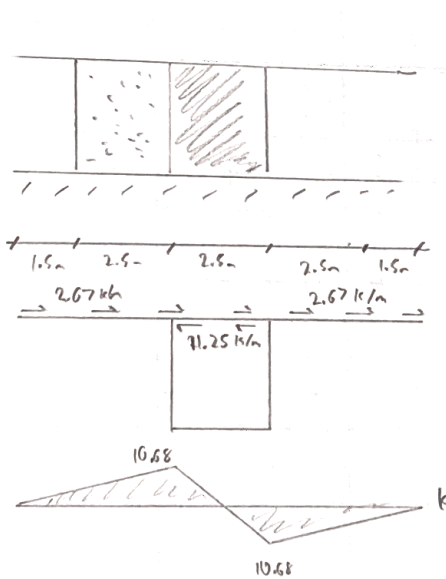
EW DIRECTION:

51.60

EVEN DIAPHRAM:



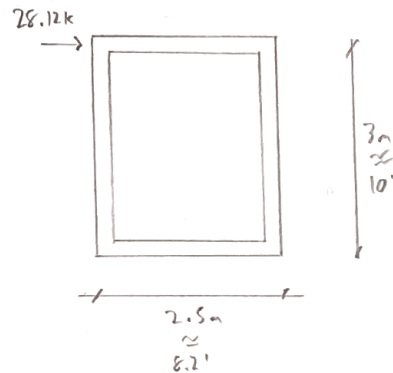
WALL A:



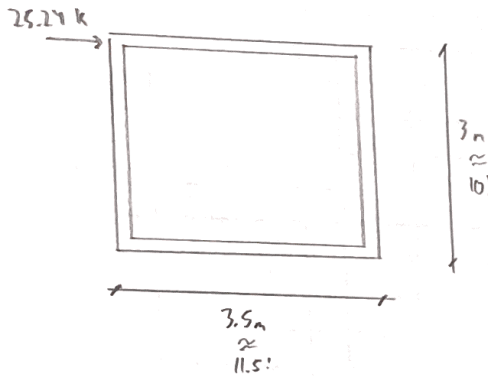
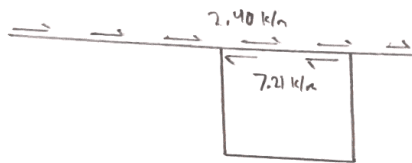
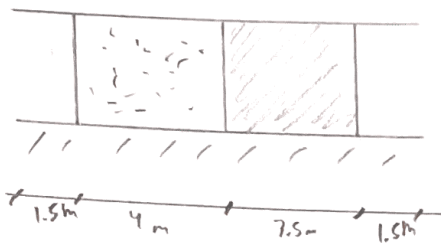
- SHEAR WALL
- NON SHEAR WALL

$$\frac{(19.80 + 8.32)}{10.5} = 2.67 \text{ k/m}$$

$$\frac{(19.80 + 8.32)}{2.8} = 11.25 \text{ k/m}$$



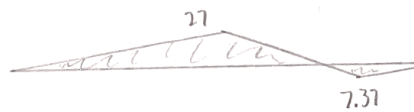
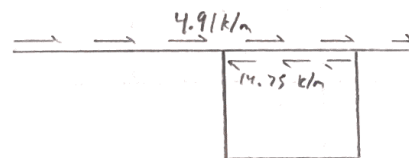
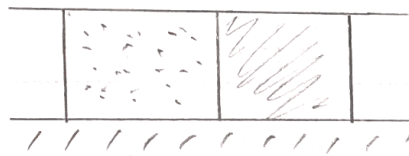
WALL D:



$$\frac{(17.96 + 7.28)}{10.5} = 2.4 \text{ k/m}$$

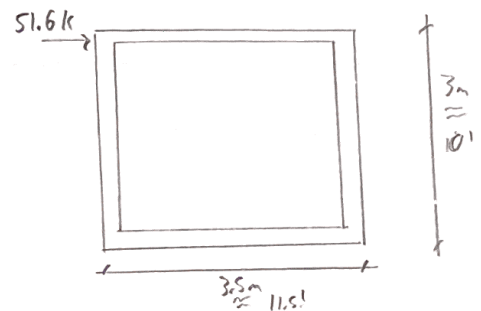
$$\frac{(17.96 + 7.28)}{3.5} = 7.21 \text{ k/m}$$

WALL E:



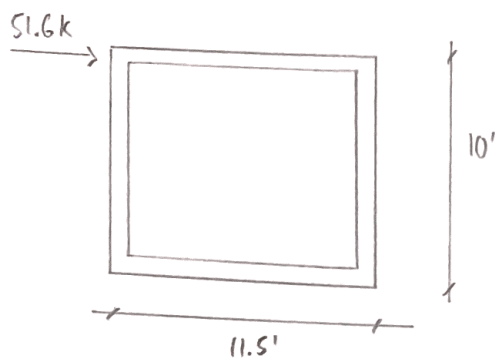
$$\frac{(25.28 + 26.32) \text{ k}}{10.5'} = 4.91 \text{ k/m}$$

$$\frac{(25.28 + 26.32) \text{ k}}{3.5'} = 14.75 \text{ k/m}$$



SHEAR WALL DESIGN

UPON INVESTIGATION: SHEAR WALL IS WORST CASE

SLENDERNESS:

$$S.R. = \frac{h_w}{t_w} = \frac{10'}{1'} = 10$$

$$10 < 27 = \text{MAX SLENDERNESS RATIO} \quad \checkmark$$

DENSITY:N/S:

$$A_w = (1')(92') = 92 \text{ sf}$$

$$A_p = (62')(35') = 2170 \text{ sf}$$

$$W_d = \frac{A_w}{A_p} 100 = 3.2\% > 2\% \text{ min} \quad \checkmark$$

E/V:

$$A_w = (1')(93.5') = 93.5 \text{ sf}$$

$$A_p = (62')(35') = 2170 \text{ sf}$$

$$W_d = \frac{A_w}{A_p} 100 = 3.26\% > 2\% \text{ min} \quad \checkmark$$

$$W_d \geq \frac{f_g w A_g}{P_{comp}}$$

$$W_d \geq \frac{(2.33)(.51 \text{ psi})(1)}{1000 \text{ psi}}$$

$$W_d \geq .1185 \quad \checkmark \text{ OK}$$

$$W_d \geq \frac{A_h f_s v n_s}{\gamma_u}$$

$$W_d \geq \frac{(1.0)(1.6)(.51 \text{ psi})(1)}{63 \text{ psi}}$$

$$W_d \geq 1.30 \quad \checkmark \text{ OK}$$

$$\gamma_u = 2\sqrt{f_c} = 2\sqrt{1000} = 63 \text{ psi}$$

STIFFNESS:

$$K_1 = \frac{E_m t_w}{\left(\frac{h_w}{L}\right)^3 + 3\left(\frac{h_w}{L}\right)}$$

$$= \frac{(456,000 \text{ psi})(12")}{\left(\frac{120"}{138"}\right)^3 + 3\left(\frac{120"}{138"}\right)}$$

$$= \frac{5,472,000}{3.27}$$

$$E_m = 456 \text{ km}$$

$$= 456 (1000)$$

$$= 456,000$$

$$K_1 = 1,673,395 \text{ p/in}$$

$$= 1,673.4 \text{ K/in}$$

IN PLANE STABILITY:COMPRESSIVE:

$$P_{comp} = K_s \times f_m$$

$$= (.85)(1000 \text{ psi})$$

$$= 850 \text{ psi}$$

$$K_s = .85 \text{ per TABLE 3.2}$$

$$P_{comp} \geq 2.6 \sigma_{d1}$$

$$P_{comp} \geq 2.6 (116.67 \text{ psi})$$

$$850 \text{ psi} \geq 52.8 \text{ psi} \quad \checkmark \text{ OK}$$

$$\sigma_{d1} = \text{max compressive stress}$$

$$= \frac{16.8 \text{ k}}{828 \text{ in}^2} \text{ FROM Pg 8}$$

$$= 20.3 \text{ psi}$$

TENSILE:

$$\sigma_t = \frac{M}{S} - \sigma_{d1}$$

$$= \frac{3,096,000 \text{ lb in}}{38,088 \text{ in}^3} - 52.8 \text{ psi}$$

$$= 81.3 \text{ psi} - 52.8 \text{ psi}$$

$$= 28.5 \text{ psi}$$

✓ OK

$$M = \frac{51,600 \text{ lb} (120")}{2} = \frac{V L}{2}$$

$$= 3,096,000 \text{ lb in}$$

$$S = \frac{t_w \times L^2}{6} = \frac{(12")(138")^2}{6}$$

$$= 38,088 \text{ in}^3$$

SHEAR:

$$\tau_u \geq \frac{V}{A_w} = \frac{51.6}{(12)(132)} = 32.57 \text{ psi}$$

$$\tau_u = .1 + \frac{\sigma_2}{6} = .1 + \frac{8,400}{6} = 100 \text{ psi}$$

$$100 \text{ psi} \geq 32.57 \text{ psi} \quad \checkmark \text{ OK}$$

OUT-OF-PLANE STABILITY:OVERTURNING:

$$M_o = \frac{Vh}{2} = \frac{51,600(120")}{2} = 3,096,000 \text{ lb}\cdot\text{in}$$

$$M_r = TL \times h_w \times k_c = (5,700 + 17,250)(120")(2.0) = 5,436,000 \text{ lb}\cdot\text{in}$$

$$\frac{5,436,000 \text{ lb}\cdot\text{in}}{3,096,000 \text{ lb}\cdot\text{in}} = 1.76 > 1.0 \quad \checkmark \text{ OK}$$

OUT OF PLANE:

$$F = A_n \times p_n \times t_w$$

$$= (1.0)(20.3)(12")$$

$$= 243.6$$

$$M_u = \frac{F h_w^2}{8} = \frac{438,480}{8} \text{ lb}\cdot\text{in}$$

$$\sigma_b = \frac{M_u}{S} = \frac{438,480}{24} = 18,270$$

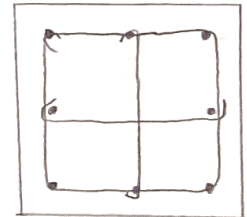
$$S = \frac{t_w^3}{6} = \frac{12^3}{6} = 24 \text{ in}^2$$

✓ OK

BOND BEAM DESIGN

START WITH 12" x 12" BEAM

- ANCHORAGE LENGTH = $L_d + 10d_b$
- STIRRUPS PROVIDED OVER ENTIRE SPICE,
- FIRST STIRRUP @ 50mm FROM FACE

LONGITUDINAL:

$$A_{st} = \frac{V}{f_y} = \frac{51.2k}{60 \text{ ksi}} = .85 \text{ in}^2$$

$$n = \frac{A_{st}}{(\pi \phi^2)/4} = \frac{.85}{(3.14 \phi^2)/4} = 4 \#4's$$

$$A_{st, min} = \frac{.85 BD}{f_y} = \frac{.85 (12")(12")}{60 \text{ ksi}} = 2.04 \text{ in}^2$$

$$n = \frac{A_{st}}{(\pi \phi^2)/4} = \frac{2.05}{(3.14 \phi^2)/4} = 8 \#5's \quad A_{st} = 2.48 \quad \checkmark \text{ OK}$$

SHEAR:

$$V_{us} = V - \sum_c B D$$

$$= 51,200 - 756(12)(12)$$

$$= -14,464 \text{ lb}$$

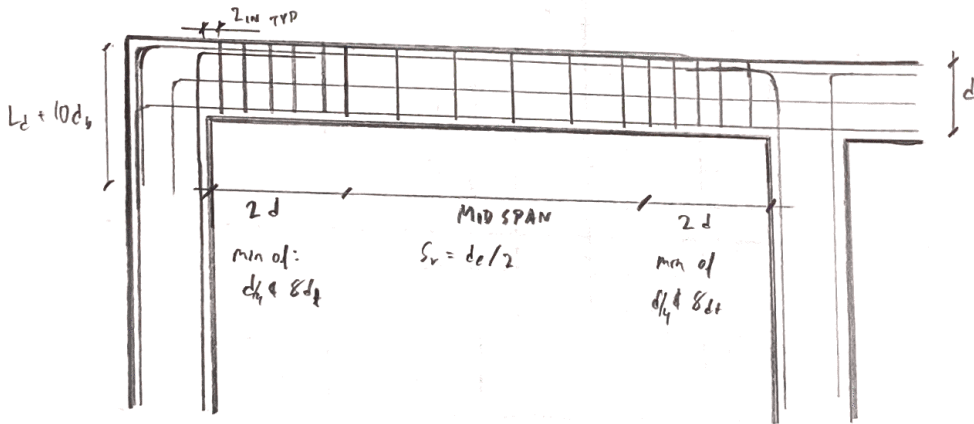
$$\tau_v = \frac{V}{(B)(D)} = \frac{51,200}{(12)(12)} = 356 \text{ psi}$$

$$L_d = \frac{\phi A_s}{4 \tau_v} = \frac{.9(50900)}{4(456)} = 30''$$

- max spacing = $d/2$
- length: $2d$ on side @ $L/4$ or $8d$

$$S_{v_{min}} = \frac{.87 \phi A_{sv}}{.4 B} = 11''$$

So!

DESIGN OF TIE COLUMN:

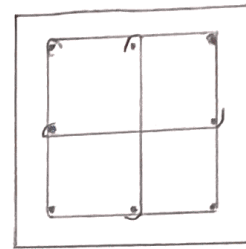
START WITH 12" x 12"

- Special reinforcing over $\rho_c/6$
- $S_v < d/4$
- Must use cross ties

$$A_{ST} = (1 + .25k) V \frac{h_w}{f_y d_y}$$

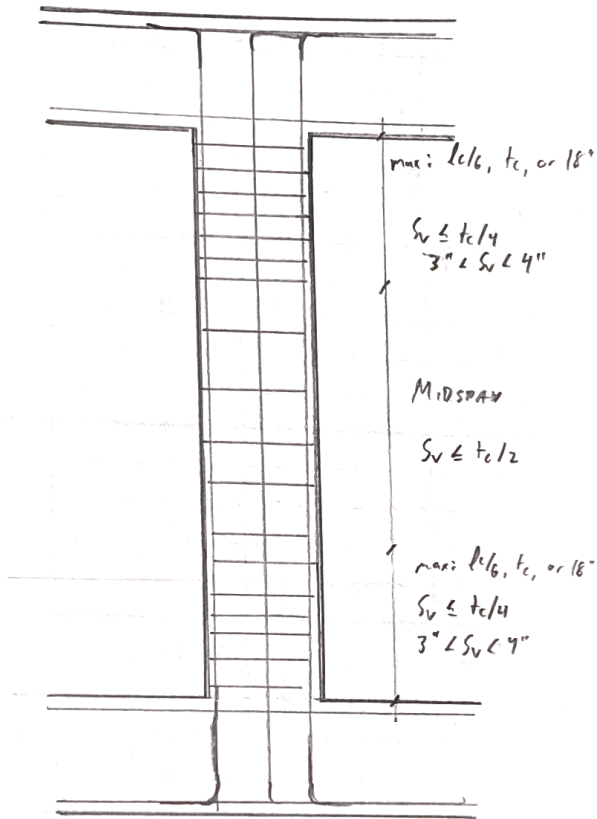
$$= (1.25)(51.2k) \left(\frac{120''}{138''(0.045)} \right)$$

$$= .93$$



$$A_{ST_{min}} = \frac{.85BD}{f_y} = \frac{.85(12'')(12'')}{60k} = 2.09 in^2$$

$$n = \frac{A_{ST}}{.01A_g} = 8 \# 5's \quad A_{ST} = 2.48 in^2 \quad \checkmark OK$$



COLLECTOR DESIGN: (STEEL)

N/S: OCCURS @ GRID 1 B/W F-E
 GRID 1 B/W B-D ← WORST CASE
 GRID 3 B/W A-C
 GRID 3 B/W F-E

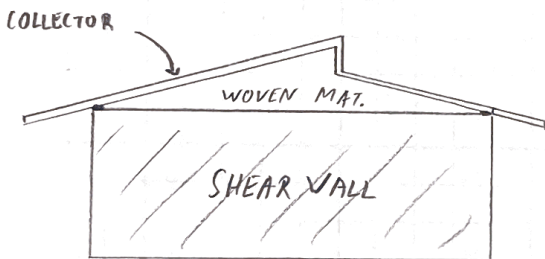
FROM PAGE L-2 MAX FORCE = 19.12 k

EFFECTIVE UNBRAISED LENGTH = 3m \approx 10'

COMPRESSIVE: HSS 8x4x1/4 = 161 k $>$ 19.12 k

CONT. TO USE HSS 8x4x1/4

E/W: OCCURS ALONG GRIDLINES A, D, & E



FROM PAGE L-5 MAX FORCE = 27 k

EFFECTIVE UNBRAISED LENGTH = 1.5m \approx 3.5'

COMPRESSIVE:

HSS 8x4x1/4 = 205 k $>$ 27 k

CONT. TO USE HSS 8x4x1/4

AISC 15th
Ed. Steel Manual
Table 4-3

AISC 15th
Ed. Steel Manual
Table 4-3

CHORD DESIGN:

N/S:

$$\text{FROM PAGE L-2} \quad \text{MAX MOMENT} = 215.7 \text{ k/ft}$$

$$\begin{aligned} \text{FORCE ON CHORD} &= M/d \\ &= 215.7 \text{ k/ft} / 82 \text{ ft} \\ &= 2.7 \text{ k} \end{aligned}$$

$$\text{UNBRACED LENGTH} = 0 = 0 \text{ ft}$$

$$\begin{aligned} \text{COMPRESSIVE STRENGTH} &= \text{TENSILE STRENGTH} \\ &= 256 \text{ k} > 2.7 \text{ k} \end{aligned}$$

CONT. USE HSS 8x4x1/4

E/W:

$$\text{FROM PAGE L-4} \quad \text{MAX MOMENT} = 250 \text{ k/ft}$$

$$\begin{aligned} \text{FORCE ON CHORD} &= M/d \\ &= 250 \text{ k/ft} / 35 \text{ ft} \\ &= 7.2 \text{ k} \end{aligned}$$

$$\text{UNBRACED LENGTH} = 0 = 0 \text{ ft}$$

$$\begin{aligned} \text{COMPRESSIVE STRENGTH} &= \text{TENSILE STRENGTH} \\ &= 110 \text{ k} > 7.2 \text{ k} \end{aligned}$$

CONT. USE HSS 3x3x1/4

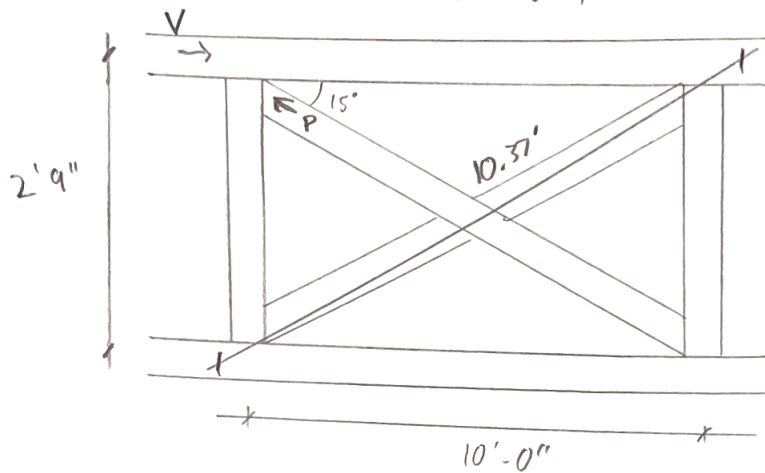
AISC 15th
Ed. Steel Manual
Table 4-3

Table 4-4

ROOF DIAPHRAM BRACE:

OCCURS @ GRID 2 B/W B&C

B/W E&F

FROM L-2 MAX $V = 37.5 \text{ k}$

FORCE TO EACH BRACE:

$$(2 \text{ BAYS})(2 \text{ MEMBERS}) = 4 \text{ BRACES}$$

$$V = (37.5 \text{ k}) / 4 = 9.4 \text{ k}$$

$$P = (9.4 \text{ k}) \left(\frac{10.37'}{10'} \right) = 9.75 \text{ k}$$

$$\text{UNBRACED LENGTH} = 10.37' \approx 11'$$

HSS $3 \times 3 \times \frac{1}{4}$

$$\text{COMPRESSIVE STRENGTH} = 39.0 \text{ k} > 9.75 \text{ k}$$

USE HSS $3 \times 3 \times \frac{1}{4}$

WELD JOINTS

ALSO 15" EI
Steel Manual
7-314-4

APPENDIX B

STRUCTURAL DRAWINGS

CHIEDZA STEWARDSHIP CENTER

ZIMBABAWE

Prepared by:

ROBERT GARLAND

June 14, 2020

JOURNEYMAN INTERNATIONAL

DESIGN CRITERIA & BUILDING CODES

THE DESIGN AND CONSTRUCTION OF THIS PROJECT IS MOSTLY GOVERNED BY THE "INTERNATIONAL BUILDING CODE (IBC)", 2015 EDITION, HEREAFTER REFERRED TO AS THE IBC, AS ADOPTED AND MODIFIED TO BE CONSTRUCTED IN ZIMBABWE.

WIND DESIGN:

MAIN WIND FORCE RESISTING SYSTEM

BASIC WIND SPEED.....120 MPH
 EXPOSURE CATEGORY.....C
 WIND IMPORTANCE.....I = 1.0
 TOPOGRAPHIC FACTOR.....K_{zr} = 1.0

SEISMIC DESIGN:

SEISMIC DESIGN CATEGORY.....SDC = D
 RESPONSE MODIFICATION FACTOR.....R = 2
 SYSTEM OVERSTRENGTH FACTOR.....OMEGA = 2
 SITE CLASSIFICATION PER ASCE 7-16.....SITE CLASS D
 SEISMIC IMPORTANCE FACTOR PER ASCE 7-16.....I_e = 1.0
 SDR COEFFICIENT (SHORT PERIOD).....SDS = 1.0

BASE SHEAR GOVERNED BY: SEISMIC

SEISMIC ANALYSIS PROCEDURE USED:
 EQUIVALENT LATERAL FORCE PROCEDURE

DESIGN LIVE LOADS:

ROOF LIVE: 20 PSF
 INTERIORS: 40 PSF

ABBREVIATIONS

@ AT
 A.B ANCHOR BOLT
 ARCH ARCHITECT; ARCHITECTURAL
 BM BEAM
 CL CENTERLINE
 COL COLUMN
 CONC CONCRETE
 CONT CONTINUOUS
 DIM DIMENSION
 DO DO OVER
 EA EACH
 EQ EQUAL
 EXT EXTERIOR
 FND FOUNDATION
 FTG FOOTING
 INT INTERIOR
 MAX MAXIMUM
 MIN MINIMUM
 MISC MISCELLANEOUS
 MTL METAL
 NO NUMBER
 NTS NOT TO SCALE
 OC ON CENTER
 REQ REQUIRED
 REINF REINFORCEMENT
 SCHED SCHEDULE
 STD STANDARD
 STL STEEL
 THK THICK
 TYP TYPICAL
 W/ WITH

GENERAL

1. THESE DRAWINGS ARE INSTRUMENTS OF SERVICE AND ARE THE PROPERTY OF JOURNEYMAN INTERNATIONAL. THE DESIGN AND INFORMATION REPRESENTED ON THESE DRAWINGS ARE EXCLUSIVE FOR THE PROJECT INDICATED AND SHALL NOT BE TRANSFERRED OR OTHERWISE REPRODUCED WITHOUT EXPRESS WRITTEN PERMISSION OF JOURNEYMAN INTERNATIONAL.
 2. STRUCTURAL DRAWINGS SHALL BE USED IN CONJUNCTION WITH THE SPECIFICATIONS AND OTHER PROJECT DRAWINGS BY OTHER DISCIPLINES.
 3. CONTRACTOR SHALL VERIFY ALL DIMENSIONS AND ELEVATIONS RELATING TO EXISTING CONDITIONS BY MAKING FIELD SURVEYS AND MEASUREMENTS PRIOR TO COMMENCING FABRICATION OR CONSTRUCTION.
 4. CONTRACTOR SHALL ENSURE THAT ALL CONSTRUCTION METHODS USED WILL NOT CAUSE DAMAGE TO UTILITIES OR THE PROPERTY. THIS IS PARTICULARLY IMPORTANT DURING FOUNDATION INSTALLATION.
 5. CONTRACTOR SHALL COMPARE AND COORDINATE THE DRAWINGS OF ALL DISCIPLINES AND REPORT ANY DISCREPANCIES BETWEEN THE DRAWINGS TO THE ARCHITECT AND ENGINEER.
 6. DETAILS LABELED "TYPICAL" SHALL APPLY TO ALL SITUATIONS THAT ARE THE SAME OR SIMILAR TO THOSE SPECIFICALLY DETAILED.
 7. WHERE CONFLICTS EXIST BETWEEN STRUCTURAL DOCUMENTS, THE STRICTEST REQUIREMENTS, AS INDICATED BY THE STRUCTURAL ENGINEER, SHALL GOVERN.
 8. THE GENERAL CONTRACTOR SHALL REVIEW AND DETERMINE THAT DIMENSIONS ARE COORDINATED BETWEEN ARCHITECTURAL AND STRUCTURAL DRAWINGS PRIOR TO FABRICATION OR START OF CONSTRUCTION.
 9. NO STRUCTURAL MEMBER SHALL BE CUT OR NOTCHED OR OTHERWISE REDUCED IN STRENGTH UNLESS APPROVED BY THE STRUCTURAL ENGINEER.
 10. THE GENERAL CONTRACTOR SHALL COORDINATE ARCHITECTURAL, MECHANICAL, ELECTRICAL AND PLUMBING DRAWINGS FOR ANCHORED, EMBEDDED OR SUPPORTED ITEMS. NOTIFY THE ARCHITECT AND ENGINEER OF ANY DISCREPANCIES.

CONCRETE

1. CONCRETE IS REINFORCED AND CAST-IN-PLACE UNLESS OTHERWISE NOTED. WHERE REINFORCING IS NOT SPECIFICALLY SHOWN OR WHERE DETAILS ARE NOT GIVEN, PROVIDE REINFORCING SIMILAR TO THAT SHOWN FOR SIMILAR CONDITIONS. SUBJECT TO REVIEW BY THE OWNER'S REPRESENTATIVE.
 2. ALL STRUCTURAL CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH AT 28 DAYS OF 3000 PSI NORMAL WEIGHT.
 3. ALL STRUCTURAL CONCRETE MIXES SHALL BE TYPE II CEMENT AND SHALL BE DESIGNED BY AN APPROVED LABORATORY.
 4. NORMAL WEIGHT CONCRETE AGGREGATES SHALL CONFORM TO ASTM C-33.
 5. NO MORE THAN ONE GRADE OF CONCRETE SHALL BE ON THE JOB SITE AT ANY ONE TIME.
 6. THOROUGHLY CLEAN AND ROUGHEN ALL HARDENED CONCRETE AND MASONRY SURFACES TO RECEIVE NEW CONCRETE. INTERFACE SHALL BE ROUGHENED TO A FULL AMPLITUDE OF 1/4" UNLESS NOTED OTHERWISE.

7. KEY AND DOWEL POUR JOINTS AS SHOWN ON THE PLANS. ANY DEVIATION FROM POUR JOINTS SHOWN ON THE PLANS MUST BE APPROVED BY THE OWNER'S REPRESENTATIVE.
 8. DEFECTIVE CONCRETE (VOIDS, ROCK POCKETS, HONEYCOMBS, CRACKING, ETC.) SHALL BE REMOVED AND REPLACED AS DIRECTED BY THE OWNER'S REPRESENTATIVE.

REINFORCEMENT

1. BARS SHALL BE FIRMLY SUPPORTED AND ACCURATELY PLACED AS REQUIRED BY THE A.C.I. STANDARDS, USING TIE AND SUPPORT BARS IN ADDITION TO REINFORCEMENT SHOWN WHERE NECESSARY FOR FIRM AND ACCURATE PLACING. ALL DOWELS SHALL BE ACCURATELY SET IN PLACE BEFORE PLACING CONCRETE.
 2. DRAWINGS SHOW TYPICAL REINFORCING CONDITIONS. CONTRACTOR SHALL PREPARE DETAILED PLACEMENT DRAWINGS OF ALL CONDITIONS SHOWING QUANTITY, SPACING, SIZE, CLEARANCES, LAPS, INTERSECTIONS AND COVERAGE
 3. REQUIRED BY STRUCTURAL DETAILS, APPLICABLE CODE AND TRADE STANDARDS. CONTRACTOR SHALL NOTIFY REINFORCING INSPECTOR OF ANY ADJUSTMENTS FROM TYPICAL CONDITIONS THAT ARE PROPOSED IN PLACEMENT DRAWINGS TO FACILITATE FIELD PLACEMENT OF REINFORCING STEEL AND CONCRETE.
 4. NO WELDING OF REINFORCEMENT (INCLUDING TACK WELDING) SHALL BE DONE UNLESS SHOWN ON THE DRAWINGS. WHERE SHOWN ON THE DRAWINGS, WELDING OF REINFORCING STEEL SHALL BE PERFORMED BY WELDERS SPECIFICALLY CERTIFIED FOR REINFORCING STEEL. USE E90XX ELECTRODES.

FOUNDATIONS

1. THE DESIGN OF THE FOUNDATION SYSTEM IS BASED UPON THE CRITERIA AND RECOMMENDATIONS CONTAINED IN THE GEOTECHNICAL INVESTIGATION REPORT ENTITLED GS-101 BY QUICKSAND TECHNOLOGIES, DATED 12-10-2016 AND SUPPLEMENTAL REPORT ENTITLED GS-102, DATED 12-10-2016.
 2. THE GEOTECHNICAL INVESTIGATION REPORT AND ITS RECOMMENDATIONS SHALL BE FOLLOWED AND SHALL BE CONSIDERED MINIMUM REQUIREMENTS UNLESS MORE STRINGENT REQUIREMENTS ARE PRESENTED IN THE SPECIFICATIONS OR ON THE DRAWINGS.
 3. PER GEOTECHNICAL INVESTIGATION REPORT, THE ALLOWABLE SOIL BEARING PRESSURES ARE AS FOLLOWS:
 A. SPREAD FOOTINGS: 4000 POUNDS PER SQUARE FOOT
 B. ALLOWABLE BEARING VALUES MAY BE INCREASED BY 33 PERCENT FOR SHORT TERM LOADING.
 4. REMOVE LOOSE SOIL AND STANDING WATER FROM FOUNDATION EXCAVATIONS PRIOR TO PLACING CONCRETE. THE GEOTECHNICAL ENGINEER SHALL INSPECT AND APPROVE ALL EXCAVATIONS, SOIL COMPACTION WORK PRIOR TO PLACEMENT OF ANY REBAR OR CONCRETE, SHORING INSTALLATIONS, BACKFILL MATERIALS AND BACK FILLING PROCEDURES.
 5. LOCATE AND PROTECT EXISTING UTILITIES TO REMAIN DURING AND/OR AFTER CONSTRUCTION.
 6. REMOVE ABANDONED FOOTINGS, UTILITIES, ETC. WHICH INTERFERE WITH NEW CONSTRUCTION, UNLESS OTHERWISE INDICATED.
 7. NOTIFY THE OWNER'S REPRESENTATIVE IF ANY BURIED STRUCTURES NOT INDICATED, SUCH AS CESSPOOLS, CISTERNS, FOUNDATIONS, ETC., ARE FOUND.
 8. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR EXCAVATION PROCEDURES INCLUDING LAGGING, SHORING, UNDERPINNING AND PROTECTION OF EXISTING CONSTRUCTION.
 9. PLACE BACKFILL BEHIND RETAINING WALLS AFTER CONCRETE OR MASONRY HAS ATTAINED FULL DESIGN STRENGTH. BRACE BUILDING AND PIT WALLS BELOW GRADE FROM LATERAL LOADS UNTIL ATTACHED FLOORS AND SLABS ON GRADE ARE COMPLETE AND HAVE ATTAINED FULL DESIGN STRENGTH



Architecture Student:
 Hannah Oltman
 hannah@journeymaninternational.org

Engineering Student:
 Robert Garland
 robert@journeymaninternational.org
 (661) 868-3215

DRAWINGS TO BE REVIEWED BY AN ARCHITECT/ENGINEER IN COUNTRY

DRAWINGS NOT FOR CONSTRUCTION

No.	Description	Date

EAST AFRICAN POWER / FOUNDATIONS FOR FARMING
 Chiedza Stewardship Center

GENERAL NOTES

Date	Issue Date
Drawn By	Author
Checked By	Checker
S 0.1	
Scale	



Architecture Student:
Hannah Oltzman
hannah@journeymainternational.org

Engineering Student:
Robert Garland
robert@journeymainternational.org
(951) 863-3515

**DRAWINGS TO BE
REVIEWED BY AN
ARCHITECT/ENGINEER
IN COUNTRY**

**DRAWINGS NOT FOR
CONSTRUCTION**

No.	Description	Date

**EAST AFRICAN
POWER /
FOUNDATIONS
FOR FARMING**

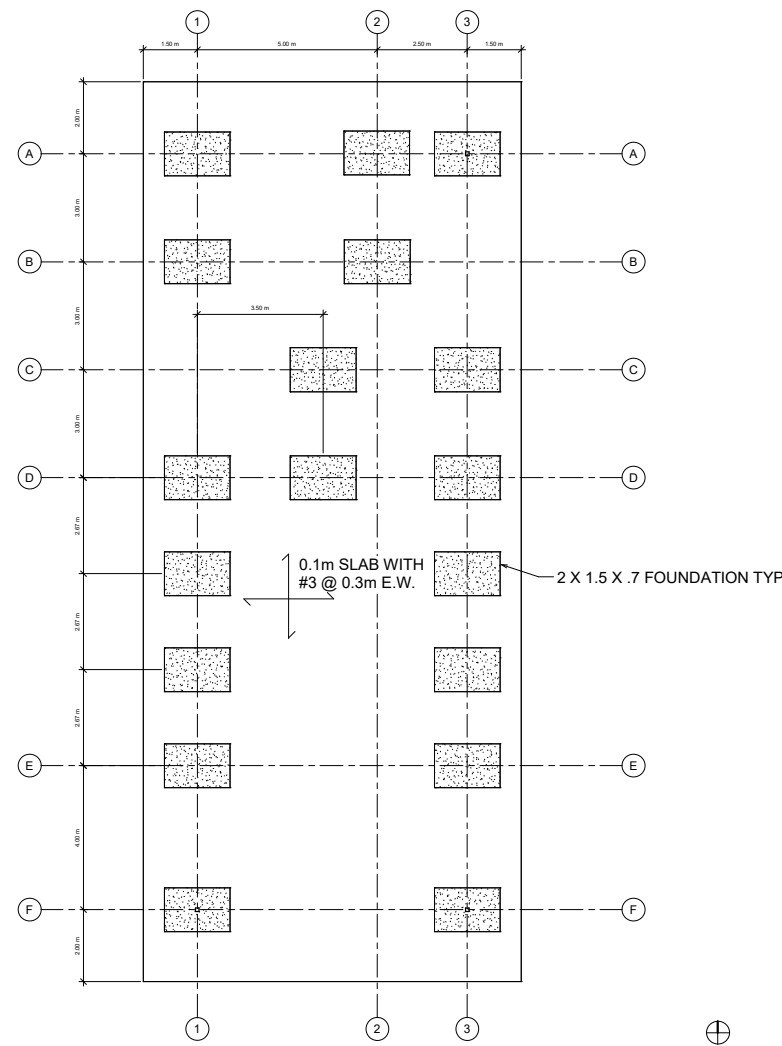
Chiedza
Stewardship Center

**FOUNDATION
PLAN**

Date	Issue Date
Drawn By	Author
Checked By	Checker

S 1.1

Scale 1 : 50



FOUNDATION PLAN
1 : 50



6/19/2007 7:26:00 PM



Architecture Student:
Hannah Oltman
hannah@journeymainternational.org

Engineering Student:
Robert Garland
robert@journeymainternational.org
(951) 863-3615

DRAWINGS TO BE
REVIEWED BY AN
ARCHITECT/ENGINEER
IN COUNTRY

DRAWINGS NOT FOR
CONSTRUCTION

No.	Description	Date

EAST AFRICAN
POWER /
FOUNDATIONS
FOR FARMING

Chiedza
Stewardship Center

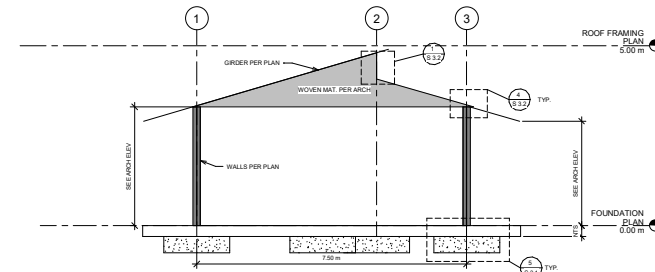
BUILDING
ELEVATIONS

Date	Issue Date
Drawn By	Author
Checked By	Checker

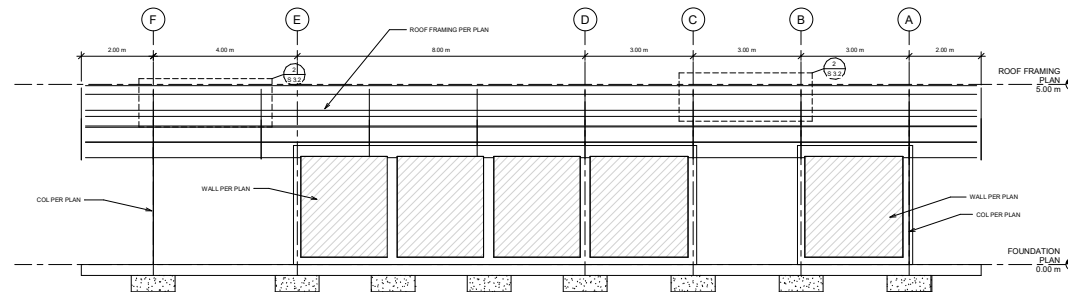
S 2.0

Scale	1 : 50
-------	--------

0 1/19/2020 7:22:41 PM



South
1:50



East
1:50



Architecture Student:
Hannah Oltzman
hannah@journeymainternational.org

Engineering Student:
Robert Garland
robert@journeymainternational.org
(951) 863-3015

**DRAWINGS TO BE
REVIEWED BY AN
ARCHITECT/ENGINEER
IN COUNTRY**

**DRAWINGS NOT FOR
CONSTRUCTION**

No.	Description	Date

**EAST AFRICAN
POWER /
FOUNDATIONS
FOR FARMING**

**Chiedza
Stewardship Center**

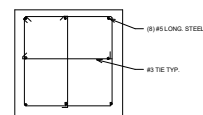
**CONCRETE
DETAILS**

Date: _____ Issue Date: _____
 Drawn By: _____ Author: _____
 Checked By: _____ Checker: _____

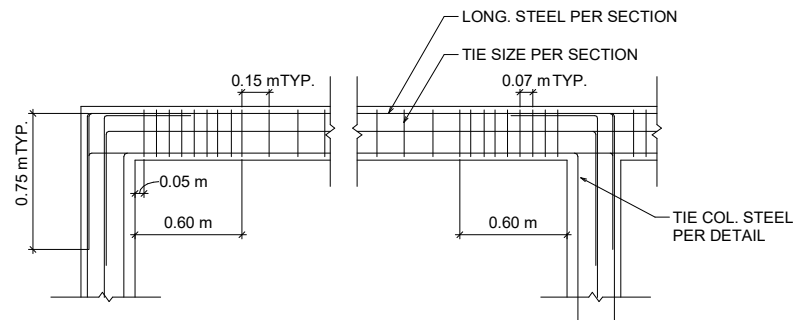
S 3.1

Scale: _____ As indicated

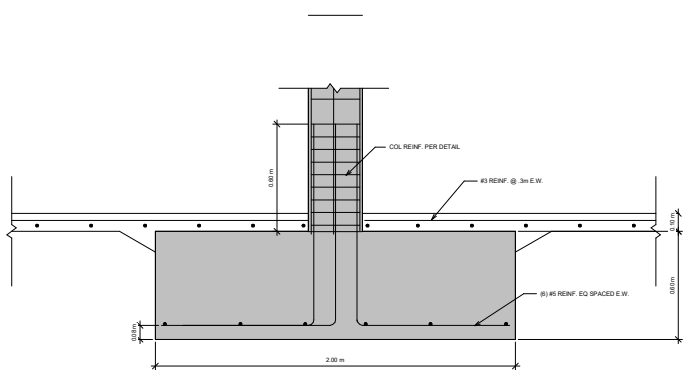
0 1/19/2007 7:29:41 PM



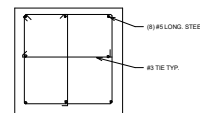
1.5 BOND BEAM SECTION



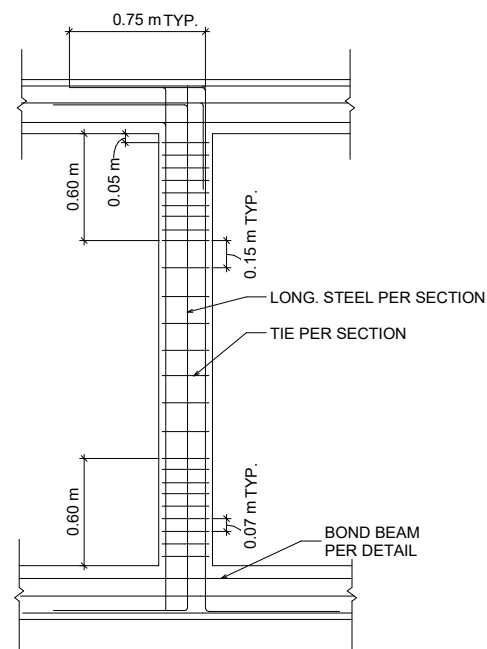
1:10 BOND BEAM ELEVATION



1:10 FOUNDATION DETAIL



1:5 TIE COLUMN SECTION



1:10 TIE COLUMN DETAIL



Architecture Student:
Hannah Oltman
hannah@journeymainternational.org

Engineering Student:
Robert Garland
robert@journeymainternational.org
(851) 863-3515

DRAWINGS TO BE REVIEWED BY AN ARCHITECT/ENGINEER IN COUNTRY

DRAWINGS NOT FOR CONSTRUCTION

No.	Description	Date

**EAST AFRICAN
POWER /
FOUNDATIONS
FOR FARMING**

**Chiedza
Stewardship Center**

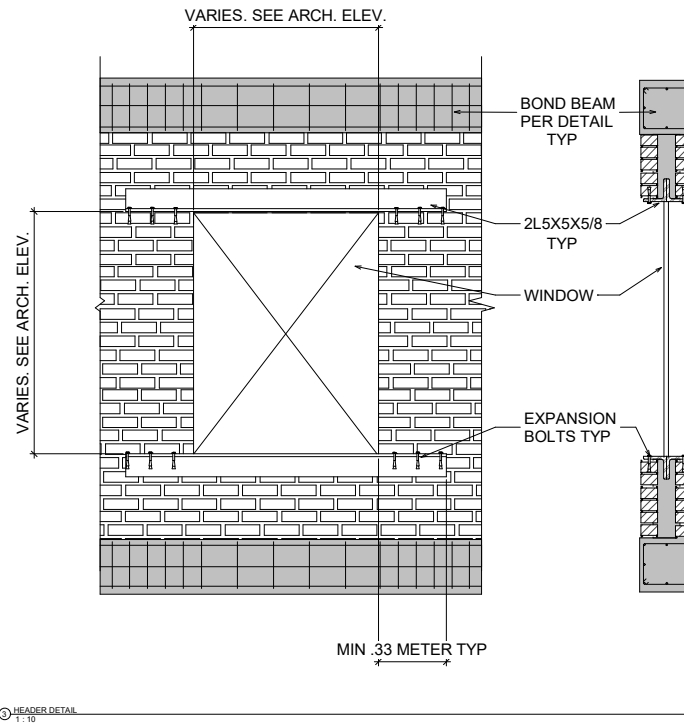
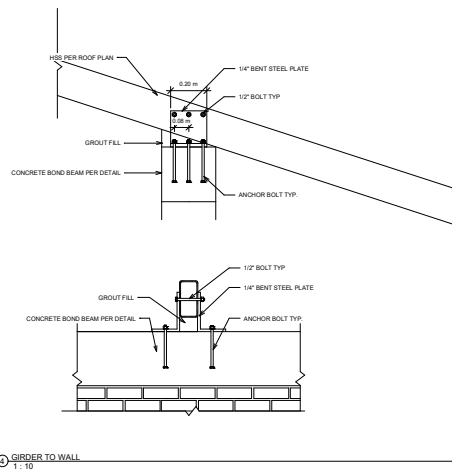
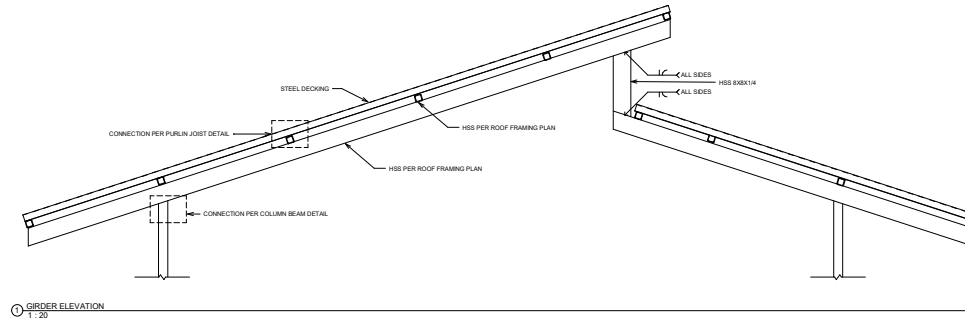
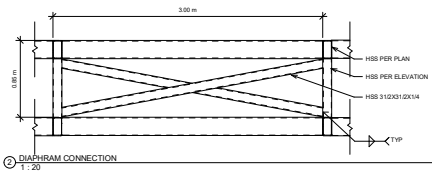
OTHER DETAILS

Date	Issue Date
Drawn By	Author
Checked By	Checker

S 3.2

Scale As indicated

0:1958007:722:417 PM



APPENDIX C

PROJECT PRESENTATION SLIDES

CHIEDZA STEWARDSHIP CENTER

ZIMBABAWE

Prepared by:

ROBERT GARLAND

June 14, 2020

JOURNEYMAN INTERNATIONAL

CHIEDZA STEWARDSHIP CENTER

PRESENTED BY ROBERT GARLAND
ADVISED BY DR. JAMES MWANGI



THE TEAM



ROBERT GARLAND

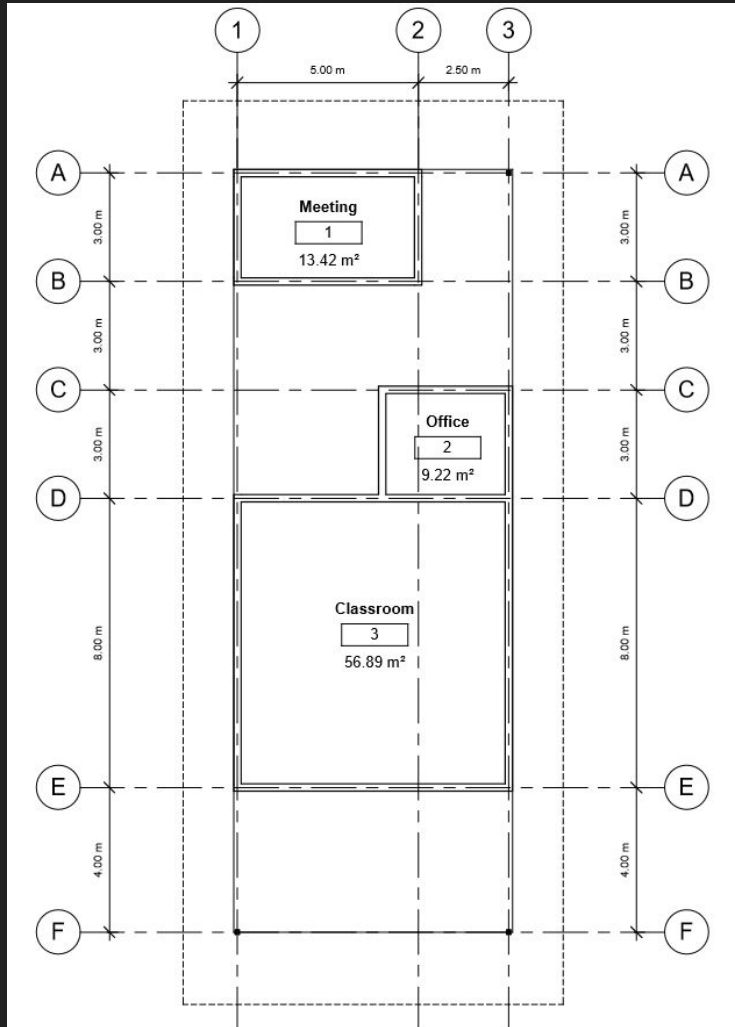


HANNAH OITZMAN



DANIEL WIENS







SPECIFICATIONS

STEEL

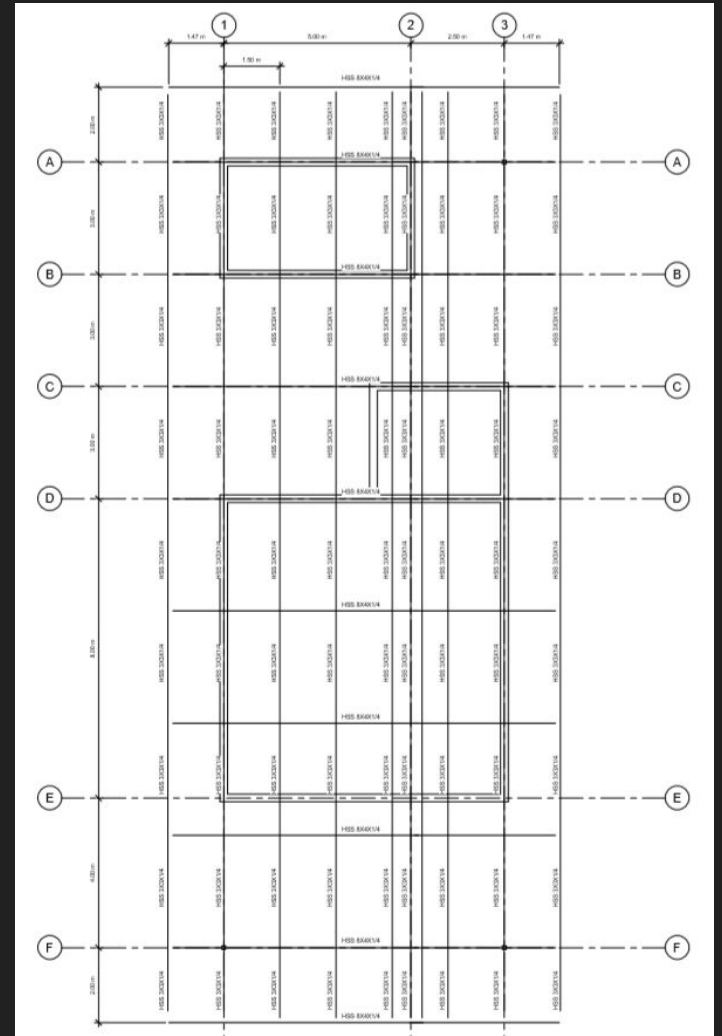
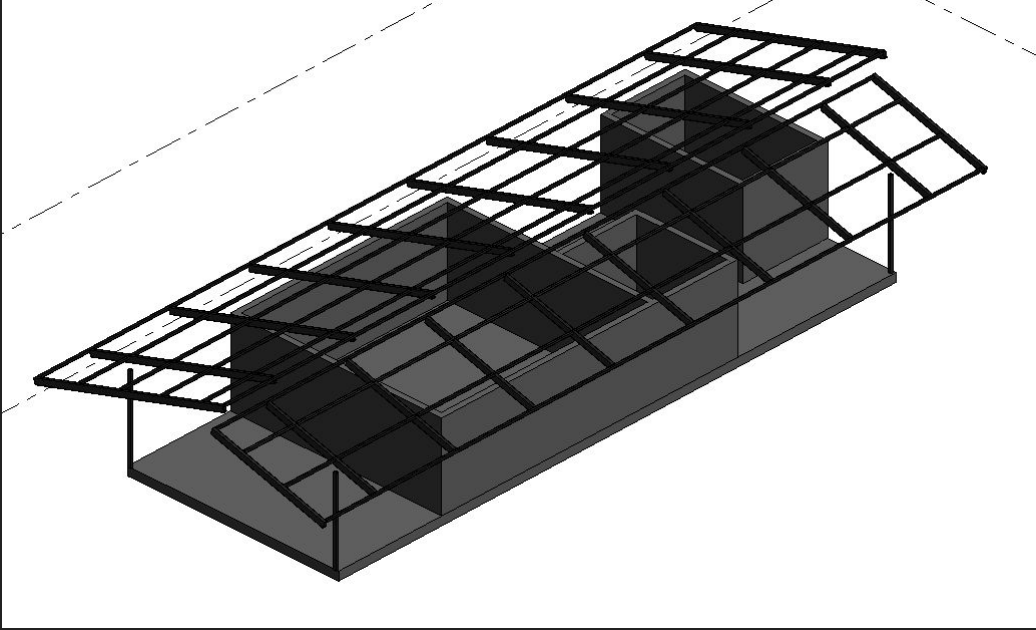
- ROOF STRUCTURE
- COLUMNS

CONFINED MASONRY

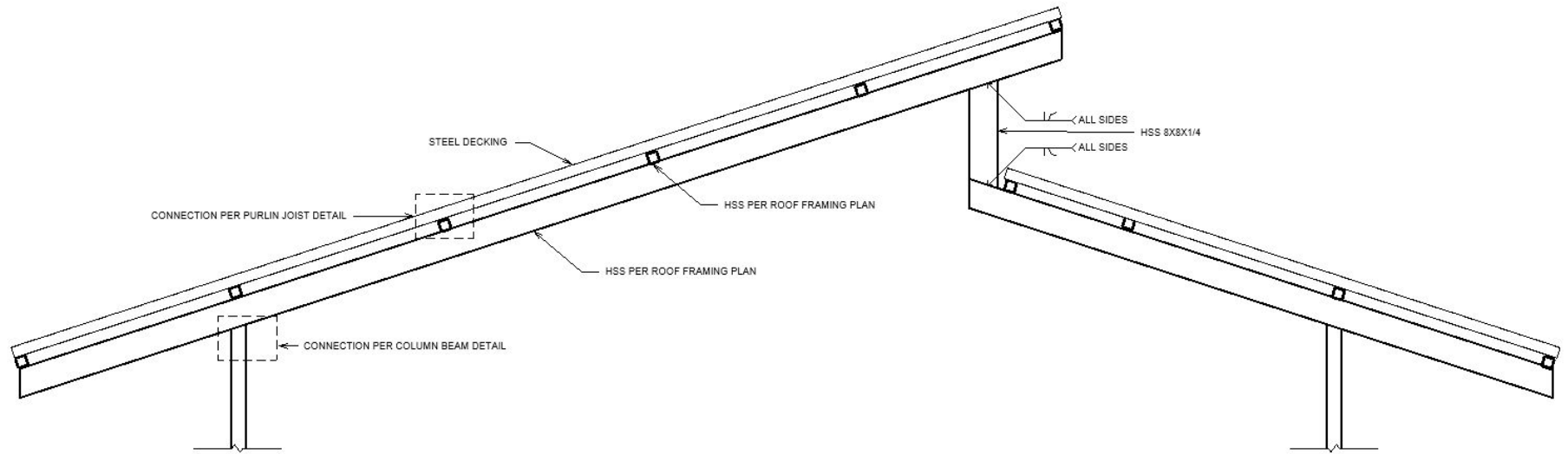
- LOCALLY MADE BRICKS
- MINIMAL CONCRETE STRENGTH
- SMALLER REBAR SIZES



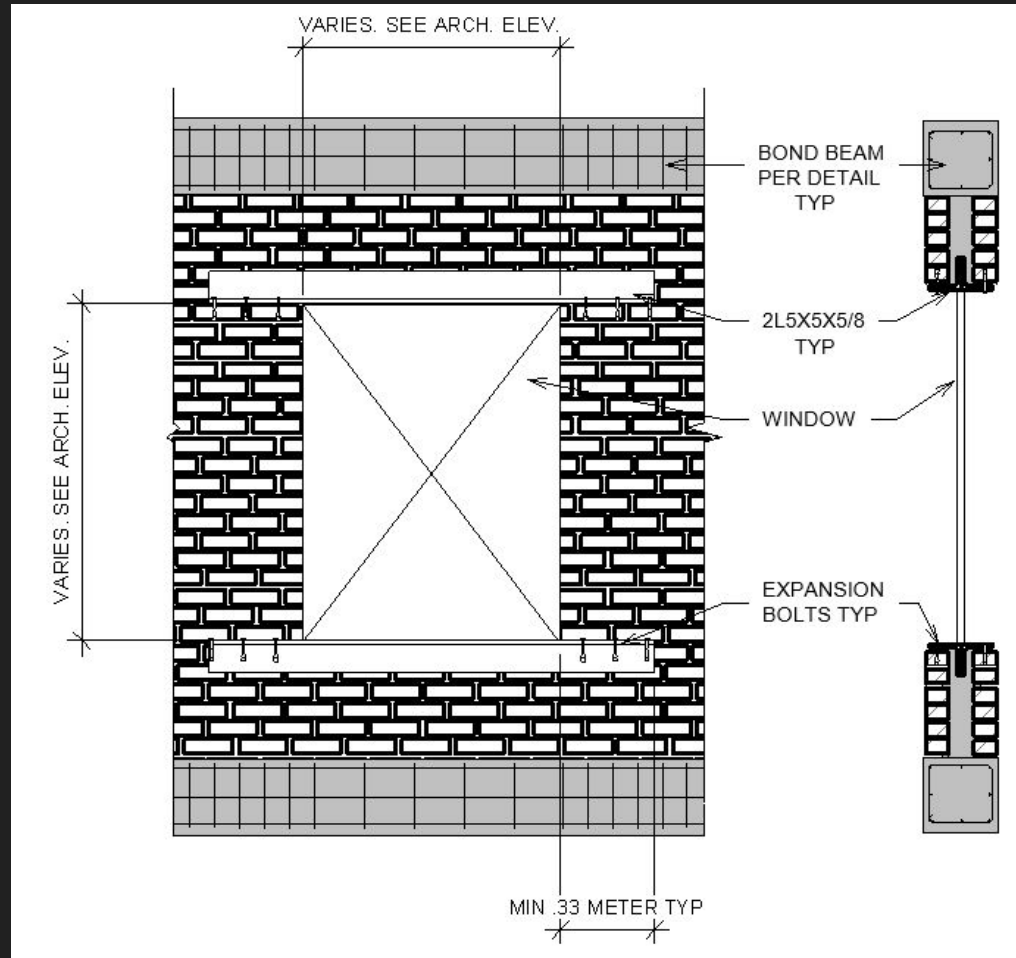
GRAVITY DESIGN



GIRDERS



HEADER



LATERAL DESIGN

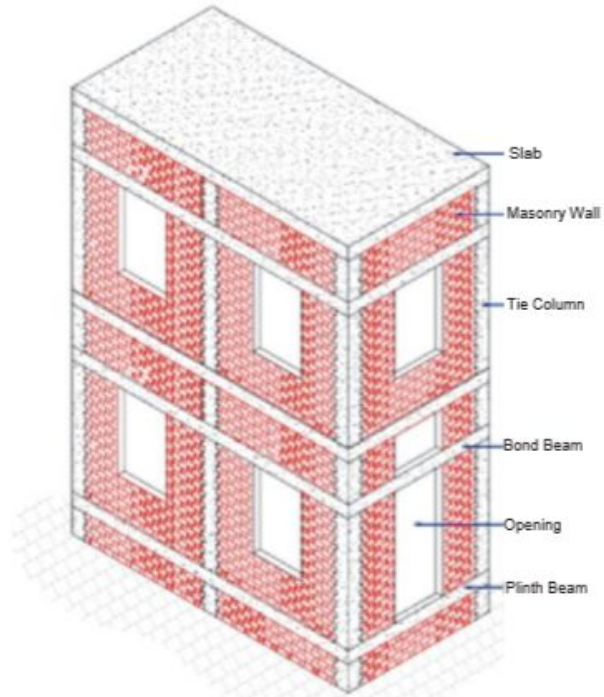
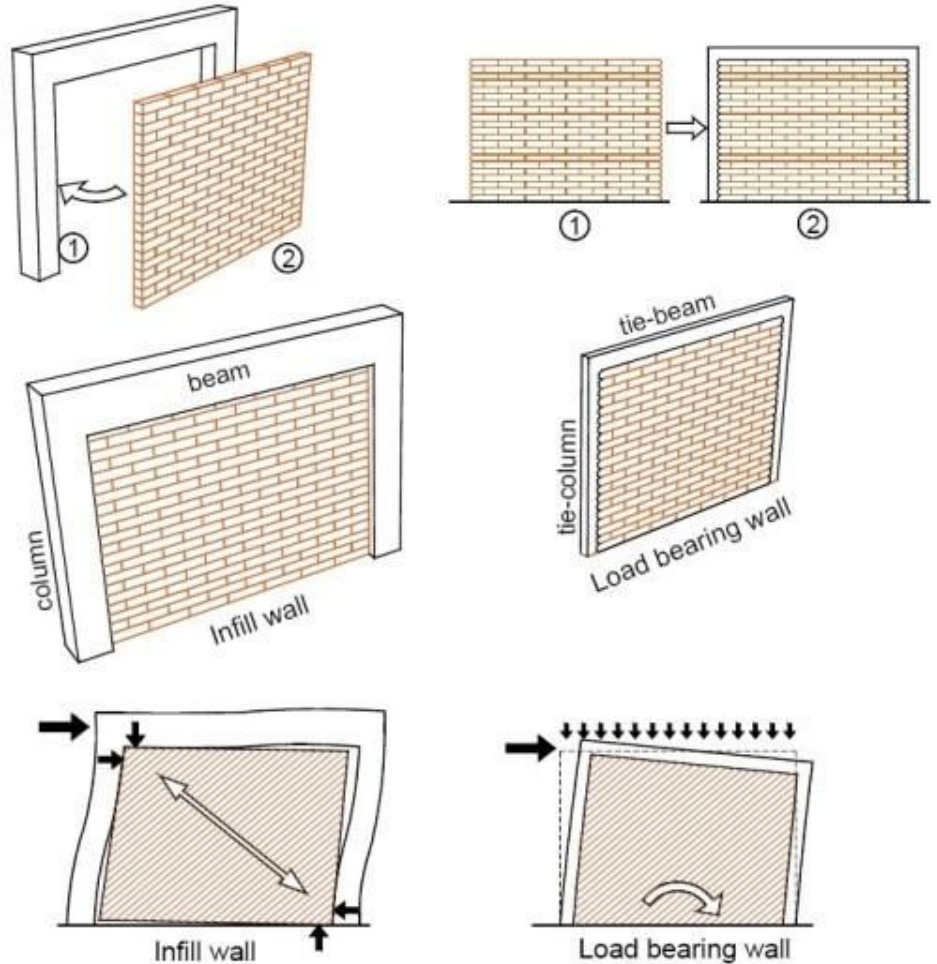
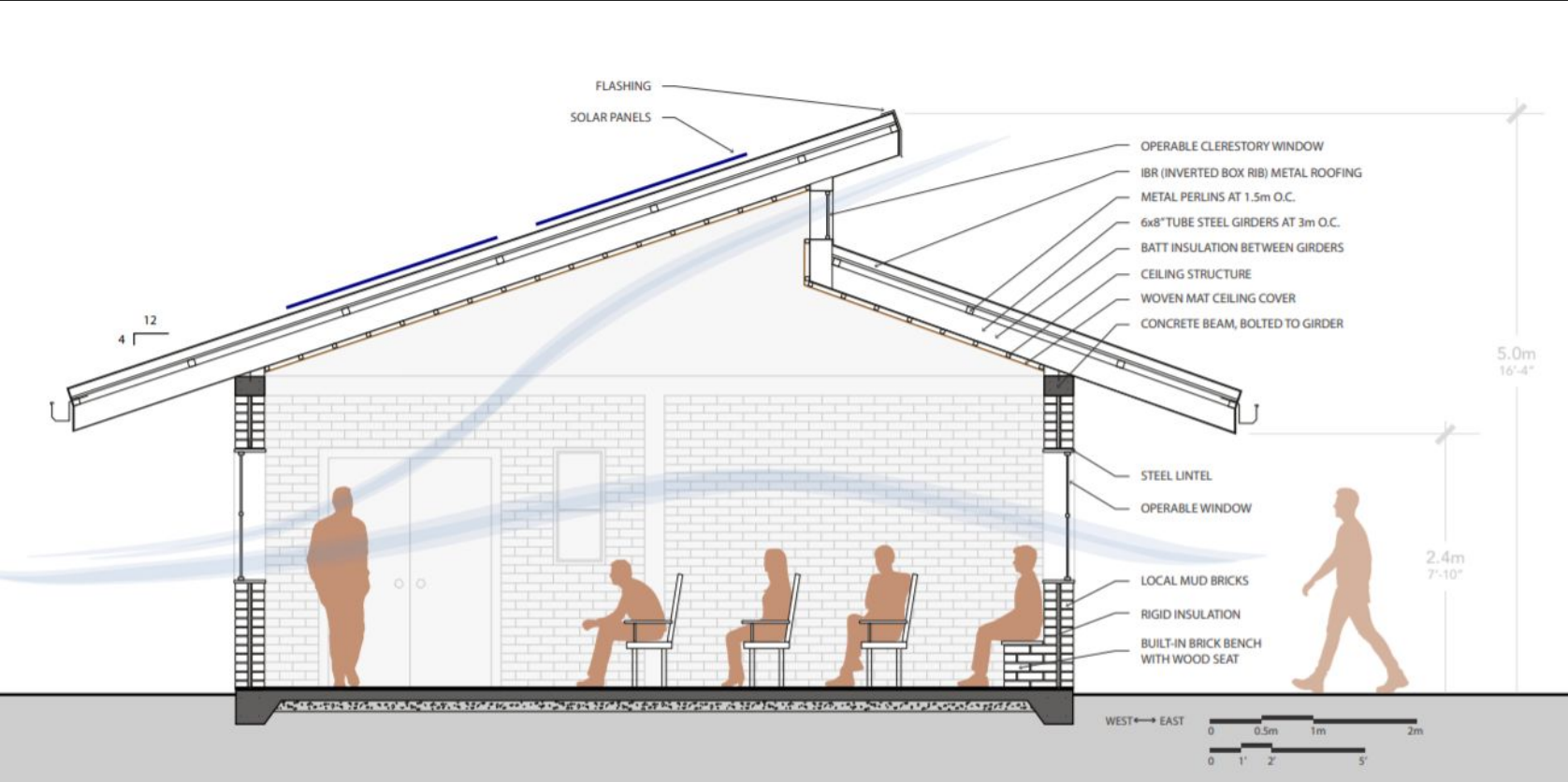
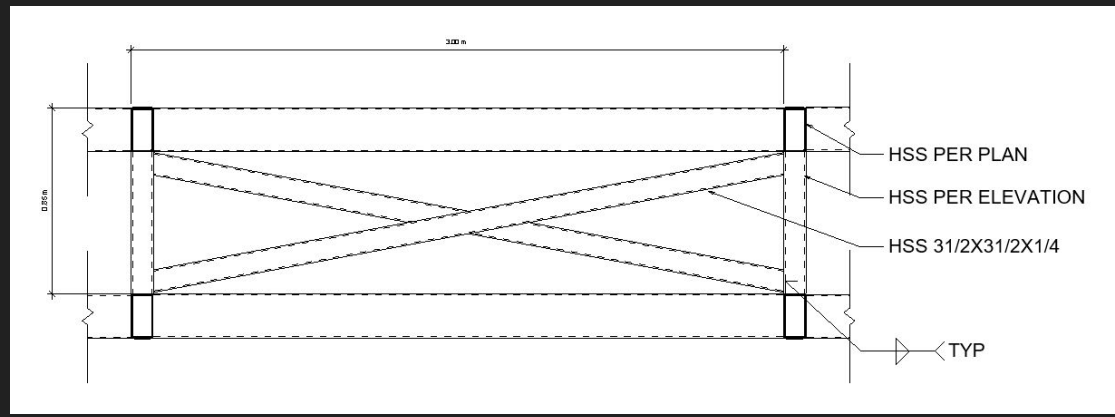
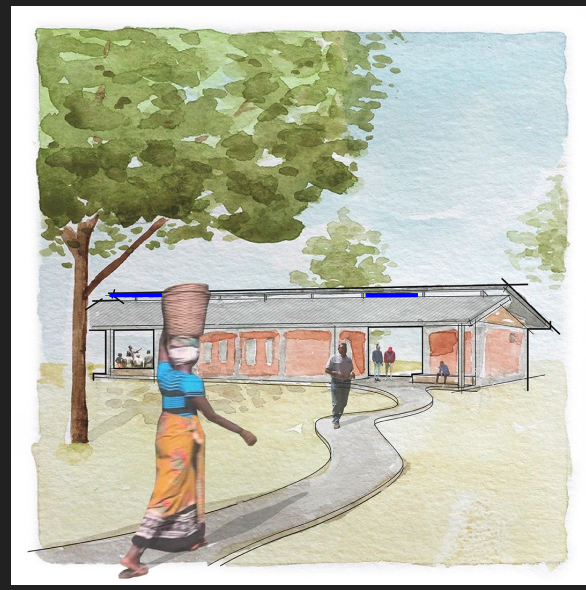
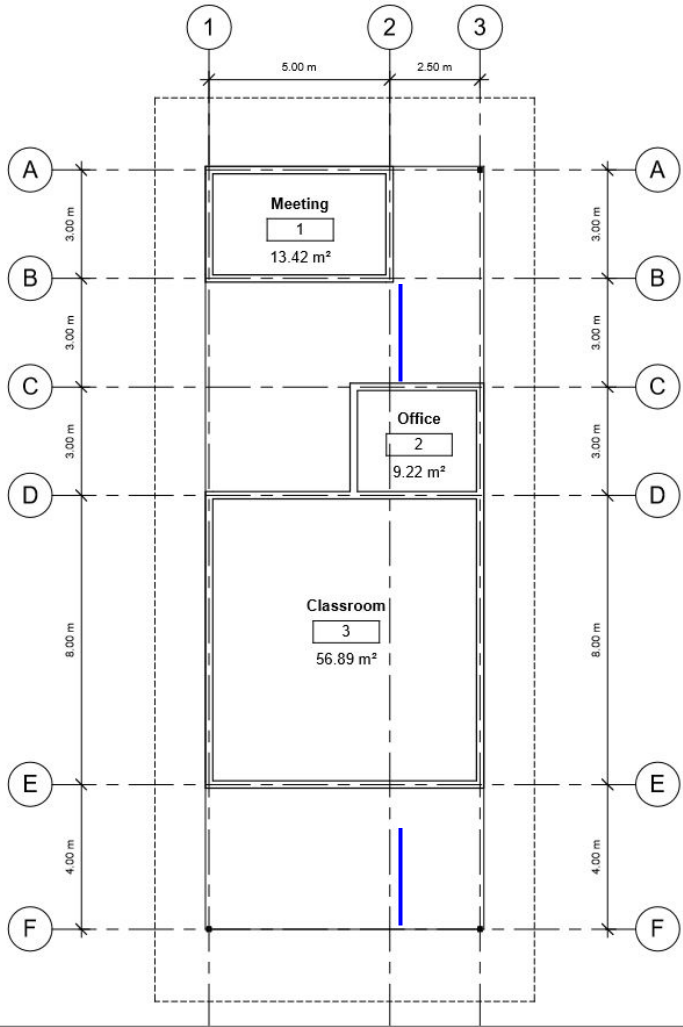


Figure 1.1 Typical Confined Masonry Building



ROOF DIAPHRAGM





THANK YOU!

- ALL RENDERINGS DONE BY HANNAH OITZMAN
- LATERAL DESIGN IMAGES
 - Chourasia, Ajay. Design Guidelines for Confined Masonry Buildings. Central Building Research Institute, 2017.
- BRICK CONSTRUCTION
 - MUSANZELNC, N. "Making Mud Bricks in Rwanda." YouTube, 24 June 2010, Making Mud Bricks in Rwanda.



CAL POLY
Architectural Engineering
**COLLEGE OF ARCHITECTURE
& ENVIRONMENTAL DESIGN**

