STRUCTURAL CALCULATIONS
FOR
SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN

12 JUNE 2021

PREPARED BY:
EMMA LAMBERT

THIS CALCULATION PACKAGE IS FOR REVIEW AND SHOULD NOT BE USED FOR CONSTRUCTION PRIOR TO BEING REVIEWED BY AN ONSITE ENGINEER

JOURNEYMAN INTERNATIONAL
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Journeyman International is a non-profit organization who partners with students and professionals to provide architectural design, architectural engineering, and construction management work for developing countries in order to combat poverty and ecological destruction on a global scale. The Salvation Academy for Disadvantaged Children is sponsored by Journeyman International and a private client to provide a school campus with a safe and productive environment for children and staff with disabilities. The campus is equipped with classrooms, outdoor gymnasiums, residences for both students and faculty, as well as computer labs and conference areas. The site is located in the Western Area of Freetown, Sierra Leone, on sandy gravel soil and consistently flat ground for the structure to reside on. This report will primarily focus on the structural design of the staff quarters building by going into great detail of the primary gravity and lateral systems. It will also discuss the global and environmental impacts and considerations that were taken and incorporated into this design.
The Salvation Academy for Disadvantaged Children is an elementary school campus for students and faculty with disabilities. This report highlights the structural engineering efforts from architectural engineering student Emma Lambert as she worked in partnership with Journeyman International (JI) an organization dedicated to fostering design projects for developing countries in an effort to combat poverty and ecological decline on a global scale. The site in question is located in the Western Area, of Freetown, Sierra Leone in a secluded area away from many of the major developments of the city. The primary beneficiary of this structure will be the children of Sierra Leone Action for the Disadvantaged (SLAD). Sierra Leone currently has approximately 2,500 children whom are disadvantaged due to widespread poverty and illiteracy. These factors greatly increase cyclical patterns of children growing up in poverty. Therefore, the mission for this project is to provide a primary school campus that is completely accessible for children and staff with disabilities at a low cost or free to families in the surrounding area. The building will consist of ten classrooms, a computer lab, a dining hall, reception area, daycare, staff rooms and quarters, along with dormitories for the students and a conference hall. This report will focus on the structural engineering behind the staff quarters building along with social and environmental impacts that will occur as a result of the construction of this structure. Due to the lack of building code in Sierra Leone all calculations for this building were designed in accordance with the International Building Code along with any material specific codes necessary for construction.
Throughout the design process of this project there were various impacts considered including: global, cultural, social, environmental, and economic impacts that were influences by the project, beneficiaries, and Journeyman International.

The Salvation Academy for Disadvantaged Children will have a large impact from a global perspective. According to the United Nations, Sierra Leone is categorized as a "least developed country," which is a tier below the developing country status. Due to this categorization the SLAD team is combating the very issue at hand by targeting beneficiaries who have a form of disability that is most commonly induced by poverty. Due to the history of illiteracy that runs within the families of Sierra Leone poverty becomes a cyclical pattern.

Therefore, by providing children with low cost or free education this school will directly impact the youth of tomorrow and aid in ending this cycle. It will also provide jobs as the faculty and staff roles will need to be fulfilled.

Due to the nature of this building consisting of an educational facility it will have great cultural implications on the Freetown community. By serving as a school it will be able to foster the culture and beauty that comes from Freetown by teaching perseverance and strength that Sierra Leone has exhibited throughout its history including the battle against the colonization from Nova Scotian settlers. The building was also design for forces that comply with it being considered an evacuation site and therefore, can be seen as safe space in time of disaster for the community. By categorizing this building as an evacuation site under Risk Category IV from the IBC the designers were able to boost moral within the culture and community.

[Fig. 2 SLAD Beneficiaries]
of the new building.

Since the Salvation Academy for Disadvantaged Youth is focused on providing education to students who are disadvantaged it will aid in shifting social views in Sierra Leone upon those who are in varying stages of poverty and as a result disability. The design of the structure has taken careful thought into creating an accessible environment for those with disabilities. All the buildings on the campus are either one story or are two stories and are equipped with elevators, ramps, and stairwells. Outdoor play areas are enclosed by other buildings and far removed from cars and access points to keep the children safe from oncoming traffic. Lastly, each building is designed to emulate the tranquility of the outdoors while keeping in mind that rooms shall not be overly lit or acoustically designed so as to prevent over

These are just a few of the many manners in which accessibility was considered throughout the design process. By designing the campus and buildings for accessibility
the design team was able to create a new narrative for disadvantaged and disabled youth in Sierra Leone from "a person with disabilities" to a person who is "differently abled." This will create a social change and view in Freetown by displaying that civilians with disabilities can be similarly capable to that of their peers without disabilities when given equal opportunity to succeed. By fostering a narrative of helping those in poverty and attempting to break the cycle of it the SLAD team has been able to "rewrite" what poverty emulates in present day Sierra Leone.

All buildings are designed with a focus on the surrounding environment and sustainable practices. The architect made use of a sustainable design approach in order to maximize natural lighting, ventilation, energy efficiency, along with connections to the surrounding outdoor environment as seen in Fig. 4. Due to the tropical environment of Freetown heavy insulation using recycled newspaper will be implemented within the airtight building to ensure warmth and comfort of its residents.
Lastly, all concrete structural elements will be made using recycled aggregate to decrease the amount of waste used on the construction site. With these environmental considerations in mind the design team was able to create a productive and comfortable learning setting for the students and faculty.

Economic considerations were of great importance to the design team throughout this process. When determining the lateral force resisting system there were a few options available, however the governing result was the most cost effective for the community. A reinforced concrete wall with a brick facade was considered for this design, however, was ultimately deemed to costly due to the vast amount of concrete used in the structure. Therefore, the structural engineering student decided to move forward with a confined masonry wall system which would drastically decrease the amount of reinforcement and concrete used within the lateral force resisting system.
The conventional Journeyman International project consists of an interdisciplinary team of California Polytechnic State University, San Luis Obispo (Cal Poly SLO) fourth year students of the disciplines, construction management, architecture, and architectural engineering. However, this project was more unconventional due to the architectural engineering student being the only person from Cal Poly SLO. The remainder of the team was based in various parts Africa. The architect, Anita Wesonga, is a masters student located in Kenya, the construction managers, Joanna Nsenga and Carly Altoff are both residing in Rwanda and the architectural engineer Emma Lambert is from California. Therefore, at the beginning of this project it posed some difficulty due to the varying time zones when it came to scheduling meetings and conference calls. However, this allowed for Emma Lambert to raise her personal strengths of communication to meet that of the others working on the team. The team made great use of the phone application "whats app" in order to maintain an open communication and dialogue. In order to supplement the shorter periods of time spent on video call emails were being sent back and forth continuously to ensure all team members were on the same page. The team also took advantage of the varying time zones. Emma became aware that if she asked a question to any other member on the team prior to nightfall of that day she would receive an answer overnight. This allowed the team to work together harmoniously in order to provide a great result for the client. All team meetings and conversations also included the client in order to accommodate different requests made along the way.
Throughout this project I learned the importance of communication and how vital it is in order to create a successful result. Working alongside masters students and industry professionals allowed me to rise to the occasion and push myself to greater lengths of personal growth. The varying times zones posed great difficulty in the beginning, however, was resolved throughout proper planning and communicating through other platforms besides email and video call.

Another hurdle I faced was the grave irregularity of the building. In our typical classes the buildings are typically rectangular in shape and do not have great variance in weight distribution. Therefore, when presented with a building with a large amount of reentrant corners and discontinuous collector lines. I was taken aback as how to solve these problems. However, after doing research of existing buildings with reentrant corners and discontinuous collector lines I found some possible solutions. These answers were solidified after discussing further with my senior project advisor James Mwangi.

The design of trusses was also a new addition for me as I had only analyzed trusses previously. Therefore, when it came to designing them out of dimensional lumber I did hit a road block due to their being no strength properties available in Sierra Leone. This led me to do research into available trade routes in Sierra Leone and along its neighboring countries Ghana and Nigeria due to their similar climates and wooded regions. I discovered there was a tremendous amount of crossover between these countries and was put into contact with another faculty member at Cal Poly SLO who lived in Ghana for many years. However, when this contact fell short I began to search deeper into the National Design Specification for Wood Construction Supplement and discovered a non-western wood species table. In this table Montane
Pine had strength properties available and was commonly found in South Africa. After researching manners to equate plant species I was able to draw comparison between it and the native species to Freetown, Plum Tik.

The last hurdle I faced through this process was designing the lateral system. I was not entirely certain how to deal with the combination of both rigid and flexible diaphragms, however, after searching through the remaining work in my design labs I was able to figure out an efficient manner in obtaining my seismic forces. This resulted in me building an entire ETABS model of the building in question. I also was unfamiliar with confined masonry walls and how they differed from reinforced concrete moment frames. Therefore, I found Youtube videos that would aid me in my understanding of the design and efficiency behind this system. After collecting my knowledge from these videos and reading research papers on the differences between both systems I was able to learn on my own how to design these walls.

Overall, this project taught me how to effectively work in a team and to be confident in my own work and competency. It allowed me to grow as an engineer and learn what work is like in the professional field beyond standard schooling.
GENERAL REQUIREMENTS
PROJECT DESCRIPTION:

This project will provide livelihood and educational opportunities to children living in disadvantaged communities in Sierra Leone. This two-story building will serve as the staff quarters while taking careful thought into account when considering accessibility to disabled staff. The main gravity system will consist of reinforced concrete columns, beams, and slabs. The roof gravity system will be comprised of timber strusses with steel decking. The lateral system consists of confined masonry in which the columns will resist flexural loading of both earthquake and wind forces.

DESIGN CRITERIA:

IBC 2018 310.3
BUILDING TYPE: TYPE R-2: RESIDENTIAL BUILDING, LIVE/WORK UNITS
DESIGN CODE: IBC 2018
WIND CRITERIA: BASIC WIND SPEED = 180 MPH
SEAOC SEISMIC DESIGN MAPS
SEISMIC CRITERIA: RISK CATEGORY IV (IBC 2018 T. 1604.5 PP 3604) (Elementary School)
SITE CRITERIA: SITE CLASS D DEFAULT (SAND/ROCK GRAVEL AND IS PRONE TO MOISTURE INFILTRATING SOIL)

MATERIAL SPECIFICATIONS (TYPICAL, UNLESS NOTED OTHERWISE):

ACI 318-19
CONCRETE: DESIGNED IN ACCORDANCE WITH ACI 318-19
MATERIAL AND WORKMANSHP PER 318-19
MATERIAL SPECIFICATIONS, TYP. UNO
SLAB \( F'c = 3000 \text{ PSI} (20,684 \text{ kPA}) \)
COLUMNS \( F'c = 3000 \text{ PSI} (20,684 \text{ kPA}) \)
OTHER STRUCTURAL ELEMENTS \( F'c = 3000 \text{ PSI} (20,684 \text{ kPA}) \)
ACI 318-19
REINFORCING STEEL: DESIGNED IN ACCORDANCE WITH ACI 318-19
MATERIAL SPECIFICATIONS, TYP. UNO
REINFORCING STEEL PER
ASTM A615M GRADE 60
ASTM A615M GRADE 40
WELDING REINFORCING STEEL PER
ASTM A706M
IBC 2018
BRICK: DESIGNED IN ACCORDANCE WITH INTERNATIONAL BUILDING CODE 2018
MATERIAL SPECIFICATIONS, TYP. UNO
CONFINED MASONRY WALLS \( F'm = 700 \text{ PSI} (4826 \text{ kPA}) \)
NDS 2018
TIMBER: DESIGNED IN ACCORDANCE WITH NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION 2018
MATERIALS AND SPECIFICATIONS, TYP. UNO, MEMBERS DESIGNED WITH
TRUSS WEB MEMBERS MONTANE PINE
TRUSS CHORDS MONTANE PINE
ACI 318-19
FOUNDATION: ASSUME SITE CLASS D (DEFAULT)
ASSUMED ALLOWABLE SOIL BEARING PRESSURE = 5000 PSF
NOTE: 1/3 ALLOWABLE INCREASE FOR WIND AND SEISMIC
LIVE LOAD LOADING DIAGRAM

BALCONY LIVE LOAD

RESIDENTIAL LIVE LOAD

REFERENCE:

1 32 4 5 6 87 9 10

A 4.00
B 5.00
C 4.51
D 2.40
E 3.40
F 2.96
G 2.06
H 1.36
J 0.63
K 3.20
L 5.20

25.64
2.20 1.85 4.35 2.00 2.00 5.50 2.93 0.88 3.94

PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

PREPARED BY: EMMA LAMBERT

DATE: 5/7/2021

SHEET: W1
LOAD TAKEOFF

### FLOOR FRAMING INFORMATION:

- **Floor slab thickness**: 5.00 inches
- **Floor joist width**: 18.00 inches
- **Floor joist depth**: 10.00 inches
- **Floor joist spacing**: 8.20 feet
- **Floor girder width**: 9.00 inches
- **Floor girder depth**: 18.00 inches
- **Floor girder spacing**: 20.34 feet
- **Column width**: 22.00 inches
- **Column depth**: 22.00 inches
- **Bay spacing**: 16.40 feet
- **Story height**: 10.09 feet

### TYPICAL FLOOR DEAD LOAD

<table>
<thead>
<tr>
<th>Materials</th>
<th>Slab</th>
<th>Joists</th>
<th>Girders</th>
<th>Columns</th>
<th>Seismic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>PSF</td>
<td>PSF</td>
<td>PSF</td>
<td>PSF</td>
<td>PSF</td>
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<tr>
<td>Lateral Frame: 8” Brick Walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

**Total Structural Weight**
- Slab: 75 PSF
- Joists: 95 PSF
- Girders: 105 PSF
- Columns: 110 PSF
- Seismic: 115 PSF

**Floor Joist Information**:

- **Bay spacing**: 8.00 feet
- **Story height**: 10.09 feet
- **Column width**: 10.00 inches
- **Column depth**: 10.00 inches

**Recommended Design Floor DL**

<table>
<thead>
<tr>
<th></th>
<th>95</th>
<th>110</th>
<th>120</th>
<th>125</th>
<th>155</th>
</tr>
</thead>
</table>

Live Loads per IBC Section 1607 / ASCE 7-16 Chapter 4:

- **Corridors**: 80 PSF
- **Residential Unit**: 40 PSF + 15 PSF = 55 PSF
- **Balcony**: 100 PSF
- **Exterior Patio**: 20 PSF

Notes:

1) 6" slab load = [(6"/12) * 150PCF] = 75 PSF
2) 10" wide x 18" deep beam load = [(18"-5")/144]*150PCF/8.2ft = 16.5 PSF
3) 12" wide x 18" deep girder load = [(18"-5")/12]/144]*150PCF/20.34ft = 8 PSF
   - Note the slab thickness has been subtracted from the overall beam and girder depth
4) 12" x 12" column load = [(12"*12")/144]*150PCF*(10.8ft-1.5ft)]/(16.7ftx16.4ft) = 5 PSF
   - Note the girder depth has been subtracted from the overall column height
5) 8" brick walls = [(4 walls) * (8"/12)(10ft)*80PCF*(10.8ft-1.5ft)]/4707.82ft²
   - Note the lateral system is typically estimated and an allowance for concrete is aprox 15-20 PSF
6) For seismic design, the ASCE 7 prescribed minimum partition load is 10 PSF
## LOAD TAKEOFF

<table>
<thead>
<tr>
<th>Materials</th>
<th>Slab</th>
<th>Joists</th>
<th>Girders</th>
<th>Columns</th>
<th>Seismic</th>
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<td>PSF</td>
<td>PSF</td>
<td>PSF</td>
<td>PSF</td>
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<td>110</td>
<td>115</td>
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<td>90</td>
<td>110</td>
<td>118</td>
<td>123</td>
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<tr>
<td>Partitions (psf)</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Total Design Floor Dead Load</td>
<td>90</td>
<td>110</td>
<td>118</td>
<td>123</td>
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<tr>
<td>Recommended Design Floor DL</td>
<td>95</td>
<td>110</td>
<td>120</td>
<td>125</td>
<td>170</td>
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</table>

Live Loads per IBC Section 1607 / ASCE 7-16 Chapter 4
- corridors = 80 PSF
- residential unit = 40 PSF + 15 PSF = 55 PSF
- balcony = 100 PSF
- exterior patio = 100 PSF

Notes:
1) 5" slab load = [(5"/12) * 150PCF] = 62.5 PSF
2) 10" wide x 18" deep beam load = [(18"-5")*10"/144]*150PCF/8.2ft = 16.5 PSF
3) 12" wide x 18" deep girder load = [(18"-5")*12"/144]*150PCF/20.34ft = 8 PSF
   • Note the slab thickness has been subtracted from the overall beam and girder depth
4) 12" x 12" column load = [(12"*12")/144]*150PCF*10.8ft-1.5ft)/(16.7ftx16.4ft) = 5 PSF
   • Note the girder depth has been subtracted from the overall column height
5) 8" brick walls = [(4 walls) * (8"/12)(10ft)*80PCF*(10.8ft-1.5ft)]/4707.82ft²
   • Note the lateral system is typically estimated and an allowance for concrete is aprox 15-
6) for seismic design, the ASCE 7 prescribed minimum partition load is 10 PSF
## LOAD TAKEOFF

### TYPICAL ROOF DEAD LOAD

<table>
<thead>
<tr>
<th>Materials</th>
<th>Decking</th>
<th>Trusses</th>
<th>Beams</th>
<th>Columns</th>
<th>Seismic</th>
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<tbody>
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<td></td>
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<tr>
<td>Units</td>
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<td>30</td>
<td>30</td>
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</tr>
<tr>
<td>Beam</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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</tr>
<tr>
<td>Columns</td>
<td>5</td>
<td>5</td>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Lateral Frame: 8&quot; Brick Walls</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Total Structural Weight</strong></td>
<td>2.8</td>
<td>32.8</td>
<td>52.8</td>
<td>57.8</td>
<td>62.8</td>
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<tr>
<td>MEP</td>
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<td>1.5</td>
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<td>1.5</td>
<td>1.5</td>
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<td>Miscellaneous</td>
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<tr>
<td><strong>Total Roof Dead Load (psf)</strong></td>
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<td>37.3</td>
<td>57.3</td>
<td>62.3</td>
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<td>5</td>
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<td><strong>Total Design Roof Dead Load</strong></td>
<td>7.3</td>
<td>37.3</td>
<td>57.3</td>
<td>62.3</td>
<td>72.3</td>
</tr>
</tbody>
</table>

**Recommended Design Roof DL**

|        | 10 | 40 | 60 | 65 | 70 |

Live Loads per IBC Section 1607 / ASCE 7-16 Chapter 4

\[
\text{roof} = 20 \text{ PSF}
\]

Notes:

1) 5" slab load = \([(5"/12) \times 150\text{PCF}] = 62.5 \text{ PSF}
2) 10" wide x 18" deep beam load = \([(18"-5")/144\] *150\text{PCF}/8.2ft = 16.5 \text{ PSF}
3) 12" wide x 18" deep girder load = \([(18"-5")/144\] *150\text{PCF}/20.34ft = 8 \text{ PSF}
   • Note the slab thickness has been subtracted from the overall beam and girder depth
4) 12" x 12" column load = \([(12" \times 12")/144\] *150\text{PCF}/(16.7ftx16.4ft) = 5 \text{ PSF}
   • Note the girder depth has been subtracted from the overall column height
5) 8" brick walls = \([(4 \times 8")/12\] *80\text{PCF}/(10.8ft-1.5ft)]/4707.82ft²
   • Note the lateral system is typically estimated and an allowance for concrete is approx 15-20 PSF
6) for seismic design, the ASCE 7 prescribed minimum partition load is 10 PSF
**BUILDING WEIGHTS PER LEVEL**

### 2ND FLOOR WEIGHT

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Trib Width (ft)</th>
<th>Length (ft)</th>
<th>Opening (ft²)</th>
<th>Area Net (ft²)</th>
<th>Weight (PSF)</th>
<th>Area x Weight (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Walls</td>
<td>10</td>
<td>137</td>
<td>0</td>
<td>1383</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Typ Floor</td>
<td>Irregular Shape</td>
<td>0</td>
<td></td>
<td>4708</td>
<td>155</td>
<td>730</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td><strong>Weight 2nd Floor (k) = 737</strong></td>
</tr>
</tbody>
</table>

### ROOF WEIGHT

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Trib Width (ft)</th>
<th>Length (ft)</th>
<th>Opening (ft²)</th>
<th>Area Net (ft²)</th>
<th>Weight (PSF)</th>
<th>Area x Weight (k)</th>
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</thead>
<tbody>
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<td>Shear Walls</td>
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<td>675</td>
<td>5</td>
<td>3</td>
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<tr>
<td>Typ Floor</td>
<td>Irregular Shape</td>
<td>0</td>
<td></td>
<td>5884</td>
<td>70</td>
<td>412</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Weight Roof (k) = 415</strong></td>
</tr>
</tbody>
</table>
GRAVITY DESIGN
ROOF FRAMING DESIGN
GRAVITY DESIGN

ROOF BEAM 1

ALL LOADS + SELF-WEIGHT ARE ACCOUNTED FOR IN ETABS MODEL TO ACCOUNT FOR

MOMENT REDISTRIBUTION, ASSUME NO PATTERN LOADING DUE TO THE SMALL SCALE OF THE STRUCTURE

NO LIVE LOAD REDUCTION ACCOUNTED FOR

ISC 2019 § 1005.2

LOAD COMBINATION: 1.20 T 1.4L EQ 16'-2

MOMENT DIAGRAM: BEAM LINE F

ASSUME TRUSS ARE SPACED AT 1M O.C.

Mmax AT MIDSPAN

Mmax = 8.8752k-ft

Mmax AT SUPPORT

Mmax = 14.428k-ft

ASSUME AN 15" x 10" ROOF BEAM BASED ON PRELIMINARY FRAMING

ESTIMATE STEEL REINFORCEMENT

\[ A_s = \frac{Mu}{\phi fy'd} \]

\[ \phi = 0.8752 \text{ k-ft}(12''/1') = 205 \text{ in}^2 \]

Try 3 # 4 bars \[ A_s = 0.61 \text{ in}^2 > 0.21 \text{ in}^2 \]

\[ A_s = 14.428 \text{ k-ft}(12''/1') = 345 \text{ in}^2 \]

Try 3 # 4 bars \[ A_s = 0.61 \text{ in}^2 > 0.21 \text{ in}^2 \]
Gravity Design

Roof Beam 1 Continued

Check Flexural Capacity

Calculate Effective Width of L-Shaped Beams

\[ \text{Effective Width} = \min \left(10'' + w(6''), 10'' + 50(1''/2) + 2''1'', 10'' + 216.85''/12 = 28'' \right) \]

Positive Moment

\[ Q = \frac{0.61(2000)(15.5'' - 0.32w/2)}{12''/1''} = 29.5\text{ k-ft} \]

\[ \phi M_n > M_u = 27.5\text{ k-ft} > 29.5\text{ k-ft} \quad \text{Okay for Flexural Capacity at Midspan} \]

Negative Moment

\[ Q = \frac{0.61(2000)(15.5'' - 0.94w/2)}{12''/1''} = 27\text{ k-ft} \]

\[ \phi M_n > M_u = 14.428\text{ k-ft} \quad \text{Okay for Flexural Capacity at Midspan} \]

Use 3 # 4 bars top and bottom for flexural reinforcement

Check Shear Capacity

Shear 2-2 Diagram: Ground F

\[ V_{ymax} = 4.948\text{ k} \quad \text{Pulled from ETABS} \]

\[ S_{max} = \frac{d/2}{15.5''/2} = 9.75'' \quad \text{Use 6'' O.C. / 15 cm O.C.} \]
### Gravity Design

**Try #3 Stirrups (2 Legged)**

\[
\phi V_n = 0.9 \left( \frac{2 \sqrt{1000 \text{ psi}}}{1000 \text{ in/kip}} \right) \left( \frac{16''}{10''} \right) + 2 \text{ Legged } \left[ \frac{1.1 \text{ in}^2}{0.8 \text{ ksi} \cdot 10''} \right] = 6''
\]

\[
\phi V_n = 44.9 \text{ k} > V = 5 \text{ k} \quad \text{OKAY FOR SHEAR} \quad \text{DCR: 117.}
\]

**Use #3 Ties @ 20 cm O.C. for confinement of longitudinal reinforcement**

### Deflection Check

**Assume simply supported for conservatism**

Minimum 

\[
h = \frac{2}{16} = 10.04 \frac{1}{12}' = 10 \frac{1}{12}'' = 10.8\text{''} < 18\text{''}
\]

OKAY NO NEED TO CHECK DEFLECTION

**Modify since steel**

\[
\phi = 0.9 \text{ ksi}
\]

### Final Sketches

![Beam Section @ Midspan](image)

![Beam Section @ Support](image)
**TRUSS DESIGN**

**WORST CASE TRUSS IS SELECTED BASED ON SPAN AND LOADING**

**TRUSS DEPTH APPROXIMATION**

<table>
<thead>
<tr>
<th>Truss Description</th>
<th>Typical Span Range</th>
<th>Approximate Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Web Joist</td>
<td>20' to 80'</td>
<td>L/20</td>
</tr>
<tr>
<td>Wood (spaced 3' on center)</td>
<td>20' to 100'</td>
<td>L/20</td>
</tr>
<tr>
<td>Steel (spaced 3' to 6' on center)</td>
<td>60' to 150'</td>
<td>L/10</td>
</tr>
</tbody>
</table>

**SHAPED TRUSS APPROXIMATE DEPTH**

\[ \text{Depth} = 50/6 = 8.33 < 10 \]

**TRUSS PROFILE SKETCHES**

**METRIC UNITS**

**IMPERIAL UNITS**
REFERENCES

TRUSS DESIGN

FACTORED DISTRIBUTED LOADING

- DL = 40 PSF [SEE DEAD TO TRUSSES]
- LL = 20 PSF

NO LL REDUCTION DUE TO 2:1 RATIO OF DEAD TO LIVE LOAD

\[ W_D = 1.2 \times (40 \text{ PSF}) \times (3.2808') = 157.5 \text{ PLF} \]

\[ W_L = 1.6 \times (20 \text{ PSF}) \times (3.2808') = 105 \text{ PLF} \]

LOADING DIAGRAM

DISTRIBUTED LOADING

- WL = 105 PLF
- WD = 157.5 PLF

8.23' 8.23' 8.23' 8.23' 8.23' 49.4'

POINT LOADING TO PREVENT MOMENT IN CHORDS

8.23' 8.23' 8.23' 8.23' 8.23' 49.4'
TRUSS DESIGN

SAP 2000 LOADING

ALL MEMBERS ARE WEIGHTLESS

UNFACTORED DEAD LOADING

MATH CHECK

\[ R = \frac{wL}{2} = \left( \frac{105 \text{PLF} + 139.5 \text{PLF}}{2} \right) \cdot 49.4' = 6480 \text{ lb} = 6.48 \text{ k} \]

REACTIONS

MODEL IS ACCURATE
PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

SUBJECT: TRUSS DESIGN

PREPARED BY: EMMA LAMBERT

DATE: 5/23/11

SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

REFERENCE DESIGN VALUES: MONTANE PINE - SOUTH AFRICA NO. 1

- Fb = 950 PSI
- Fe = 300 PSI
- Fc = 950 PSI
- Fv = 135 PSI
- Em = 400,000 PSI

CHORD DESIGN

DESIGN BOTTOM CHORD FOR TENSION

F' = Ft : Cb : Cm : Ct : Cf : Cs

MODIFICATION FACTORS

- NDS § 2.3.2 Cb = 1.6 WIND/EARTHQUAKE
- NDS § 4.1.9 Cm = 1.0
- NDS § 2.3.3 Cb = 1.0 AVERAGE TEMP IN FREETOWN, SIERRA LEONE IS 81°F < 100°F
- NDS § 4.3.0 Cf = 1.0 ASUME 1.0 FOR CONSERVATION
- NDS § 4.3.4 Cs = 1.0

:. F' = 950 PSI : 1.6 : 1.0 = 1520 PSI
TRUSS DESIGN

SOLVE FOR REQUIRED AREA

\[ A = \frac{P}{F'} \]
\[ P = 11,954 \text{kN} \quad \text{(SAP 2000)} \]
\[ A = \frac{11,954 \text{kN}}{490 \text{psi}} = 24.3 \text{in}^2 \]

\[ \text{TRY A} = 30.3 \text{in}^2 \quad \Rightarrow \quad A = 1.3 \]

\[ P' \text{ADJUSTED} = 490 \text{psi} (1.3) = 647 \text{psi} \]

\[ f_s = \frac{P}{A} = \frac{11,954 \text{kN}}{30.3 \text{in}^2} \approx 395.9 \text{psi} < f' = 624 \text{psi} \]

OKAY FOR TENSION \( D.C. \)

USE A 6 x 6 MONTANE PINE OF NO. 1 GRADE

DESIGN TOP CHORD FOR COMPRESSION

\[ P' = F' = C_d \cdot C_m \cdot C_r \cdot C_f \cdot C_e \cdot C_p \]

MODIFICATION FACTORS

\[ \text{NDS } \S 2.3.2 \]
\[ C_d = 1.6 \quad \text{WIND/earthquake} \]

\[ \text{NDS } \S 4.1.4 \]
\[ C_m = 1.91 \quad \text{Assume for conservatism} \]

\[ \text{NDS } \S 2.3.3 \]
\[ C_r = 1.0 \quad \text{Average temp in Freetown, Sierra Leone is } 81^\circ \text{F} < 100^\circ \text{F} \]

\[ \text{NDS } \S 4.3.0 \]
\[ C_f = 1.0 \quad \text{Assume 1.0 for conservatism} \]

\[ \text{NDS } \S 4.3.4 \]
\[ C_e = 1.0 \]

\[ f_c^0 = f_c \cdot C_d \cdot C_m \cdot C_r \cdot C_f \cdot C_e \cdot C_p = 950 \text{ psi} (1.6 \cdot 1.91) = 1383.2 \text{ psi} \]

SOLVE FOR REQUIRED AREA

\[ A = \frac{P}{f_c^0} \]
\[ P = 12,425 \text{kN} \]
\[ A = \frac{12,425 \text{kN}}{950 \text{ psi}} = 13 \text{ in}^2 \]

FOR CONTINUITY OF CHORD MEMBERS TRY A 6 x 6 IN

\[ f_c' \text{ ADJUSTED} = 950 \text{ psi} \cdot 1.6 \cdot 1.91 \cdot 1 \cdot 0.91 \cdot 1.6 = 912.9 \text{ psi} \]

\[ C_d = 1.6 \quad \text{(Sawn lumber)} \]

\[ C_r = 1.0 \]

\[ C_f = 1.0 \]

\[ C_e = 1.0 \]

\[ C_p = 1.0 \]

\[ C_m = 1.91 \quad \text{Assume for conservatism} \]

\[ \text{NDS } \S 3.7.1 \]
\[ E_{\text{MIN'}} = 0.922 \quad E_{\text{MIN}} = 0.922 (3,900,000 \text{ psi}) = 3,597.4 \quad \text{psi} \]

\[ (12/4)^2 = 9 \frac{22}{300} \]

\[ \text{ASSUMED TO BE} \]

\[ (12/16)^2 \left( 3,900,000 \text{ psi} (1.91) \cdot 3,900,000 \text{ psi} \right) = 3,000 \]

\[ 5.5 \text{ psi} \]

\[ C_e = 0.9 \quad \text{(Sawn lumber)} \]

\[ C_r = 1.0 \]

\[ C_f = 1.0 \]

\[ f_c' \text{ ADJUSTED} = 950 \text{ psi} \cdot 1.6 \cdot 1.91 \cdot 0.91 \cdot 1.6 = 912.9 \text{ psi} \]
## PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

**PREPARED BY:** EMMA LAMBERT

**SUBJECT:** TRUSS DESIGN

| SHEET: R9 | DATE: 5/23/21 |

### REFERENCES

**TRUSS DESIGN**

\[ f_c = \frac{P}{A} = 12,425 \text{ lb} / 30.38 \text{ in}^2 = 410.9 \text{ psi} < f_c' \text{ (M) } = 912 \text{ psi} \]

**USE A 6" x 6" MONTANA PINE OF NO. 1 GRADE**

**CALCULATIONS**

### DESIGN VERTICAL WEB MEMBERS FOR TENSION

\[ f' = F_t \cdot C_t \cdot C_m \cdot C_f \cdot C_p \]

**MODIFICATION FACTORS**

| NOS § 2.3.2 | C_p: 1.6 WIND/EARTHQUAKE |
| NOS § 4.1.9 | C_m: 1.0 |
| NOS § 2.3.3 | C_t: 1.0 AVERAGE TEMP IN FREETOWN, SIERRA LEONE IS 81°F < 100°F |
| NOS § 4.3.6 | C_f: 1.0 ASSUME 1.0 FOR CONSERVATION |
| NOS § 4.3.8 | C_i: 1.0 |

\[ F_t = \frac{300 \text{ psi} \cdot 1.0}{1.0} = 300 \text{ psi} \]

**SOLVE FOR REQUIRED AREA**

\[ A = \frac{P}{F_t} \]

\[ P = 3,914 \text{ lb} = 3,914 \text{ lb} \]

\[ A = \frac{3,914 \text{ lb}}{300 \text{ psi}} = 9.71 \text{ in}^2 \]

**TRY A 2" x 6 = 9.35 \text{ in}^2 : C_f = 1.3**

\[ F_t' \text{ (ADJUSTED)} = 490 \text{ psi} \cdot 1.3 = 637 \text{ psi} \]

\[ f' = \frac{P}{A} = \frac{3,914 \text{ lb}}{9.71 \text{ in}^2} = 402 \text{ psi} < f' = 637 \text{ psi} \]

**OKAY FOR TENSION DCR = 90%**

**USE A 6" x 6" MONTANA PINE OF NO. 1 GRADE**

### DESIGN OF DIAGONAL WEB MEMBERS FOR COMPRESSION

\[ f_c = f_c \cdot C_t \cdot C_m \cdot C_f \cdot C_i \cdot C_p \]

**MODIFICATION FACTORS**

| C_p: 1.6 WIND/EARTHQUAKE |
| C_m: 1.91 ASSUME FOR CONSERVATION |
| C_t: 1.0 AVERAGE TEMP IN FREETOWN, SIERRA LEONE IS 81°F < 100°F |
| C_f: 1.0 ASSUME 1.0 FOR CONSERVATION |
| C_i: 1.0 |

\[ f_c' = f_c \cdot C_t \cdot C_m \cdot C_f \cdot C_i \cdot C_p = 950 \text{ psi} \cdot 1.6 \cdot 0.91 \cdot 1.0 = 1,383.2 \text{ psi} \]

**SOLVE FOR REQUIRED AREA**

\[ A = \frac{P}{f_c'} \]

\[ P = 3,914 \text{ lb} = 3,914 \text{ lb} \]

\[ A = \frac{3,914 \text{ lb}}{1,383.2 \text{ psi}} = 2,876 \text{ in}^2 : C_f = 1.0 \]

\[ 950 \text{ psi} \cdot 1.3 = 1,235 \text{ psi} > 950 \text{ psi} \]

**OKAY FOR COMPRESSION DCR = 76%**

**USE A 2" x 6" MONTANA PINE OF NO. 1 GRADE**

**REFERENCES**

| NOS 540P, T.1B PP.14 |
**PROJECT:** SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

**SUBJECT:** TRUSS DESIGN

**PREPARED BY:** EMMA LAMBERT

**DATE:** 5/23/11

**SHEET:** R10

---

### TRUSS DESIGN

- $F_c$ ADJUSTED MUST BE CALCULATED

- **COLUMN STABILITY FACTOR**

  
  
  \[
  C_p = \frac{1}{2C} \left[ \frac{1}{1 + \left( \frac{F_c}{F_{c0}} \right)^{\frac{2}{1-2C}}} \right]
  \]

- $F_c^2 = 950$ PSI : $1.6 \cdot 1.6 = 1216$ PSI

- $F_{c0} = 0.922$ 

  
  
  \[
  E_{\text{min}}' = \frac{922 \cdot (32000 \text{ PSI})}{(10 \text{ in})^2} = 828
  \]

  **ASSUMED TO BE 1**

- $C = 0.9$ (SAWN LUMBER)

- $C_p = 0.9$

- $F_c$ ADJUSTED = $950$ PSI : $1.6 \cdot 1.6 \cdot 0.9 = 535$ PSI

- $F_c = P/A = 29141/3.25 \text{ in}^2 = 353$ PSI $< F_c$ ADJUSTED = 535 PSI **OKAY FOR COMPRESSION**

---

### USE A 2 x 6 MONTANE PINE OF NO. 1 GRADE

---

**FINAL TRUSS DESIGN**

- **WEB MEMBERS ARE** 5CM X 15CM BOARDS IN "PLUM TIK"

- **CHORD MEMBERS ARE** 15CM X 15CM BOARDS IN "PLUM TIK"

---

**REFERENCES**

**CALCULATIONS**
FLOOR FRAMING DESIGN
REFERENCES

DESIGN

SECOND FLOOR SLAB DESIGN

LOADING

DL: 45 PSF

LL: 40 PSF + 15 PSF = 55 PSF 

ASSUME RESIDENTIAL UNIT PARTITIONS

FACTOR LOADS

IBC 2018 § 1603.2

[EQ. 16.2] 1.2D + 1.6L = 1.2(45 PSF) + 1.6(55 PSF) = 202 PSF

USE 1' STRIP WIDTH: W4 = 1'. 202 PSF = 202 psf = .3 ksf

ASSUME LARGEST SPAN OF SLAB FOR CONSERVATION

TYPICAL SLAB SECTION

INDUSTRY

FIND REQUIRED SLAB THICKNESS (UNCRAVED): UPPERBOUND

Fr = 9.5 / f'c = 9.5 / 5000 psi = 410.4 ft ksi

EQ. 9.13

M + L = 5300 psi = 312 ksi

\[ M_{MIN} = \frac{L}{2} = 12'' (4'') \]

Fr = \( \frac{6}{b} \)

BACK SOLVE THICKNESS

\[ t = \frac{N}{12''/\text{strip}} \]

\[ M = 0.09 \times L = 0.09 (24s_f) \times (4') = 1.296 \text{ k-ft / 1' strip} \]

\[ t = \frac{4(1.296 \times 24)/1'}{12'' (41 ksi)} \]

\[ t = 4'' \text{ USE 5'' FOR FIRE RATING} \]
## Gravity Design

### Second Floor Slab Design

### Deflection Check

\[ \Delta = \frac{5WL^4}{384EI} \]

TREAT SLAB AS SIMPLY SUPPORTED BEAM FOR CONSERVATION

\[ E = 3122 \, ksi \]

\[ L_a = 9'12''/1' = 108\, in \]

\[ I = \frac{12'' - 5''}{12} \times 121\, in^4 \]

\[ w = (100\, psf + 5\, psf) \times \frac{1'}{12''} = .015\, klf/\text{in} \]

\[ \Delta = \frac{5}{124} \left( \frac{.015\, klf/\text{in}}{108\, \text{in}} \right)^6 = .006\, \text{in.} \]

\[ 124 \left( \frac{3122\, ksi}{121\, \text{in}^4/\text{ft}} \right) \]

Check with L/240 (DL+LL)

\[ \Delta_{\text{ALLOWABLE}} = \frac{L}{240} = 9'12''/1'/240 = .45'' \]

\[ .45'' \times .006'' = \text{OKAY FOR DEFLECTION} \]

### Shear Check

Assume 100% shear resistance

\[ V_{\text{MAX}} = V_u \times (\text{Tributary Width}) = \frac{5}{6} \times \left( \frac{.2\, klf}{q'} \right) = 1.125\, klf \]

[Upper Bound]

\[ \Phi = \frac{1}{2} \left( 1 + \frac{q'}{q} \right) \]

\[ \frac{d}{2} \times \frac{V_{\text{u}} - 1000}{1.125\, klf} = 1.14'' \]

[Assumed Width]

\[ q' = 9' \times 3000\, psi = 2.3'' \]

[Lower Bound]

\[ 2d \times \frac{9'}{1} \times \frac{1.19''}{d} = \text{OKAY FOR MIN. THICKNESS} \]

Thickens of slab: 5'' + 1.19'' = 2.3''

Thickens of slab: 5'' + 1.19'' = 2.3''

Use a 15 cm concrete slab [4'' slab in imperial units]

Instead of 5'' use 6'' as prescribed by architect

### Flexural Steel Requirement

[End Span — Discontinuous End Unrestrained]

\[ M_t = \frac{Wu^2}{11} = 2\, klf \left( \frac{9'}{9} \right)^2 = 1.5\, kN \cdot \text{ft} \]

Midspan Moment

\[ M_t = \frac{Wu^2}{11} = 2\, klf \left( \frac{9'}{9} \right)^2 = 1.5\, kN \cdot \text{ft} \]

[End Exterior of First Interior Support — Two spans] Two spans for conservative

\[ M_t = \frac{Wu^2}{11} = 2\, klf \left( \frac{9'}{9} \right)^2 = 1.5\, kN \cdot \text{ft} \]

Moment at support
GRAVITY DESIGN

SECOND FLOOR SLAB DESIGN

ESTIMATE TENSION STEEL

\[ A_s = \frac{M_u}{f_y} \cdot \frac{12''}{12''} = \frac{1.5 \cdot \text{ft/ft} (12''/12'')}{0.95 \cdot 0.9 (40ksi)} \cdot \frac{1}{3} \]

TRY #5 12" O.C.

CHECK MINIMUM REINFORCEMENT REQUIREMENTS

\[ 12''/12'' = \frac{x}{3.14/12''} \cdot \frac{0.314}{12''} \cdot \frac{3.14}{12''} = 0.004 > 0.003 \]

OKAY FOR MIN. REINFORCEMENT

CHECK MOMENT CAPACITY

\[ M = A_s f_y \cdot \frac{12''}{12''} = 0.95 \cdot 0.9 (40ksi) \cdot \frac{12''}{12''} = 3.9 \text{ ft/ft} \cdot \frac{1}{12''} \]

\[ M = 2.89 \text{ ft/ft} \cdot \frac{1}{12''} \]

OKAY FOR FLEXURAL CAPACITY

USE #5 30 cm O.C. FOR FLEXURAL STEEL REINFORCEMENT

[ #5 @ 12" O.C.]

ESTIMATE SHRINKAGE + TEMPERATURE STEEL

\[ A_{et} = 0.001 \cdot A_g = 0.001 (6''/12'') \cdot \frac{1}{12''} \]

USE #4 30 cm O.C. FOR SHRINKAGE + TEMPERATURE STEEL REINFORCEMENT

REINFORCEMENT LAYOUT
PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

PREPARED BY: EMMA LAMBERT

SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

GRAVITY FRAMING PLAN

REFERENCES

CALCULATIONS

**GRAVITY DESIGN**

**FLOOR BEAMS: EQUAL SPAN**

**ASSUME DIL ON ALL SPANS, IGNORE PATTERN LOADING SINCE BUILDING IS SMALLER SCALE**

**SCHEMATIC**

**TRIBUTARY AREA**

**LOADING**

**DL + HO SF**

**LL: 40 PSF + 15 PSF = 55 PSF**  **ASSUME RESIDENTIAL UNIT PARTITIONS**

**ASSUME NO LIVE LOAD REDUCTION DUE TO THE 2:1 RATIO BETWEEN DEAD & LIVE LOAD**

**FACTOR LOADS**

**IBC 2018 §1005.2**

**EQ. 16-2**  

**DL + 1.6 LL = 1.2 (110 PSF) + 1.6 (55 PSF) = 220 PSF**

**DISTRIBUTED LOAD**

**W4 = 220 PSF (6.5') = 1911 PLF = 1.5 KLF**

**MOMENT**

**[END SPAN → DISCONTINUOUS END UNRESTRAINED]**

**M^2 = WuL^2 / 12**  

**M^2 = WuL^2 / 12**  

**ACI 318-19 R.6.5.2 PP. 99**

**EXTERIOR FACE OF FIRST INTERIOR SUPPORT → TWO SPANS**

**N^2 = WgA^2 / q**  

**N^2 = WgA^2 / q**  

**ACI 318-19 R.6.5.2 PP. 99**

**MOMENT AT SUPPORT**

**49.45 K-FT**
**Gravity Design**

**Floor Beams: Equal Bay Span**

**Estimate Steel Reinforcement**

Based on preliminary sizing, 15" x 10" concrete beam, assume 1 layer of steel.

**Assume Cover: 1 5/8"**

\[
\begin{align*}
A_s^t &= \frac{M_u}{\phi_f y_d} = \frac{39.64 \text{ k-ft}(12"/1')}{0.9 (40ksi)(0.93)(15.5")} = 9.1 \text{ in}^2 \\
\end{align*}
\]

Try 3 # 6 Rebar \( \phi = 0.97 \), \( A_x = 1.32 \text{ in}^2 \), 0.94 in² at midspan.

**As" = \frac{M_u}{\phi_f y_d} = \frac{49.43 \text{ k-ft}(12"/1')}{0.9 (40ksi)(0.93)(15.5")} = 1.15 \text{ in}^2 \\
\]

Try 3 # 6 Rebar \( \phi = 0.97 \), \( A_x = 1.32 \text{ in}^2 \), 0.94 in² at supports.

**Calculate B/E**

**T-shaped Sections**

\[
\begin{align*}
B_f &= \min \left\{ \frac{b_w + 2(l_h/2) = 10" + 2(4.8") = 10.5"}{b_w + 2(l_d/2) = 10" + 1(19.06,15"/1')/2 = 11.3"}, \frac{b_w + 2(b_n/2) = 10" + 2(13.1'/2"/1')/0 = 49.3"}{11.3"} \right. \\
\end{align*}
\]

GOVERNS

**Check Moment Capacity**

**At Midspan** \( [3 \# 6 \text{ Rebar } A_s = 1.32 \text{ in}^2] \)

\[
\begin{align*}
Q &= A_s f_y \left( \frac{1.32 \text{ in}^2(40ksi)}{0.95(3ksi)(10")} \right) \\
&= \frac{3.18 \text{ in}^2(40ksi)(15.3" - 2"/12"/1')}{12"/1'} = 39.64 \text{ k-ft} \quad \text{DCR} = 62.7. \\
\end{align*}
\]

\( \checkmark \) OKAY FOR FLEXURAL DEMAND

**At Support** \( [3 \# 6 \text{ Rebar } A_s = 1.32 \text{ in}^2] \)

\[
\begin{align*}
Q &= A_s f_y \left( \frac{1.32 \text{ in}^2(40ksi)}{0.95(3ksi)(30")} \right) \\
&= \frac{3.18 \text{ in}^2(40ksi)(15.3" - 2"/12"/1')}{12"/1'} = 48.04 \text{ k-ft} \quad \text{DCR} = 72.7. \\
\end{align*}
\]

\( \checkmark \) OKAY FOR FLEXURAL DEMAND
**PROJECT:** SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

**SUBJECT:** GRAVITY FRAMING PLAN

**PREPARED BY:** EMMA LAMBERT

**DATE:** 4/21/21

**SHEET:** F6

---

**REFERENCES**

**CALCULATIONS**

**GRAVITY DESIGN**

**FLOOR BEAMS: EQUAL BAY SPAN**

**CHECK SHEAR CAPACITY**

**Load Case/Load Combination**

- **Component:** Major (V2 and M3)
- **Display Location:** Scroll for Values

**Critical Shear Value**

\[ V_{\text{MAX}} = 12.243 \text{ kip} \]

**Load Case:**

\[ 1.2 \times D + 1.6 \times L \]

**End Offset Location**

- **Length:** 17.0604 ft
- **J-End:** 17.0604 ft
- **i-End:** 0.0000 ft

**Component:**

<table>
<thead>
<tr>
<th>Major (V2 and M3)</th>
<th>Scroll for Values</th>
</tr>
</thead>
</table>

**End Offset Location:**

- **i-End:** 0.0000 ft
- **J-End:** 17.0604 ft
- **Length:** 17.0604 ft

**Check Shear Capacity**

\[ S_{\text{MAX}} = \frac{d/2}{15.5/2} = 7.75 \]

**Try: #3 Stirrups (2 Legged)**

\[ \phi V_n = 0.75 \left( \frac{2 \times 3000 \text{ psi}}{1000 \text{ in}^2/1 \text{ kip}} \right) \left( \frac{16\text{ in}}{10\text{ in}} \right) + 2 \text{ Legged} \left( \frac{11 \text{ in}}{2 \text{ in}} \right) \times 60 \text{ ksi} \times 15\text{ in} = 44.5 \text{ kip} \]

**Use #3 Ties @ 20 cm O.C. for Confinement of Longitudinal Reinforcement**

**Deflection Check**

Assume Simply Supported for Conservatism

**Minimum:**

\[ h = \frac{8}{16} = 19.05 \times \frac{12}{16} = 12 \text{ in} \]

**Use:**

\[ (4 + 40,000 \text{ psi} / 100,000) = 9.6 < 19 \text{ in} \]

**Modify since Steel:**

\[ fy = 40 \text{ ksi} \]

**OKAY. No need to check deflection.**

**Final Sketches**

**Beam Section @ Midspan**

- 15 cm x 10 cm beam with 3 #6 bars top and bottom for floor beam 1

**Beam Section @ Support**

- 45 cm x 25 cm with 3 #6 bars top and bottom for floor beam 1

**Use a 25 cm x 25 cm with 3 #6 bars top and bottom for floor beam 1.**

**With #3 stirrups @ 20 cm O.C.**
Project: Salvation Academy School for Disadvantaged Children, Sierra Leone

Subject: Gravity Framing Plan

Prepared by: Emma Lambert

Date: 4/21/21

Sheet: F7

**References**

**Calculation**

**Gravity Design**

**Floor Girder 1**

All loads & self-weight are accounted for in ETABS model to account for moment redistribution. Assume no pattern loading due to the small scale of the structure. No live load reduction accounted for.

IBC 2018 §1005.2

**ETABS Output**

Assume an 15" x 12" girder based on preliminary sizing.

**Critical Moments**

\[ M_u = 66.69 \text{ k}-\text{ft} \]

\[ M_v = -61.99 \text{ k}-\text{ft} \]

Estimate flexural steel sizes.

Based on preliminary sizing, 15" x 12" concrete beam assume cover=1.5".

**Calculations**

\[ A_{st} = \frac{M_v}{\phi f_yd} = \frac{66.69 \text{ k}-\text{ft}(12"/1")}{0.9(40 \times 1)(93)(15.5")} = 1.59 \text{ in}^2 \]

Try 6 # 6 reinforcing at midspan.

\[ A_{st} = \frac{M_v}{\phi f_yd} = \frac{61.99 \text{ k}-\text{ft}(12"/1")}{0.9(40 \times 1)(93)(15.5")} = 1.49 \text{ in}^2 \]

Try 4 # 6 reinforcing at support. Use 4 # 6 for continuity at support.

\[ A_{st} = 1.767 \times 1.55 \text{ in}^2 / \text{in}^2 \]
**Project:** Salvation Academy School for Disadvantaged Children, Sierra Leone  
**Prepared By:** Emma Lambert  
**Date:**  
**Sheet:**

**Gravity Framing Plan**

**Check Flexural Capacity**

\[ \text{AGI 310-19} \]

**Positive Moment**

\[ Q = \frac{Ax_{fy}}{b} \cdot \frac{0.65f'c}{0.55} \cdot (15.5 - 3.21) \]

\[ \phi M_{max} \left( Ax_{fy} (d - 0.12) \right) = 0.1 \left( 1.7 \cdot 10^2 (40kbf) \right) \cdot 0.31 \text{ in} \]

\[ = 91 \text{ K}\cdot\text{ft} \]

**Negative Moment**

\[ Q = \frac{Ax_{fy}}{b} \cdot \frac{0.65f'c}{0.45} \cdot (12) \]

\[ \phi M_{max} \left( Ax_{fy} (d - 0.12) \right) = 0.9 \left( 1.7 \cdot 10^2 (40kbf) \right) \cdot 2.3 \text{ in} \]

\[ = 35.7 \text{ K}\cdot\text{ft} \]

**Use 4 #6 bars top and bottom for flexural reinforcement**

\[ \text{OKAY FOR BENDING AT MIDSPAN} \]

\[ \text{OKAY FOR BENDING AT SUPPORTS} \]
**REFERENCES**

**CALCULATIONS**

**GRAVITY DESIGN**

**FLOOR GIRDER 1**

**SHEAR CAPACITY**

**SHEAR DIAGRAM: GIRDER LINE K**

Shear diagram is altered due to using membrane as floor element in ETABS input, rather than shell-thin.

**ETABS OUTPUT**

**REFERENCES**

**CALCULATIONS**

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**ETABS OUTPUT**

VUMAX = 20.68K [PULLED FROM ETABS]

SMAX = d/2 = 15.5"/2 = 7.75"  USE 6" O.C. 15 CM O.C.

**TRY #3 STIRRUPS (2 LEGGED)**

\[
\phi \cdot V_n = \frac{3}{2} \left( \frac{2 \cdot 3000 \text{PSI}}{1000 \text{IN} / \text{kip}} \right) (10" \cdot 12") + 2 \text{ LEGGED} \left[ \frac{.11 \text{in}^2}{40 \text{ksi}} \cdot 18" \right] \]

\[
\phi \cdot V_n = 9.3K > V_n = 20.68K \quad \text{OKAY FOR SHEAR CAPACITY} \quad \%C = 44% \quad \text{STIRRUPS NOT NEEDED} \quad \text{CONCRETE SHEAR CAPACITY IS SUFFICIENT}
\]

**TRADE OFF TO DEMAND TO #3 STIRRUPS**

Smax = d/2 = 15.5"/2 = 7.75"

USE #3 TIES @ 20 CM O.C. FOR CONFINEMENT OF LONGITUDINAL REINFORCEMENT

**DEFLECTION CHECK**

ASSUME SIMPLY SUPPORTED FOR CONSERVATISM

\[
\text{MINIMUM } h = \frac{3}{16} = 10.64\text{"} / 11/16 = 12\text{"} \quad (\frac{3 \cdot 40,000 \text{PSI}}{100,000}) = 10.9" < 12" \quad \text{MODIFY SINCE STEEL} \quad f_y = 40\text{ksi}
\]

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**DEFLECTION CHECK**

ASSUME SIMPLY SUPPORTED FOR CONSERVATISM

\[
\text{MINIMUM } h = \frac{3}{16} = 10.64\text{"} / 11/16 = 12\text{"} \quad (\frac{3 \cdot 40,000 \text{PSI}}{100,000}) = 10.9" < 12" \quad \text{MODIFY SINCE STEEL} \quad f_y = 40\text{ksi}
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\]

**REFERENCE**

ACI 318-19

T.4.3.1.1
USE 4 \#6 BARS TOP AND BOTTOM FOR A 30CM BY 45CM BEAM W/ \#3 STIRRUPS @ 20CM O.C.
COLUMN DESIGN


**References**

**Gravity Design**

**Column Design**

**Exterior Column 1**

---

**Schematic Drawing**

![Schematic Drawing]

---

**Calculations**

**All Loads & Moments were pulled from ETABS for this design.**

See beginning calculations for 3D views of ETABS model.

**Assume Column Bases are Pinned**

**Beam Interaction on Gridline L1**

**Ground to Second Floor Column: Shear and Moment Diagram**

---

**ETABS Output**

**Load Case/Load Combination**

- Load Case
- Load Combination
- Modal Case

**1.2 D + 1.6 L**

---

**Component**

- Minor (V3 and M2)

**Display Location**

- Show Max
- Scroll for Values

**Shear V3**

-1.590 kip
  at 3.8288 ft

**Moment M2**

16.6075 kip-ft
  at 9.8288 ft

---
PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

SUBJECT: GRAVITY FRAMING PLAN

PREPARED BY: EMMA LAMBERT

DATE: 5/4/21

SHEET: C2

REFERENCES

CALCULATIONS

GRAVITY DESIGN

COLUMN DESIGN: EXTERIOR COLUMN 1

BEAM INTERACTION ON GRIDLINE L/6

SECOND FLOOR TO ROOF COLUMN: SHEAR AND MOMENT DIAGRAM

ETABS OUTPUT

GROUND TO SECOND FLOOR COLUMN: SHEAR AND MOMENT DIAGRAM

<table>
<thead>
<tr>
<th>Load Case/Load Combination</th>
<th>End Offset Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L-End: 0.0000 ft</td>
</tr>
<tr>
<td></td>
<td>J-End: 9.8425 ft</td>
</tr>
</tbody>
</table>

Component: Minors (V3 and M2)
Display Location: Show Max

Shear V3

-0.071 kip

Moment M2

-1.9542 kip-ft

GIRDER INTERACTION ON GRIDLINE L/6

GROUND TO SECOND FLOOR COLUMN: SHEAR AND MOMENT DIAGRAM

<table>
<thead>
<tr>
<th>Load Case/Load Combination</th>
<th>End Offset Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L-End: 0.0000 ft</td>
</tr>
<tr>
<td></td>
<td>J-End: 9.8268 ft</td>
</tr>
</tbody>
</table>

Component: Majors (V2 and M3)
Display Location: Show Max

Shear V2

-0.340 kip
at 9.8268 ft

Moment M3

3.3416 kip-ft
at 9.8268 ft
GRAVITY FRAMING PLAN

REFERENCES

COLUMN DESIGN: EXTERIOR COLUMN 1
GIRDER INTERACTION ON GRIDLINE L/6
SECOND FLOOR TO ROOF COLUMN: SHEAR AND MOMENT DIAGRAM

END OFFSET LOCATION

Component: Major (V2 and M3)

Display Location: Scroll for Values

End Offset Location:
- i-End: 0.0000 ft
- J-End: 8.8425 ft
- Length: 0.0425 ft

Shear V2:
-0.911 kip

Moment M3:
2.3785 kip-ft

GROUND TO SECOND FLOOR COLUMN: AXIAL FORCE DIAGRAM

END OFFSET LOCATION

Component: Axial (P and T)

Display Location: Scroll for Values

End Offset Location:
- i-End: 0.0000 ft
- J-End: 9.8268 ft
- Length: 10.8268 ft

Axial Force P:
-35.554 kip
**CALCULATIONS**

**SECTION DESIGN:** EXTERIOR COLUMN 1

**SECOND FLOOR TO ROOF COLUMN AXIAL FORCE DIAGRAM**

**ETABS OUTPUT**

**SUMMARY OF ETABS OUTPUT**

**LEGEND**

- **Axial Force**
- **In-Plane Moment Girder Interaction**
- **Out-of Plane Moment Beam Interaction**

---

**REFERENCES**

- **Gravity Design**
- **Column Design: Exterior Column 1**
- **Second Floor to Roof Column Axial Force Diagram**
- **Gravity Framing Plan**
- **End Offset Location**

**Axial Force P**

- **Bottom of Column**
- **End Offset Location**
  - L-End: 0.0000 ft
  - J-End: 8.8425 ft
  - Length: 9.8425 ft

**Load Case/Load Combination**

- **Component**
  - Axial (P and T)

**Display Location**

- Show Max
- Scroll for Values

**Axial Force P**

- **Third Level**
  - 2.885 k-ft
  - 1.954 k-ft

- **Second Level**
  - 3.3416 K

- **Ground Level**
  - 8.794 kip

---

**Graphical Diagram**

- **Third Level**
- **Second Level**
- **Ground Level**

**Measurements**

- **Height:**
  - 9.83 ft
  - 20.5 ft
  - 10.83 ft
Now use SP COLUMN to design the columns. Design each floor individually to account for moments.

SP COLUMN INPUT

$f_c' = 3000$ psi

$f_y = 40$ ksi

Assume a 12" x 9" column

Clear cover = 1.5"

SEE APPENDIX FOR SP COLUMN OUTPUT

USE 4 #4 LONGITUDINAL BARS

TIE BAR SPACING

USE #3 TO ENCLOSE NO. 10 OR SMALLER LONGITUDINAL BARS

$s_{min, tie} \geq \min \left\{ \frac{14 \text{ d.b}}{14 (0.5 \text{ in})} = 8" \quad \text{GOVERNS} \right. $

$4 \frac{4}{8} = 4 \frac{1}{8} (0.125)" = 1\frac{1}{8}"

Smallest dim. of column = 8"

MINIMAL SHEAR DEMAND IN COLUMNS \( \Delta \) MIN IS MET

USE #3 STIRRUPS @ 20 cm O.C.

FINAL SKETCHES

Use #3 TIES @ 20 cm O.C.

4 #4 BARS EQUALLY SPACED

GROUND TO SECOND FLOOR

SECOND FLOOR TO ROOF
FOUNDATION DESIGN
REFERENCES

GRAVITY DESIGN

INTERIOR FOOTING DESIGN: SPREAD FOOTING

SCHEMATIC

ALLOWABLE BEARING PRESSURE = 5000 PSF
[SEE MATERIAL SPECIFICATIONS]

LOADING ON GRIDLINE 4B

FOOTING 4B IS DETERMINED TO BE THE WORST CASE AXIAL LOADING FROM ETABS

LOAD COMBINATION 1.2 + 1.6L = Pu = 55.32 k

Pu = 55.32 k

D + L (UNFACTORED) = Pu = 59.5 k

Pu = 59.5 k

Areq = Pu / BEARING PRESSURE = 59.5 k / 5 ksf = 11.95

LENGTH x WIDTH = \sqrt{11.95} = 3.43 → TRY 1.5 m x 1.5 m SQUARE FOOTING

TRY A 5' x 5' SQUARE FOOTING
REFERENCES

GRAVITY DESIGN

DETERMINE CRITICAL SECTION FOR M_U "C"

COLUMN OR PEDESTAL → FACE OF COLUMN OR PEDESTAL

\[ C = \frac{1}{2} (5' - 1') = 2' \]

\[ C = \frac{1}{2} (5' - 9"/12") = 2.16' \]

**USE THIS "C" SINCE IT WILL PRODUCE A LARGER HEIGHT**

ESTIMATE EFFECTIVE DEPTH, \( d \), OF FOOTING

\[ d = 2.2 \sqrt{\frac{C}{10}} \]

**USE TOTAL FACTORED LOADING FOR \( F_U \)**

\[ d = 4" \times 0.24" + 4" = 12.24" \] **OKAY FOR FOOTING**

DETERMINE REINFORCEMENT

\[ A_{S} = 0.0018bh = 0.0018 \times (12.24" \times 5'12"/1') = 1.32 \text{in}^2 \]

**USE 13 \# 5 BARS EACH WAY \([A_S = 9.03 \text{in}^2] \)** \[ A_S = 7.33 \text{in}^2/\text{ft} \]

STRENGTH CHECK: \[ 95.32k/25 \text{ft}^2 : 3.012k/\text{ft} < 5k/\text{ft} \]

CRITICAL SECTION FOR ONE-WAY SHEAR

CHECK BEAM SHEAR

\[ V_U @ d = F_{Bu} (C - d) = 3.012k/\text{ft} (2.16' - 0.24"/12") \]

\[ V_U @ d = 4.9k \]

\[ \Phi V_U = \Phi (2) \sqrt{F_c \cdot bd} = 0.8 \cdot 3000ps/12" \times 0.24" = 8k \]

**ASSUME 2' STRIP**

\[ \Phi V_U > V_U \quad \Phi > 4.9k \quad \text{OKAY FOR BEAM SHEAR} \]
GRAVITY DESIGN
INTERIOR FOOTING DESIGN
SPREAD FOOTING

CRITICAL SECTION FOR PUNCHING SHEAR

\[
\begin{align*}
\text{Base: } & \quad 4 \sqrt{f'c} = 4 \sqrt{3000} = 219 \text{ lb} \\
\text{Column shape: } & \quad \left( \frac{274}{B_c} \right) \sqrt{f'c} \\
\text{Column location: } & \quad (2 + \frac{a_d}{b_0}) \sqrt{f'c} = 2.4 \left( \frac{329}{272.96} \right) = 3.71 \text{ lb} \\
\end{align*}
\]

\[\text{AS} = 40 \text{ for interior columns}
\]

\[\phi V_n = 0.75 \times 219 \text{ lb} > V_n = 195.6 \text{ lb}
\]

\[\text{OKAY FOR PUNCHING SHEAR}
\]

CHECK FLEXURE

Assume 1" strip

\[\text{Mu} = \frac{1}{2} (3.0128 \times 3.0128) (2.16^2) = 9.023 \text{ k-ft}
\]

\[\phi M_n = 8 \times (d - 0.12)
\]

\[= 0.79 \times 0.88 \times 3.0128 \times 2.16^2 = 96.46 \text{ k-in} \times \text{ft}
\]

\[Q = 33 \times 1 = 33 \text{ in}^2/\text{ft} (40 \times 81) = 339 \text{ in}^2/\text{ft}
\]

\[\phi M_n = 3.023 \text{ k-ft} \text{ OKAY FOR FLEXURE}
\]

\[\text{USE A 1.5m x 1.5m SPREAD FOOTING FOR ALL COLUMNS W/ 13 #5 BARS EACH WAY}
\]
LATERAL DESIGN
**CENTER OF MASS AND CENTER OF RIGIDITY**

The center of mass and center of rigidities were calculated to be within 5% of each other in accordance with ASCE 7-16 in order to help with irregularities of the structure and optimizing shear wall location.

<table>
<thead>
<tr>
<th>Item</th>
<th>L (ft)</th>
<th>W (ft)</th>
<th>A (ft²)</th>
<th>x (ft)</th>
<th>y (ft)</th>
<th>Ax (ft³)</th>
<th>Ay (ft³)</th>
<th>Line x (ft)</th>
<th>y (ft)</th>
<th>Rx</th>
<th>Ry</th>
<th>Ry*xi</th>
<th>Rx*yi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Area 1</td>
<td>14.2</td>
<td>28.6</td>
<td>407</td>
<td>13.68</td>
<td>86.61</td>
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<td>91244</td>
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<tr>
<td>Floor Area 2</td>
<td>1.0</td>
<td>12.5</td>
<td>12</td>
<td>35.19</td>
<td>80.05</td>
<td>432</td>
<td>982</td>
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<td>Floor Area 3</td>
<td>36.1</td>
<td>33.5</td>
<td>1208</td>
<td>23.95</td>
<td>60.88</td>
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<td>7.2</td>
<td>31</td>
<td>6.48</td>
<td>45.65</td>
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<td>1438</td>
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</tr>
<tr>
<td>Floor Area 5</td>
<td>9.9</td>
<td>13.5</td>
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</table>

\[ R = \frac{1}{Δ} = \frac{4(h/L)^3 + 3(h/L)/t}{-1} \]

Center of Rigidity (C.O.R.)

Center of Mass (C.O.M.)

*For blown up version of this table see appendix*
LATERAL FORCE DISTRIBUTION

ETABS model was created to solve for the forces on the rigid diaphragm, however, calculated the roof story forces and diaphragm forces by hand since it is a rigid diaphragm. After these forces were calculated they then were applied to the ETABS model.

STORY FORCES & DIAPHRAGM FORCES

*DUE TO CONFINED MASONRY NOT BEING AVAILABLE IN ASCE 7-16 NO REDUCTION R, Cd, ETC. SHALL BE TAKEN THEREFORE, THEY EQUAL 1

CALCULATION OF Cs

\[ \text{Ta} = 0.19 \]  
\[ \text{SD1} = 0.09 \]  
\[ \text{TL} = 12 \]  
\[ \text{Cs} = 0.1395 \]  
\[ \text{Cs}_{\text{max}} = 0.6854 \]  
\[ \text{Cs}_{\text{min}} = 0.0061 \]  
Therefore,  
\[ \text{Cs} = 0.1395 \]

<table>
<thead>
<tr>
<th>Level</th>
<th>Fx (kip)</th>
<th>Dz (kip)</th>
<th>h (ft)</th>
<th>Wx (kip)</th>
<th>Coeff.</th>
<th>Fx = Coeff. * W</th>
<th>Pe (kip)</th>
<th>0.2SDS</th>
<th>Iw (kip)</th>
<th>DX (kip)</th>
<th>Cpx</th>
<th>Scale Factor</th>
<th>Cx</th>
<th>Cz</th>
<th>Cx</th>
<th>Cz</th>
<th>k</th>
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<tr>
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Σ = 1152 15992 1 0.1395*W 160.7

*FOR BLOWN UP VERSION OF THIS TABLE SEE APPENDIX
## Roof Shear Wall Forces

### 1' UNIT STRIP METHOD

### Building Weight

<table>
<thead>
<tr>
<th>Section</th>
<th>Roof (Gridline 1-2)</th>
<th>Total</th>
<th>Exterior Walls (Concrete)</th>
<th>Total</th>
<th>Roof (Gridline A-B)</th>
<th>Total</th>
<th>Exterior Brick Wall</th>
<th>Total</th>
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<td>Distributed Loads</td>
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<td>Section</td>
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<td>A&lt;sub&gt;s&lt;/sub&gt;</td>
<td>F&lt;sub&gt;s&lt;/sub&gt;</td>
<td></td>
<td>W&lt;sub&gt;s&lt;/sub&gt;</td>
<td>A&lt;sub&gt;s&lt;/sub&gt;</td>
<td>F&lt;sub&gt;s&lt;/sub&gt;</td>
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<td>KLF</td>
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<tr>
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ETABS MODEL
MATERIAL/SECTION PROPERTY INPUT:
WALL INPUT DATA: F'C=700 PSI
BEAM INPUT DATA: F'C=3000 PSI
GIRDERR INPUT DATA: F'C=3000 PSI
SLAB INPUT DATA: F'C=3000 PSI

LOADING INPUT DATA:
ROOF GRAVITY LOADS ARE APPLIED AS FRAME LOADS TO BEAMS
FLOOR GRAVITY LOADS ARE APPLIED AS AREA LOADS ON SLAB
ALL SELF-WEIGHT OF STRUCTURAL MEMBERS ARE ACCOUNTED FOR ACCORDINGLY
FLEXIBLE DIAPHRAGM LATERAL LOADING IS APPLIED TO COLLECTORS ALONG ROOF

RIGID DIAPHRAGM
FLEXIBLE DIAPHRAGM
ETABS MODEL

FLEXIBLE DIAPHRAGM ROOF LOADING X-DIRECTION

FLEXIBLE DIAPHRAGM ROOF LOADING Y-DIRECTION
ETABS MODEL

RIGID DIAPHRAGM SEISMIC LOADING INPUT:

RIGID DIAPHRAGM WIND LOADING INPUT:
**ETABS MODEL**

**GOVERNING LOAD CASE AND SHEAR WALL WITH THE LARGEST FORCES**

<table>
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<tr>
<th>Story</th>
<th>Pier</th>
<th>Output Case</th>
<th>P</th>
<th>V2</th>
<th>V3</th>
<th>T</th>
<th>M2</th>
<th>M3</th>
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PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

SUBJECT: SHEAR WALL DESIGN

PREPARED BY: EMMA LAMBERT

DATE: 5/18/21

SHEET: LD9

REFERENCES:
- ETABS
- PIER KEY PLAN
- PLAN VIEW

CALCULATIONS:
- EARTHQUAKE LOAD COMBO INPUT: 1.20 + 1.6L + EQE
- EQE = 1 [FLEXIBLE DIAPHRAGM + RIGID DIAPHRAGM LOADS]

ETABS PLAN VIEW

PIER 1
PIER 2
PIER 3
PIER 4
PIER 5
PIER 6
PIER 7
PIER 8
PIER 9
PIER 10
PIER 11

LD9
SHEAR WALL KEY PLAN: SECOND FLOOR

ORIGIN FOR C.O.R. AND C.O.M. CALCULATIONS

SW 1
SW 2
SW 3
SW 4
SW 5
SW 6
SW 7
SW 8
SW 9

1 2 3 4 5 6 7 8 9 10

2.20 1.85 4.35 2.00 2.00 5.50 2.93 0.88 3.40

25.64

5/5/2021

PREPARED BY: EMMA LAMBERT

DATE: 5/5/2021

PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

SUBJECT: LATERAL DESIGN

SHEET: LD10
SHEAR WALL KEY PLAN: ROOF

SW 1
SW 2
SW 3
SW 4
SW 5
SW 6
SW 7
SW 8
SW 9

1 2 3 4 5 6 7 8 9 10

2.20 1.85 4.35 2.00 2.00 5.50 2.93 0.88 3.94 25.64

5/5/2021

LD11
MINIMUM DIAPHRAGM LAYOUT FROM CONFINED MASONRY WALL LOCATION
### Shear Wall Design

**Worst Case Shear Wall is Pier 11 According to ETABS**

Confined masonry is used for LFRS

<table>
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<th>Legend</th>
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<tr>
<td>= Concrete</td>
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<tr>
<td>= Brick</td>
</tr>
</tbody>
</table>

### Shear Wall Loading Diagram: Pier 11

Assume columns take all flexure: calculate TIC couple due to shear wall.

Seismic forces govern over wind according to ETABS output.

Load combination: 1.20 + 1.65L + 0.2E [loading pulled from governing shear wall in ETABS]

**Statics**

\[ \Sigma \text{MA} = 0 \]

\[ -63.4 K (10.83') - 14.5 K (10.83') = [90 K + 19 K] 9.5' \text{C (19')} = 0 \]

\[ C = 101 K \text{ (Downward)} \]

\[ T = 101 K - 60 K - 19 K - t = 0 \]

\[ T = 2 K \text{ (Uplift)} \]

Since assumption is that columns take all flexural capacity, check gravity columns for uplift + compression.
### Shear Wall Design

**SP Column Input Values for Compression Column**

Worst case moment applied to column due to gravity:

- $M_{Uc} = 16.6\text{k}-\text{ft}$
- $M_{Uy} = 3.3\text{K}-\text{ft}$

Output:

4 #4 bars equally spaced

**SP Column Input Values for Tension Column**

Worst case moment applied to column due to gravity:

- $M_{Uc} = 16.6\text{k}-\text{ft}$
- $M_{Uy} = 3.3\text{K}-\text{ft}$

Output:

4 #6 bars equally spaced

#### Check Axial Strength of Brick Wall

**No Reinforcement in Brick Wall**

- $f_y = \frac{3}{12} = \frac{1}{4} = 2.3^\circ$
- $f_y = 30.66^\circ - 12^\circ/2.3^\circ = 109^\circ > 99^\circ$

**Use** $P_n = 0.8 \left[ f_y \left( A_{n, pt} + A_{n, st} \right) \right]

\text{Output:}

- $P_n = 331\text{k}$
- $P_n > P_u = 190,000\text{lb} / 1000 = 190\text{K}$
- $\phi P_n = 0.9(331) = 298\text{K}$
- $\phi P_n > P_u = 190,000\text{lb} / 1000 = 190\text{K}$

**OKAY for Axial Strength.**

#### Check Shear Strength of Brick Wall

**TMS 402 \\ 4.3.4.1.2 \\ PP C = 138**

- $V_n = (V_{nm} + V_{ns})_{\phi_g}$
- **Assume $\phi_g = 1.0$ (Fully Grouted Wall)**

Assume $\mu/vv = 1$

\[ V_{nm} = \left[ \frac{4-I_{ST}(1)}{A_y \cdot 12}\right] \left[ \frac{1000}{1000} + 0.26 (99,000\text{lb}) / 1000 \right] = 123\text{k} \quad \text{(Eq 9-20)} \]

**$V_{ns} = 0$ (No Reinforcing Steel Present)**

**$V_n = (123 + 0) = 123\text{k}$**

**Upper Limit**

- Since $\mu/vv = 1$ use Eq 9-19 for shear capacity of masonry.

\[ V_n = \left( 4.5 A_y f' m \right)_{\phi_g} = 4 \left( \frac{1}{8} \cdot 12 \cdot 12 \right) \sqrt{1000} / 1000 = 173\text{k} > 123\text{k} \quad \text{OKAY for Upper Limit} \]
SHEAR WALL DESIGN

FINAL SHEAR CHECK
\[ V_d = 0.8 (122k) = 97.6k \]
\[ V_u = 77.9k \]
\[ \text{OKAY FOR SHEAR CAPACITY} \]

USE 4 #6 IN COLUMNS FOR FLEXURE IN CONFINED MASONRY WALL

SECTION A OF CONFINED MASONRY WALL
# 2ND FLOOR DIAPHRAGM FORCES

## 1' UNIT STRIP METHOD

<table>
<thead>
<tr>
<th>Building Weight</th>
<th>2nd Floor 1' Strip Weight N/S</th>
<th>2nd Floor 1' Strip Weight E/W</th>
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</thead>
<tbody>
<tr>
<td>2nd Floor Area</td>
<td>PSF Total</td>
<td>2nd Floor Area</td>
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<tr>
<td>Interior Walls (Concrete)</td>
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<td>Roof (Gridline 1-2) Area</td>
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<td>Exterior Walls (Concrete)</td>
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<td>Roof Weight</td>
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<td>Total / 1' Strip (kip/ft)</td>
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<td>2nd Floor 1' Strip Weight N/S</td>
<td>Roof (Gridline 1-2) Area</td>
<td>PSF Total</td>
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<td>Exterior Brick Wall</td>
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<tr>
<td>Total / 1' Strip (kip/ft)</td>
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<td>Total / 1' Strip (kip/ft)</td>
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<td>2nd Floor 1' Strip Weight E/W</td>
<td>Roof (Gridline 2-3) Area</td>
<td>PSF Total</td>
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<td>Total / 1' Strip (kip/ft)</td>
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<td>Total / 1' Strip (kip/ft)</td>
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<td>Roof (Gridline 2-3) Area</td>
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<td>Exterior Brick Wall 9.8 5 49.2</td>
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<td>Total / 1' Strip (kip/ft)</td>
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<td>PSF Total</td>
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## Distributed Loads

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## ROOF DIAPHRAGM FORCES

### 1' UNIT STRIP METHOD

### Building Weight

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<th>Area</th>
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### Distributed Loads

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### Roof Forces N/S

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1' UNIT WEIGHT STRIP METHOD NORTH/SOUTH DIRECTION DIAPHRAGM FORCES: 2ND FLOOR

DIAPHRAGM AND COLLECTOR DESIGN

PREPARED BY: EMMA LAMBERT
DATE: 5/5/2021
SHEET: LD20
1' UNIT WEIGHT STRIP METHOD EAST/WEST DIRECTION DIAPHRAGM FORCES: 2ND FLOOR

DIAPHRAGM AND COLLECTOR DESIGN

LD21
1' UNIT WEIGHT STRIP METHOD NORTH/SOUTH DIRECTION DIAPHRAGM FORCES: ROOF

A
B
C
D
E
F
G
H
J
K
L

7.2' 6.1' 14.3' 6.6' 6.6' 18.1' 9.6' 12.9'

7.4 K 24.4 K 38.2 K 3 K 24.9 K 4.59 K

1.922 KLF 1.663 KLF 0.946 KLF 1.075 KLF 0.459 KLF

7.6 KLF 2.65 KLF 1.265 KLF
1' UNIT WEIGHT STRIP METHOD EAST/WEST DIRECTION DIAPHRAGM FORCES: ROOF

DIAPHRAGM AND COLLECTOR DESIGN

LD23
DIAPHRAGM AND COLLECTOR FORCES

PROJECT: SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

SUBJECT: DIAPHRAGM AND COLLECTOR FORCES

PREPARED BY: EMMA LAMBERT

DATE: 5/18/21

SHEET: LD24

REFERENCE:

DIAPHRAGM DESIGN

SHEAR UNIT SHEAR NORTH/SOUTH/COLLECTOR DESIGN

2ND FLOOR

UNIT SHEAR CALCULATIONS

\[ V = \frac{V}{\text{depth of diaphragm}} \]

IGNORE OPENINGS

\[ V_1 = \frac{27.4K}{27.4} = 1.0 \text{KLF} \]
\[ V_2 = \frac{10.6K}{93.94} = 0.11 \text{KLF} \]
\[ V_3 = \frac{93.9K}{93.18} = 1 \text{KLF} \]
\[ V_4 = \frac{90.4K}{96.5} = 1 \text{KLF} \]
\[ V_5 = \frac{127.1K}{80} = 1.6 \text{KLF} \]
\[ V_6 = \frac{108.5K}{94.9} = 2.22 \text{KLF} \]
\[ V_7 = \frac{117.6K}{98.6} = 2.4 \text{KLF} \]
\[ V_8 = \frac{4.2K}{10.9} = 0.4 \text{KLF} \]

GOVERNING UNIT SHEAR FOR COLLECTOR

\[ V_{\text{gov.}} = \frac{2.22 \text{KLF} + 2.4 \text{KLF} = 4.62 \text{KLF}} \]

ON GRIDLINE B
REFERENCES

DIAPHRAGM DESIGN

SHEAR UNIT SHEAR NORTH/SOUTH/Collector DESIGN

ROOF

UNIT SHEAR CALCULATIONS

\[ V = \frac{V}{\text{depth of diaphragm}} \]

IGNORE OPENINGS

\[ V_1 = 7.4 \text{ kKLF} \]
\[ V_2 = 6 \text{ kKLF} \]
\[ V_3 = 24.4 \text{ kKLF} \]
\[ V_4 = 20 \text{ kKLF} \]
\[ V_5 = 19.2 \text{ kKLF} \]
\[ V_6 = 18.4 \text{ kKLF} \]
\[ V_7 = 24.9 \text{ kKLF} \]
\[ V_8 = 19.3 \text{ kKLF} \]

GOVERNING UNIT SHEAR FOR COLLECTOR

\[ V_{\text{gov}} = 0.96 \text{ kKLF} \]
DIAPHRAGM AND COLLECTOR FORCES

DIAPHRAGM DESIGN

SHEAR UNIT SHEAR EAST/WEST /COLLECTOR DESIGN

2ND FLOOR

UNIT SHEAR CALCULATIONS

\[ V = \frac{V}{\text{depth of diaphragm}} \]

IGNORE OPENINGS

- \[ V_1 = \frac{82.6 K}{7.5'} = 11.4 \text{ klf} \]
- \[ V_2 = \frac{82.6 K}{8.12'} = 9.9 \text{ klf} \]
- \[ V_3 = \frac{164.6 K}{9.12'} = 1.8 \text{ klf} \]
- \[ V_4 = \frac{125.3 K}{8.6'} = 4.5 \text{ klf} \]

GOVERNING UNIT SHEAR FOR COLLECTOR

\[ V_{\text{gov}} = 4.5 \text{ klf} \]

ON GRIDLINE A
**PROJECT:** SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN, SIERRA LEONE

**PREPARED BY:** EMMA LAMBERT

**SUBJECT:** DIAPHRAGM AND COLLECTOR FORCES

**DATE:** 5/18/21

**SHEET:** LD27

---

### REFERENCES

DIAPHRAGM DESIGN/COLLECTOR DESIGN

### SHEAR UNIT SHEAR EAST/WEST

### ROOF

---

#### UNIT SHEAR CALCULATIONS

\[ U = \frac{V}{\text{Depth of Diaphragm}} \]

**Ignore Openings**

- \[ V_1 = 21.7 \text{ kips} / 33.5' = 0.6 \text{ kips/ft} \]
- \[ V_2 = 21.2 \text{ kips} / 99.12' = 0.2 \text{ kips/ft} \]
- \[ V_3 = 43.6 \text{ kips} / 69.12' = 0.6 \text{ kips/ft} \]
- \[ V_4 = 33 \text{ kips} / 47.12' = 1.2 \text{ kips/ft} \]

#### Governing Unit Shear for Collector

\[ U_{\text{gov}} = 1.2 \text{ kips/ft} \]

ON GRIDLINE A
**DIAPHRAGM AND COLLECTOR DESIGN**

**DESIGN FOR THE WORST CASE COLLECTOR**

Therefore, design collector on gridline A in east/west direction.

\[ V = 4.5 \text{ KLF} \]

**VALUE FROM 2ND FLOOR SHEAR EAST/WEST**

\[ V = 125.3 \text{ KLF} / 20.3' = 6.17 \text{ KLF} \]

**VALUE FROM 2ND FLOOR SHEAR EAST/WEST**

**AXIAL FORCE DIAGRAM**

**CHECK DIAPHRAGM SHEAR**

\[ V_u \text{ OF DIAPHRAGMS SHALL NOT EXCEED} \]

Assume 1' STRIP OF SLAB

\[ V_u = \frac{Acv}{2} \left( \frac{f_c + f_y}{2} \right) = 12'' \cdot \omega'' \left( \frac{2(1)}{3000 \text{ psi}} + 0.009(40,000 \text{ psi}) \right) \]

\[ V_u = 19,407 \text{ PLF} = 19.4 \text{ KLF} \]

\[ V_u = 0.9 \cdot f_c \cdot \frac{Acv}{6} = 0.9 \cdot 3000 \text{ psi} \cdot 12'' \cdot \omega'' = 31548 \text{ PLF} = 31.5 \text{ KLF} \]

\[ \cdot \text{ USE} 19.4 \text{ KLF} \]

\[ \frac{V_u}{V_n} = \frac{0.9(19.4 \text{ KLF})}{11.64 \text{ KLF}} > V_u = 4.5 \text{ KLF} \]

**OKAY FOR DIAPHRAGM SHEAR**
DIAPHRAGM DESIGN / COLLECTOR DESIGN

CHECK AXIAL FORCE WITH WORST CASE MOMENT FROM GRAVITY DESIGN

SP COLUMN INPUT VALUE

TRY 6" X 18" BEAM

f↓ = 3000 PSI

f↑ = 40,000 PSI

Pu = 32.9 k [PULLED FROM AXIAL FORCE DIAGRAM]

Mux = 66.69 k-ft [PULLED FROM SLAB GRAVITY FRAMING OF FLOOR GIRDER 1]

SP COLUMN OUTPUT

AN 8" X 18" COLLECTOR W/ 6 #6 SIDES DIFFERENT EQUAL SPACING

USE A 20cm X 45cm COLLECTOR WITH 6 #6 BARS BOTH SIDES EQUAL SPACING

FINAL SKETCHES
**REFERENCES**

IRREGULARITY CHECK

REDUNDANCY FACTOR

Seismic Design Category: C

\[ p = \text{Redundancy Factor} \]

HORIZONTAL STRUCTURAL IRREGULARITIES

ALL CHECKS MADE FOR RIGID DIAPHRAGM ON 2ND FLOOR

1. TORRISONAL IRREGULARITY

N/E DIRECTION

\[ x_1 = \text{AVG.} \]

\[ x_2 = \text{LOAD} \]

EAST/WEST DIRECTION

\[ x_3 = \text{LOAD} \]

Utilize ETABS Model

Assume 100K at G.O.M. Since displacements are relative

N/E DIRECTION

ETABS force in Y-direction displacement output

**SUMMARY**

\[ x_{\text{AVG}} = \left( x_1, x_2 \right) = \left( \text{0.002464}, \text{0.004949} \right) \]

\[ x_{\text{AVG}} = \text{0.003535} \] (N/E Direction)

\[ x_1 < 1.2 \times x_{\text{AVG}} \]

\[ x_1 = \text{0.002464} < 1.2 \times \text{0.003535} \]

\[ \therefore \text{No Torsional Irregularity} \]
REFERENCES

IRREGULARITY CHECK

HORIZONTAL STRUCTURAL IRREGULARITIES

10. TORSIONAL IRREGULARITY

**CONTINUED**

**ETABS FORCE IN X-DIRECTION DISPLACEMENT OUTPUT**

**SUMMARY**

\[
\text{X}_{\text{Avg}} = \left( \text{X}_{1} + \text{X}_{2} \right) / 2 = \frac{0.03726 + 0.03931}{2}
\]

\[
\text{X}_{\text{Avg}} = 0.038285
\]

\[
\text{X}_{1} < \text{X}_{2} \quad \text{or} \quad \text{X}_{1} > \text{X}_{2}
\]

\[
\text{X}_{\text{Avg}} = 0.038285
\]

\[
\text{X}_{\text{Avg}} = 1.04 < 1.2
\]

\[
\text{X}_{\text{Avg}} = 0.038285
\]

\[
\therefore \text{NO TORSIONAL IRREGULARITY}
\]

11. EXTREME TORSIONAL IRREGULARITY

**SEE 3A FOR CALCULATION**

3. REENTRANT CORNER IRREGULARITY

**POSSIBLE REENTRANT CORNER**

\[
\text{L}_{1} = \frac{93.16}{0.15} = 13 \cdot 159' < 13.7' \quad \therefore \text{DOES NOT PASS}
\]

\[
\text{L}_{2} = \frac{94.12}{0.15} = 12 \cdot 452' < 27.7' \quad \therefore \text{DOES NOT PASS}
\]

\[
\therefore \text{REENTRANT CORNER PRESENT, HOWEVER SDC C SO NO ACTION NEEDED}
\]
<table>
<thead>
<tr>
<th>IRREGULARITY CHECK</th>
<th>CALCULATIONS</th>
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<tr>
<td><strong>HORIZONTAL STRUCTURAL IRREGULARITIES</strong></td>
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<td>3. DIAPHRAGM DISCONTINUITY IRREGULARITY</td>
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<tr>
<td>OPENINGS IN THE DIAPHRAGM ACCOUNT FOR LESS THAN 50% OF THE GROSS FLOOR AREA</td>
<td>NO DIAPHRAGM DISCONTINUITY OCCURS</td>
</tr>
<tr>
<td>4. OUT-OF-PLANE OFFSET IRREGULARITY</td>
<td></td>
</tr>
<tr>
<td>ALL VERTICAL WALL ELEMENTS (SHEAR WALLS) ARE CONTINUOUS THROUGH BUILDING HEIGHT</td>
<td>NO OUT-OF-PLANE OFFSET OCCURS</td>
</tr>
<tr>
<td>5. NONPARALLEL SYSTEM IRREGULARITY</td>
<td></td>
</tr>
<tr>
<td>THE DIAPHRAGM AND VERTICAL LATERAL FORCE RESISTING ELEMENTS ARE ORTHOGONAL</td>
<td>NO NONPARALLEL SYSTEM IRREGULARITY</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>ASCE7-16 T-12.3-2 PP.94</td>
</tr>
<tr>
<td>VERTICAL STRUCTURAL IRREGULARITIES</td>
<td>ALL CHECKS MADE FOR RIGID DIAPHRAGM ON 2ND FLOOR</td>
</tr>
<tr>
<td>1A. STIFFNESS - SOFT STORY IRREGULARITY</td>
<td></td>
</tr>
<tr>
<td>AS SEEN IN THE CENTER OF RIGIDITY / CENTER OF MASS CALCULATIONS ALL THICKNESSES ARE THE SAME AND FLOOR TO FLOOR HEIGHTS ARE LESS THAN 5% DIFFERENT</td>
<td>NO SOFT STORY IRREGULARITIES</td>
</tr>
<tr>
<td>1B. STIFFNESS - EXTREME SOFT STORY IRREGULARITY</td>
<td>SEE 1A.</td>
</tr>
<tr>
<td>2. WEIGHT (MASS) IRREGULARITY</td>
<td></td>
</tr>
<tr>
<td>ROOF WEIGHT = 915k</td>
<td></td>
</tr>
<tr>
<td>2ND FLOOR WEIGHT = 737k</td>
<td></td>
</tr>
<tr>
<td>NO FLOOR WEIGHT IS 150% OF AN ADJACENT FLOOR</td>
<td>NO WEIGHT IRREGULARITY IS PRESENT</td>
</tr>
<tr>
<td>3. VERTICAL GEOMETRIC IRREGULARITY</td>
<td></td>
</tr>
<tr>
<td>SHEAR WALLS ARE CONTINUOUS THROUGH BUILDING HEIGHT</td>
<td>NO VERTICAL GEOMETRY IRREGULARITY</td>
</tr>
</tbody>
</table>
IRREGULARITY CHECK

VERTICAL STRUCTURAL IRREGULARITIES

4. IN-PLANE DISCONTINUITY IN VERTICAL LATERAL FORCE-RESISTING ELEMENT IRREGULARITY

Shear walls are continuous through building height

\[ \therefore \text{NO IN-PLANE DISCONTINUITY OCCURS} \]

5a. DISCONTINUITY IN LATERAL STRENGTH-WEAK STORY IRREGULARITY

Shear walls have the same flexural reinforcement and strength

\[ \therefore \text{NO WEAK STORY IRREGULARITY OCCURS} \]

5b. DISCONTINUITY IN LATERAL EXTREME STRENGTH-WEAK STORY IRREGULARITY

See 5a.

REDUNDANCY CHECK

NORTH DIRECTION: 39.94 m of shear wall

EAST DIRECTION: 10.05 m of shear wall

Heights/Widths: 3.15 m / 1.05 m = 3.0 > 1

\[ \frac{1.85}{1.05} \times 100 = 177 \% \text{ NO EXTRA REDUNDANCY REQ.} \]
CONNECTION DESIGN
## Development Length

### Development Length for Bars in Tension

<table>
<thead>
<tr>
<th>Bar</th>
<th>Development Length</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>40,000 psi (1.3) (1.0)</td>
<td>$d_b = 39.995 d_b = 39.995 \times 10.42'' = 114.24'' = 290 cm$</td>
</tr>
<tr>
<td>4</td>
<td>39.995 (0.5)</td>
<td>$d_b = 39.995 (0.5) = 19.9975'' = 50 cm$</td>
</tr>
<tr>
<td>5</td>
<td>39.995 (0.25)</td>
<td>$d_b = 39.995 (0.25) = 19.9975'' = 50 cm$</td>
</tr>
<tr>
<td>6</td>
<td>39.995 (0.125)</td>
<td>$d_b = 39.995 (0.125) = 19.9975'' = 50 cm$</td>
</tr>
</tbody>
</table>

### Development Length of Hooked Bars in Tension

<table>
<thead>
<tr>
<th>Bar</th>
<th>Development Length</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10.49 (3'')</td>
<td>$d_b = 10.49 (3'') = 14.99'' = 38 cm$</td>
</tr>
<tr>
<td>4</td>
<td>10.49 (2'')</td>
<td>$d_b = 10.49 (2'') = 14.99'' = 38 cm$</td>
</tr>
<tr>
<td>5</td>
<td>10.49 (1'')</td>
<td>$d_b = 10.49 (1'') = 14.99'' = 38 cm$</td>
</tr>
<tr>
<td>6</td>
<td>10.49 (1/2'')</td>
<td>$d_b = 10.49 (1/2'') = 14.99'' = 38 cm$</td>
</tr>
</tbody>
</table>

### Development Length of Bars in Compression

<table>
<thead>
<tr>
<th>Bar</th>
<th>Development Length</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Greater</td>
<td>$d_b = 50 \times 1.3 = 149.4$</td>
</tr>
<tr>
<td>4</td>
<td>$\theta'' = 20''$</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>$\theta'' = 23''$</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$\theta'' = 30''$</td>
<td></td>
</tr>
</tbody>
</table>

### Tensile Lapsplice Length

<table>
<thead>
<tr>
<th>Bar</th>
<th>Lapsplice Length</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.52''</td>
<td>$d_b = 14.99'' + 8.52'' = 23.51'' = 59.75 cm$</td>
</tr>
<tr>
<td>4</td>
<td>8.52''</td>
<td>$d_b = 14.99'' + 8.52'' = 23.51'' = 59.75 cm$</td>
</tr>
<tr>
<td>5</td>
<td>8.52''</td>
<td>$d_b = 14.99'' + 8.52'' = 23.51'' = 59.75 cm$</td>
</tr>
<tr>
<td>6</td>
<td>8.52''</td>
<td>$d_b = 14.99'' + 8.52'' = 23.51'' = 59.75 cm$</td>
</tr>
</tbody>
</table>
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<table>
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<tr>
<th>File Name</th>
<th>c:\users\emmal\onedrive\documents\school\senior project\sp column files\column1groundtosecond.col</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>SLAD</td>
</tr>
<tr>
<td>Column</td>
<td>Ext Col 1</td>
</tr>
<tr>
<td>Engineer</td>
<td>ECL</td>
</tr>
<tr>
<td>Code</td>
<td>ACI 318-19</td>
</tr>
<tr>
<td>Bar Set</td>
<td>ASTM A615</td>
</tr>
<tr>
<td>Units</td>
<td>English</td>
</tr>
<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
</tr>
<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
</tr>
</tbody>
</table>

2. Material Properties

2.1. Concrete

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f'_c$</td>
<td>3 ksi</td>
</tr>
<tr>
<td>$E_c$</td>
<td>3122.02 ksi</td>
</tr>
<tr>
<td>$f_c$</td>
<td>2.55 ksi</td>
</tr>
<tr>
<td>$\varepsilon_u$</td>
<td>0.003 in/in</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.85</td>
</tr>
</tbody>
</table>

2.2. Steel

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_y$</td>
<td>40 ksi</td>
</tr>
<tr>
<td>$E_s$</td>
<td>29000 ksi</td>
</tr>
<tr>
<td>$\varepsilon_{yt}$</td>
<td>0.00137931 in/in</td>
</tr>
</tbody>
</table>

3. Section

3.1. Shape and Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>8 in</td>
</tr>
<tr>
<td>Depth</td>
<td>12 in</td>
</tr>
<tr>
<td>$A_g$</td>
<td>96 in$^2$</td>
</tr>
<tr>
<td>$I_x$</td>
<td>1152 in$^4$</td>
</tr>
<tr>
<td>$I_y$</td>
<td>512 in$^4$</td>
</tr>
<tr>
<td>$r_x$</td>
<td>3.4641 in</td>
</tr>
<tr>
<td>$r_y$</td>
<td>2.3094 in</td>
</tr>
<tr>
<td>$X_o$</td>
<td>0 in</td>
</tr>
<tr>
<td>$Y_o$</td>
<td>0 in</td>
</tr>
</tbody>
</table>
3.2. Section Figure

![Column Section Diagram]

Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Bar</th>
<th>Diameter (in)</th>
<th>Area (in²)</th>
<th>Bar</th>
<th>Diameter (in)</th>
<th>Area (in²)</th>
<th>Bar</th>
<th>Diameter (in)</th>
<th>Area (in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>0.38</td>
<td>0.11</td>
<td>#4</td>
<td>0.50</td>
<td>0.20</td>
<td>#5</td>
<td>0.63</td>
<td>0.31</td>
</tr>
<tr>
<td>#6</td>
<td>0.75</td>
<td>0.44</td>
<td>#7</td>
<td>0.88</td>
<td>0.60</td>
<td>#8</td>
<td>1.00</td>
<td>0.79</td>
</tr>
<tr>
<td>#9</td>
<td>1.13</td>
<td>1.00</td>
<td>#10</td>
<td>1.27</td>
<td>1.27</td>
<td>#11</td>
<td>1.41</td>
<td>1.56</td>
</tr>
<tr>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
<td>#18</td>
<td>2.26</td>
<td>4.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2. Confinement and Factors

- Confinement type: Tied
- For #10 bars or less: #3 ties
- For larger bars: #4 ties

Capacity Reduction Factors
- Axial compression, (a): 0.8
- Tension controlled ϕ, (b): 0.9
- Compression controlled ϕ, (c): 0.65

4.3. Arrangement

- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #4
### APPENDIX: SP COLUMN OUTPUT
#### WORST CASE RESIDENTIAL COLUMN
#### GROUND TO SECOND FLOOR

<table>
<thead>
<tr>
<th>Total steel area, $A_s$</th>
<th>0.80 in$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rho</td>
<td>0.83 %</td>
</tr>
<tr>
<td>Minimum clear spacing</td>
<td>3.25 in</td>
</tr>
</tbody>
</table>

(Note: Rho < 1.0%)

5. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on “Moment Capacity” Method.

<table>
<thead>
<tr>
<th>No.</th>
<th>Demand</th>
<th>Capacity</th>
<th>Parameters at Capacity</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_u$</td>
<td>$M_{ux}$</td>
<td>$M_{uy}$</td>
<td>$\phi P_n$</td>
</tr>
<tr>
<td>1</td>
<td>39.55</td>
<td>16.61</td>
<td>3.34</td>
<td>39.55</td>
</tr>
</tbody>
</table>
6. Diagrams
6.1. PM at $\theta=0$ [deg]
6.2. PM at $\theta=11$ [deg]

### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

### Materials
- $f_y = 3$ ksi
- $E_y = 3122.02$ ksi
- $f_p = 40$ ksi
- $E_p = 29000$ ksi

### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_p = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4
- **Confinement type**: Tied
- **Total steel area, $A_s$**: 0.80 in$^2$
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in

### Table
<table>
<thead>
<tr>
<th>No.</th>
<th>$P_x$ (kip)</th>
<th>$M_{xx}$ (k-ft)</th>
<th>$M_{yy}$ (k-ft)</th>
<th>$\phi P_x$ (kip)</th>
<th>$\phi M_{xx}$ (k-ft)</th>
<th>$\phi M_{yy}$ (k-ft)</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39.6</td>
<td>16.6</td>
<td>3.3</td>
<td>39.55</td>
<td>23.76</td>
<td>4.78</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.70
6.3. PM at θ=90 [deg]

<table>
<thead>
<tr>
<th>General Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>SLAD</td>
</tr>
<tr>
<td>Column</td>
<td>Ext Col 1</td>
</tr>
<tr>
<td>Engineer</td>
<td>ECL</td>
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<tr>
<td>Code</td>
<td>ACI 318-19</td>
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<tr>
<td>Bar Set</td>
<td>ASTM A615</td>
</tr>
<tr>
<td>Units</td>
<td>English</td>
</tr>
<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
</tr>
<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
</tr>
</tbody>
</table>

| Materials | |
|-----------|
| f_y       | 3 ksi |
| E_c       | 3122.02 ksi |
| f_y       | 40 ksi |
| E_s       | 29000 ksi |

| Section | |
|---------|
| Type    | Rectangular |
| Width   | 8 in |
| Depth   | 12 in |
| A_y     | 96 in² |
| I_y     | 1152 in⁴ |
| I_y     | 512 in⁴ |

| Reinforcement | |
|---------------|
| Pattern       | All sides equal |
| Bar layout    | Rectangular     |
| Cover to      | Transverse bars |
| Clear cover   | 1.5 in |
| Bars          | 4 #4 |
| Confinement type | Tied |
| Total steel area, A_s | 0.80 in² |
| Rho           | 0.83 % |
| Min. clear spacing | 3.25 in |
6.4. MM at $P=0$ [kip]

### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

### Materials
- $f_y = 3$ ksi
- $E_c = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_y = 29000$ ksi

### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_o = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4
- **Confinement type**: Tied

### Summary
- **Total steel area, $A_s$**: 0.80 in$^2$
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in
6.5. MM at P=40 [kip]

**General Information**
- Project: SLAD
- Column: Ext Col 1
- Engineer: ECL
- Code: ACI 318-19
- Bar Set: ASTM A615
- Units: English
- Run Option: Investigation
- Run Axis: Biaxial
- Slenderness: Not Considered
- Column Type: Structural
- Capacity Method: Moment capacity

**Materials**
- $f_y = 3$ ksi
- $E_c = 31220.02$ ksi
- $f_y = 40$ ksi
- $E_s = 29000$ ksi

**Section**
- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_s = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

**Reinforcement**
- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #4

**Confinement type**: Tied

**Total steel area, $A_s = 0.80$ in$^2$**

**Rho**: 0.83 %

**Min. clear spacing**: 3.25 in
6.6. PM+ at θ=11 [deg] [User]

General Information
Project: SLAD
Column: Ext Col 1
Engineer: ECL
Code: ACI 318-19
Bar Set: ASTM A615
Units: English
Run Option: Investigation
Run Axis: Biaxial
Stiffness: Not Considered
Column Type: Structural
Capacity Method: Moment capacity

Materials
fy = 3 ksi
Ec = 3122.02 ksi
fcs = 40 ksi
Ec = 29000 ksi

Section
Type: Rectangular
Width: 8 in
Depth: 12 in
A = 96 in²
Ix = 1152 in⁴
Iy = 512 in⁴

Reinforcement
Pattern: All sides equal
Bar layout: Rectangular
Cover to: Transverse bars
Clear cover: 1.5 in
Bars: 4 #4

Confinement type: Tied

Total steel area, A_s: 0.80 in²
Rho: 0.83 %
Min. clear spacing: 3.25 in
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   6.2. PM at θ=39 [deg] .......................................................... 7
   6.3. PM at θ=90 [deg] .......................................................... 8
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Figure 1: Column section ......................................................... 4
1. General Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>C:\Users\emmal\OneDrive\Documents\School\Senior Project\SP Column Files\column1secondtoroof.col</th>
</tr>
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<tbody>
<tr>
<td>Project</td>
<td>SLAD</td>
</tr>
<tr>
<td>Column</td>
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</tr>
<tr>
<td>Engineer</td>
<td>ECL</td>
</tr>
<tr>
<td>Code</td>
<td>ACI 318-19</td>
</tr>
<tr>
<td>Bar Set</td>
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</tr>
<tr>
<td>Units</td>
<td>English</td>
</tr>
<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
</tr>
<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
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2. Material Properties

2.1. Concrete

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
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<tbody>
<tr>
<td>$f'_{c}$</td>
<td>3 ksi</td>
</tr>
<tr>
<td>$E_{c}$</td>
<td>3122.02 ksi</td>
</tr>
<tr>
<td>$f_{c}$</td>
<td>2.55 ksi</td>
</tr>
<tr>
<td>$e_{u}$</td>
<td>0.003 in/in</td>
</tr>
<tr>
<td>$\beta_{1}$</td>
<td>0.85</td>
</tr>
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</table>

2.2. Steel

<table>
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<th>Standard</th>
</tr>
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<tbody>
<tr>
<td>$f_{y}$</td>
<td>40 ksi</td>
</tr>
<tr>
<td>$E_{s}$</td>
<td>29000 ksi</td>
</tr>
<tr>
<td>$\epsilon_{yt}$</td>
<td>0.00137931 in/in</td>
</tr>
</tbody>
</table>

3. Section

3.1. Shape and Properties

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<tr>
<th>Type</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>8 in</td>
</tr>
<tr>
<td>Depth</td>
<td>12 in</td>
</tr>
<tr>
<td>$A_{g}$</td>
<td>96 in$^2$</td>
</tr>
<tr>
<td>$I_{x}$</td>
<td>1152 in$^4$</td>
</tr>
<tr>
<td>$I_{y}$</td>
<td>512 in$^4$</td>
</tr>
<tr>
<td>$r_{x}$</td>
<td>3.4641 in</td>
</tr>
<tr>
<td>$r_{y}$</td>
<td>2.3094 in</td>
</tr>
<tr>
<td>$X_{o}$</td>
<td>0 in</td>
</tr>
<tr>
<td>$Y_{o}$</td>
<td>0 in</td>
</tr>
</tbody>
</table>
3.2. Section Figure

![Column Section]

Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Bar</th>
<th>Diameter</th>
<th>Area</th>
<th>Bar</th>
<th>Diameter</th>
<th>Area</th>
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</thead>
<tbody>
<tr>
<td>#3</td>
<td>0.38</td>
<td>0.11</td>
<td>#6</td>
<td>0.75</td>
<td>0.44</td>
</tr>
<tr>
<td>#9</td>
<td>1.13</td>
<td>1.00</td>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
</tr>
<tr>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2. Confinement and Factors

Confinement type
- Tied
- For #10 bars or less: #3 ties
- For larger bars: #4 ties

Capacity Reduction Factors
- Axial compression, (a): 0.8
- Tension controlled \( \phi \), (b): 0.9
- Compression controlled \( \phi \), (c): 0.65

4.3. Arrangement

<table>
<thead>
<tr>
<th>Pattern</th>
<th>All sides equal</th>
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</thead>
<tbody>
<tr>
<td>Bar layout</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Cover to</td>
<td>Transverse bars</td>
</tr>
<tr>
<td>Clear cover</td>
<td>1.5 in</td>
</tr>
<tr>
<td>Bars</td>
<td>4 #4</td>
</tr>
</tbody>
</table>
### 5. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Moment Capacity" Method.

<table>
<thead>
<tr>
<th>No.</th>
<th>Demand</th>
<th>Capacity</th>
<th>Parameters at Capacity</th>
<th>Capacity Ratio</th>
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<tbody>
<tr>
<td></td>
<td>$P_u$</td>
<td>$M_{ux}$</td>
<td>$M_{uy}$</td>
<td>$\phi P_u$</td>
</tr>
<tr>
<td>1</td>
<td>8.79</td>
<td>2.38</td>
<td>1.95</td>
<td>8.79</td>
</tr>
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</table>

Total steel area, $A_s = 0.80 \text{ in}^2$

Rho = 0.83 %

Minimum clear spacing = 3.25 in

(Note: Rho < 1.0%)
6. Diagrams

6.1. PM at $\theta=0$ [deg]

---

**General Information**
- Project: SLAD
- Column: Ext Col 1
- Engineer: ECL
- Code: ACI 318-19
- Bar Set: ASTM A615
- Units: English
- Run Option: Investigation
- Run Axis: Biaxial
- Slienderness: Not Considered
- Column Type: Structural
- Capacity Method: Moment capacity

**Materials**
- $f_y$: 3 ksi
- $E_s$: 31220.2 ksi
- $f_y$: 40 ksi
- $E_s$: 29000 ksi

**Section**
- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_s$: 96 in$^2$
- $I_x$: 1152 in$^4$
- $I_y$: 512 in$^4$

**Reinforcement**
- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #4
- Confinement type: Tied

**Total steel area, $A_s$: 0.80 in$^2$
- Rho: 0.83 %
- Min. clear spacing: 3.25 in**
### 6.2. PM at $\theta=39$ [deg]

<table>
<thead>
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<td>ECL</td>
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<td>Units</td>
<td>English</td>
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<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
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<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
</tr>
</tbody>
</table>

#### Materials

- $f_y = 3$ ksi
- $E_y = 3122.02$ ksi
- $f_p = 40$ ksi
- $E_p = 29000$ ksi

#### Section

- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_p = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

#### Reinforcement

- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #4

#### Confinement type: Tied

- Total steel area, $A_s = 0.80$ in$^2$
- Rho: 0.83 %
- Min. clear spacing: 3.25 in
### 6.3. PM at $\theta=90$ [deg]

#### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

#### Materials
- $f_y = 3$ ksi
- $E_c = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_s = 29000$ ksi

#### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_y = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

#### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4
- **Confinement type**: Tied

- **Total steel area, $A_s = 0.80$ in$^2$**
- **Rho = 0.83 %**
- **Min. clear spacing**: 3.25 in
### 6.4. MM at P=0 [kip]

**General Information**
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Stiffness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

**Materials**
- \( f_y = 3 \) ksi
- \( E_c = 3122.02 \) ksi
- \( f_y = 40 \) ksi
- \( E_s = 29000 \) ksi

**Section**
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- \( A_g = 96 \) in²
- \( I_y = 1152 \) in⁴
- \( I_y = 512 \) in⁴

**Reinforcement**
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4

**Confinement type**: Tied
- **Total steel area, \( A_s \)**: 0.80 in²
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in
6.5. MM at P=9 [kip]

APPENDIX: SP COLUMN OUTPUT
WORST CASE RESIDENTIAL COLUMN
SECOND FLOOR TO ROOF

GRAVITY SECTION

General Information
Project SLAD
Column Ext Col 1
Engineer ECL
Code ACI 318-19
Bar Set ASTM A615
Units English
Run Option Investigation
Run Axis Biaxial
Slenderness Not Considered
Column Type Structural
Capacity Method Moment capacity

Materials
f'c 3 ksi
Ec 3122.02 ksi
f'w 40 ksi
Ew 29000 ksi

Section
Type Rectangular
Width 8 in
Depth 12 in
A0 96 in²
I0 1152 in⁴
Iy 512 in⁴

Reinforcement
Pattern All sides equal
Bar layout Rectangular
Cover to Transverse bars
Clear cover 1.5 in
Bars 4 #4

Confinement type Tied

Total steel area, A_s 0.80 in²
Rho 0.83 %
Min. clear spacing 3.25 in

<table>
<thead>
<tr>
<th>No.</th>
<th>P_0</th>
<th>M_w</th>
<th>M_wp</th>
<th>φP_0</th>
<th>φM_w</th>
<th>φM_wp</th>
<th>Capacity</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.8</td>
<td>2.4</td>
<td>2.0</td>
<td>8.79</td>
<td>10.45</td>
<td>8.59</td>
<td>0.23</td>
<td></td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.23
6.6. PM+ at θ=40 [deg] [User]

**General Information**
- **Project:** SLAD
- **Column:** Ext Col 1
- **Engineer:** ECL
- **Code:** ACI 318-19
- **Bar Set:** ASTM A615
- **Units:** English
- **Run Option:** Investigation
- **Run Axis:** Biaxial
- **Slenderness:** Not Considered
- **Column Type:** Structural
- **Capacity Method:** Moment capacity

**Materials**
- $f_y = 3$ ksi
- $E_y = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_y = 29000$ ksi

**Section**
- **Type:** Rectangular
- **Width:** 8 in
- **Depth:** 12 in
- $A_y = 96$ in$^2$
- $I_y = 1152$ in$^4$
- $I_y = 512$ in$^4$

**Reinforcement**
- **Pattern:** All sides equal
- **Bar layout:** Rectangular
- **Cover to:** Transverse bars
- **Clear cover:** 1.5 in
- **Bars:** 4 #4

**Concrete**
- Confinement type: Tied
- Total steel area, $A_s = 0.80$ in$^2$
- $Rho = 0.83$ %
- Min. clear spacing = 3.25 in

**APPENDIX: SP COLUMN OUTPUT**

**WORST CASE RESIDENTIAL COLUMN**

**SECOND FLOOR TO ROOF**

**GRAVITY SECTION**
### SLAD

**Latitude, Longitude:** 30.059128, -89.962061

<table>
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<th>Value</th>
<th>Description</th>
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<td>$S_S$</td>
<td>0.087</td>
<td>MCE$_R$ ground motion. (for 0.2 second period)</td>
</tr>
<tr>
<td>$S_1$</td>
<td>0.054</td>
<td>MCE$_R$ ground motion. (for 1.0s period)</td>
</tr>
<tr>
<td>$S_{MS}$</td>
<td>0.139</td>
<td>Site-modified spectral acceleration value</td>
</tr>
<tr>
<td>$S_{M1}$</td>
<td>0.13</td>
<td>Site-modified spectral acceleration value</td>
</tr>
<tr>
<td>$S_{DS}$</td>
<td>0.093</td>
<td>Numeric seismic design value at 0.2 second SA</td>
</tr>
<tr>
<td>$S_{D1}$</td>
<td>0.087</td>
<td>Numeric seismic design value at 1.0 second SA</td>
</tr>
<tr>
<td>SDC</td>
<td>C</td>
<td>Seismic design category</td>
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<tr>
<td>$F_a$</td>
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<td>Site amplification factor at 0.2 second</td>
</tr>
<tr>
<td>$F_v$</td>
<td>2.4</td>
<td>Site amplification factor at 1.0 second</td>
</tr>
<tr>
<td>PGA</td>
<td>0.042</td>
<td>MCE$_G$ peak ground acceleration</td>
</tr>
<tr>
<td>$F_{PGA}$</td>
<td>1.6</td>
<td>Site amplification factor at PGA</td>
</tr>
<tr>
<td>$PGA_{M}$</td>
<td>0.068</td>
<td>Site modified peak ground acceleration</td>
</tr>
<tr>
<td>$T_L$</td>
<td>12</td>
<td>Long-period transition period in seconds</td>
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<tr>
<td>$S_{sRT}$</td>
<td>0.087</td>
<td>Probabilistic risk-targeted ground motion. (0.2 second)</td>
</tr>
<tr>
<td>$S_{sUH}$</td>
<td>0.092</td>
<td>Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration</td>
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<tr>
<td>$S_{sD}$</td>
<td>1.5</td>
<td>Factored deterministic acceleration value. (0.2 second)</td>
</tr>
<tr>
<td>$S_{1RT}$</td>
<td>0.054</td>
<td>Probabilistic risk-targeted ground motion. (1.0 second)</td>
</tr>
<tr>
<td>$S_{1UH}$</td>
<td>0.061</td>
<td>Factored uniform-hazard (2% probability of exceedance in 50 years) spectral acceleration</td>
</tr>
<tr>
<td>$S_{1D}$</td>
<td>0.6</td>
<td>Factored deterministic acceleration value. (1.0 second)</td>
</tr>
<tr>
<td>$PG_{Ad}$</td>
<td>0.5</td>
<td>Factored deterministic acceleration value. (Peak Ground Acceleration)</td>
</tr>
<tr>
<td>$C_{RS}$</td>
<td>0.949</td>
<td>Mapped value of the risk coefficient at short periods</td>
</tr>
<tr>
<td>$C_{R1}$</td>
<td>0.883</td>
<td>Mapped value of the risk coefficient at a period of 1 s</td>
</tr>
</tbody>
</table>
## Center of Mass

<table>
<thead>
<tr>
<th>Item</th>
<th>L (ft)</th>
<th>W (ft)</th>
<th>A (ft²)</th>
<th>xi (ft)</th>
<th>yi (ft)</th>
<th>Axi (ft³)</th>
<th>Ayi (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Area 1</td>
<td>14.2</td>
<td>28.6</td>
<td>407</td>
<td>13.68</td>
<td>86.61</td>
<td>5567</td>
<td>35243</td>
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<tr>
<td>Floor Area 2</td>
<td>1.0</td>
<td>12.5</td>
<td>12</td>
<td>35.19</td>
<td>80.05</td>
<td>432</td>
<td>982</td>
</tr>
<tr>
<td>Floor Area 3</td>
<td>36.1</td>
<td>33.5</td>
<td>1208</td>
<td>23.95</td>
<td>60.88</td>
<td>28925</td>
<td>73521</td>
</tr>
<tr>
<td>Floor Area 4</td>
<td>4.4</td>
<td>7.2</td>
<td>31</td>
<td>6.48</td>
<td>45.65</td>
<td>204</td>
<td>1438</td>
</tr>
<tr>
<td>Floor Area 5</td>
<td>9.9</td>
<td>13.5</td>
<td>133</td>
<td>6.05</td>
<td>38.44</td>
<td>807</td>
<td>5123</td>
</tr>
<tr>
<td>Floor Area 6</td>
<td>44.2</td>
<td>26.1</td>
<td>1156</td>
<td>42.24</td>
<td>21.42</td>
<td>48812</td>
<td>24757</td>
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<tr>
<td>Floor Area 7</td>
<td>17.8</td>
<td>13.0</td>
<td>231</td>
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<td>40.42</td>
<td>18079</td>
<td>9349</td>
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<td>Floor Area 8</td>
<td>6.0</td>
<td>3.8</td>
<td>23</td>
<td>69.69</td>
<td>46.54</td>
<td>1606</td>
<td>1073</td>
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<tr>
<td>SW 1</td>
<td>20.34</td>
<td>0.67</td>
<td>14</td>
<td>17</td>
<td>93</td>
<td>236</td>
<td>1264</td>
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<tr>
<td>SW 2</td>
<td>14.27</td>
<td>0.67</td>
<td>10</td>
<td>20</td>
<td>34</td>
<td>194</td>
<td>325</td>
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<tr>
<td>SW 3</td>
<td>18.04</td>
<td>0.67</td>
<td>12</td>
<td>50</td>
<td>0</td>
<td>598</td>
<td>0</td>
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<tr>
<td>SW 4</td>
<td>27.56</td>
<td>0.67</td>
<td>18</td>
<td>13</td>
<td>9</td>
<td>244</td>
<td>157</td>
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<tr>
<td>SW 5</td>
<td>16.40</td>
<td>0.67</td>
<td>11</td>
<td>28</td>
<td>55</td>
<td>301</td>
<td>606</td>
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<tr>
<td>SW 6</td>
<td>10.50</td>
<td>0.67</td>
<td>7</td>
<td>71</td>
<td>22</td>
<td>498</td>
<td>156</td>
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<td>SW 7</td>
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<td>0.67</td>
<td>9</td>
<td>0</td>
<td>41</td>
<td>0</td>
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<td>SW 8</td>
<td>16.86</td>
<td>0.67</td>
<td>11</td>
<td>84</td>
<td>40</td>
<td>946</td>
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<td>107449</td>
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### Center of Rigidity

<table>
<thead>
<tr>
<th>Line</th>
<th>xi (ft)</th>
<th>yi (ft)</th>
<th>Rx</th>
<th>Ry</th>
<th>Ry*xi</th>
<th>Rx*yi</th>
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<tbody>
<tr>
<td>SW 1</td>
<td>17</td>
<td>93</td>
<td>0.52</td>
<td>0.00</td>
<td>0</td>
<td>48.92</td>
</tr>
<tr>
<td>SW 2</td>
<td>20</td>
<td>34</td>
<td>0.30</td>
<td>0.00</td>
<td>0</td>
<td>10.09</td>
</tr>
<tr>
<td>SW 3</td>
<td>50</td>
<td>0</td>
<td>0.44</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SW 4</td>
<td>13</td>
<td>9</td>
<td>0.80</td>
<td>0.00</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>SW 5</td>
<td>28</td>
<td>55</td>
<td>0.38</td>
<td>0.00</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>SW 6</td>
<td>71</td>
<td>22</td>
<td>0.16</td>
<td>0.00</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>SW 7</td>
<td>0</td>
<td>41</td>
<td>0.25</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SW 8</td>
<td>84</td>
<td>40</td>
<td>0.39</td>
<td>0.00</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>SW 9</td>
<td>0</td>
<td>87</td>
<td>0.25</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Σ 1.26 1.98 65.6 59.01

R = 1/Δ = (4(h/L)³ + 3(h/L)/t)⁻¹

Center of Rigidity (C.O.R.)

<table>
<thead>
<tr>
<th>X (ft)</th>
<th>Y (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>47</td>
</tr>
</tbody>
</table>
**APPENDIX: STORY AND DIAPHRAGM FORCES**

*Due to confined masonry not being available in ASCE 7-16 no reductions through R, C_d, etc. shall be taken, therefore, they equal 1*

**Calculation of C_s**

- \( T_a = 0.19 \) [ASCE 7-16 Section 12.8.2.1 PP.102]
- \( S_{D_1} = 0.09 \) [SEAOSC Seismic Design Maps]
- \( T_L = 12.00 \) [SEAOSC Seismic Design Maps]
- \( C_s = 0.1395 \) [ASCE 7-16 EQ 12.8-2]
- \( C_{s_{max}} = 0.6854 \) [ASCE 7-16 EQ 12.8-3]
- \( C_{s_{min}} = 0.0061 \) [ASCE 7-16 EQ 12.8-5]

Therefore, \( C_s = 0.1395 \)

| LEVEL     | \( \text{Wx} \) (kips) | \( 2\text{Wx} \) (kips) | \( \text{hx} \) (ft) | \( \text{Wx}^*\text{hx}^2 \) | \( \text{Wx}^*\text{hx}^2/2(\text{Wx}^*\text{hx}^2) \) | Coefficient * \( W \) (kips) | \( F_x \) (kips) | \( \Sigma F_x \) (kips) | \( A_x \) (coeff.) | \( F_p \) (kips) | \( 0.25\text{Wx}^*\text{hx}^2 \) (kips) | \( 0.45\text{Wx}^*\text{hx}^2 \) (kips) | \( C_p \) | Scale Factor | \( \text{CS} \) | \( S_{D_1} \) | \( l_s \) | \( k \) |
|-----------|------------------------|--------------------------|---------------------|-----------------------------|--------------------------------|------------------------|--------------|------------------|----------------|--------------|------------------------|------------------------|--------|----------------|--------|--------|--------|
| ROOF      | 415                    | 415                      | 20.2                | 8379                        | 0.524                          | 0.0731*W               | 84.2        | 84.2             | 0.2            | 84           | 11.6                    | 23.2                    | 0.056  | 0.275          |        |        |        |
| 2ND FLR   | 737                    | 1152                     | 10.3                | 7613                        | 0.476                          | 0.0664*W               | 76.5        | 160.7            | 0.1            | 103          | 20.6                    | 41.1                    | 0.056  | 0.537          |        |        |        |
| \( \Sigma \) | 1152                      | 15992                   |                     | 160.7                        |                               |                        |              |                  |                |              |                          |                          |        |                |        |        |        |

\( F_p = 0.1395*W \)
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   2.2. Steel ................................................................................. 3
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1. General Information

<table>
<thead>
<tr>
<th>File Name</th>
<th>C:\Users\em...\Column1LateralCheckCompression.col</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>Column</td>
<td>Ext Col 1</td>
</tr>
<tr>
<td>Engineer</td>
<td>ECL</td>
</tr>
<tr>
<td>Code</td>
<td>ACI 318-19</td>
</tr>
<tr>
<td>Bar Set</td>
<td>ASTM A615</td>
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<tr>
<td>Units</td>
<td>English</td>
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<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
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<td>Column Type</td>
<td>Structural</td>
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<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
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2. Material Properties

2.1. Concrete

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f'_{c}$</td>
<td>3 ksi</td>
</tr>
<tr>
<td>$E_{c}$</td>
<td>3122.02 ksi</td>
</tr>
<tr>
<td>$f_{c}$</td>
<td>2.55 ksi</td>
</tr>
<tr>
<td>$\varepsilon_{u}$</td>
<td>0.003 in/in</td>
</tr>
<tr>
<td>$\beta_{1}$</td>
<td>0.85</td>
</tr>
</tbody>
</table>

2.2. Steel

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_{y}$</td>
<td>40 ksi</td>
</tr>
<tr>
<td>$E_{s}$</td>
<td>29000 ksi</td>
</tr>
<tr>
<td>$\varepsilon_{yt}$</td>
<td>0.00137931 in/in</td>
</tr>
</tbody>
</table>

3. Section

3.1. Shape and Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>8 in</td>
</tr>
<tr>
<td>Depth</td>
<td>12 in</td>
</tr>
<tr>
<td>$A_{g}$</td>
<td>96 in$^2$</td>
</tr>
<tr>
<td>$I_{x}$</td>
<td>1152 in$^4$</td>
</tr>
<tr>
<td>$I_{y}$</td>
<td>512 in$^4$</td>
</tr>
<tr>
<td>$r_{x}$</td>
<td>3.4641 in</td>
</tr>
<tr>
<td>$r_{y}$</td>
<td>2.3094 in</td>
</tr>
<tr>
<td>$X_{c}$</td>
<td>0 in</td>
</tr>
<tr>
<td>$Y_{c}$</td>
<td>0 in</td>
</tr>
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</table>
3.2. Section Figure

![Figure 1: Column section](image)

4. Reinforcement

4.1. Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Bar</th>
<th>Diameter</th>
<th>Area</th>
<th>Bar</th>
<th>Diameter</th>
<th>Area</th>
<th>Bar</th>
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<th>Area</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>in</td>
<td>in²</td>
<td></td>
<td>in</td>
<td>in²</td>
<td></td>
<td>in</td>
<td>in²</td>
</tr>
<tr>
<td>#3</td>
<td>0.38</td>
<td>0.11</td>
<td>#4</td>
<td>0.50</td>
<td>0.20</td>
<td>#5</td>
<td>0.63</td>
<td>0.31</td>
</tr>
<tr>
<td>#6</td>
<td>0.75</td>
<td>0.44</td>
<td>#7</td>
<td>0.88</td>
<td>0.60</td>
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<td>0.79</td>
</tr>
<tr>
<td>#9</td>
<td>1.13</td>
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<td>1.27</td>
<td>#11</td>
<td>1.41</td>
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<tr>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
<td>#18</td>
<td>2.26</td>
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<td></td>
<td></td>
<td></td>
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</tbody>
</table>

4.2. Confinement and Factors

<table>
<thead>
<tr>
<th>Confinement type</th>
<th>Tied</th>
</tr>
</thead>
<tbody>
<tr>
<td>For #10 bars or less</td>
<td>#3 ties</td>
</tr>
<tr>
<td>For larger bars</td>
<td>#4 ties</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity Reduction Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial compression, (a)</td>
<td>0.8</td>
</tr>
<tr>
<td>Tension controlled φ, (b)</td>
<td>0.9</td>
</tr>
<tr>
<td>Compression controlled φ, (c)</td>
<td>0.65</td>
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</table>

4.3. Arrangement

<table>
<thead>
<tr>
<th>Pattern</th>
<th>All sides equal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar layout</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Cover to</td>
<td>Transverse bars</td>
</tr>
<tr>
<td>Clear cover</td>
<td>1.5 in</td>
</tr>
<tr>
<td>Bars</td>
<td>4 #4</td>
</tr>
</tbody>
</table>
### Total steel area, $A_s$

0.80 in$^2$

### Rho

0.83 %

### Minimum clear spacing

3.25 in

(Note: Rho < 1.0%)

#### 5. Factored Loads and Moments with Corresponding Capacity Ratios

**NOTE:** Calculations are based on "Moment Capacity" Method.

<table>
<thead>
<tr>
<th>No.</th>
<th>Demand</th>
<th>Capacity</th>
<th>Parameters at Capacity</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_u$</td>
<td>$M_{ux}$</td>
<td>$M_{uy}$</td>
<td>$\phi P_n$</td>
</tr>
<tr>
<td>1</td>
<td>101.00</td>
<td>16.61</td>
<td>3.34</td>
<td>101.00</td>
</tr>
</tbody>
</table>
6. Diagrams

6.1. PM at θ=0 [deg]

**Diagram:**
- **Dimensions:** 8 x 12 in

**General Information**
- **Project:** SLAD
- **Column:** Ext. Col. 1
- **Engineer:** ECL
- **Code:** ACI 318-19
- **Bar Set:** ASTM A615
- **Units:** English
- **Run Option:** Investigation
- **Run Axis:** Biaxial
- **Slenderness:** Not Considered
- **Column Type:** Structural
- **Capacity Method:** Moment capacity

**Materials**
- \( f_y \): 3 ksi
- \( E_s \): 31222.02 ksi
- \( f_y \): 40 ksi
- \( E_s \): 29000 ksi

**Section**
- **Type:** Rectangular
- **Width:** 8 in
- **Depth:** 12 in
- \( A_s \): 96 in²
- \( I_x \): 1152 in⁴
- \( I_y \): 512 in⁴

**Reinforcement**
- **Pattern:** All sides equal
- **Bar layout:** Rectangular
- **Cover to:** Transverse bars
- **Clear cover:** 1.5 in
- **Bars:** 4 #4
- **Confinement type:** Tied

**Total steel area, \( A_s \):** 0.80 in²
- **Rho:** 0.83 %
- **Min. clear spacing:** 3.25 in
6.2. PM at $\theta=11$ [deg]

**General Information**
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderess**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

**Materials**
- $f_y = 3$ ksi
- $E_c = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_s = 29000$ ksi

**Section**
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_s = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

**Reinforcement**
- **Pattern**: All sides equal
- **Bar Layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear Cover**: 1.5 in
- **Bars**: 4 #4

**Confinement Type**: Tied

**Total Steel Area, $A_s$**: 0.80 in$^2$

**Rho**: 0.83 %

**Min. Clear Spacing**: 3.25 in

---

**APPENDIX: SP COLUMN OUTPUT**

**WORST CASE SHEAR WALL COLUMN COMPRESSION**

**FLEXURE DOMINATED**

**LATERAL SECTION**

**PM at 11.0 [deg]**

---

**APPENDIX: SP COLUMN OUTPUT**

**WORST CASE SHEAR WALL COLUMN COMPRESSION**

**FLEXURE DOMINATED**

**LATERAL SECTION**

---

**PM at 11.0 [deg]**

---

**Model Data**

<table>
<thead>
<tr>
<th>No.</th>
<th>$P_s$</th>
<th>$M_{lx}$</th>
<th>$M_{ly}$</th>
<th>$\phi P_s$</th>
<th>$\phi M_{lx}$</th>
<th>$\phi M_{ly}$</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>101.0</td>
<td>16.6</td>
<td>3.3</td>
<td>101.00</td>
<td>21.70</td>
<td>4.37</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.77
6.3. PM at $\theta=90$ [deg]

**General Information**
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

**Materials**
- $f_y = 3$ ksi
- $E_c = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_s = 29000$ ksi

**Section**
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_b = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

**Reinforcement**
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4

**Confinement type**: Tied
- **Total steel area, $A_s$**: 0.80 in$^2$
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in
### 6.4. MM at P=0 [kip]

![Diagram of 8 x 12 in section](image)

#### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

#### Materials
- $f_y$: 3 ksi
- $E_c$: 3122.02 ksi
- $f_y$: 40 ksi
- $E_y$: 29000 ksi

#### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_s$: 96 in²
- $I_x$: 1152 in⁴
- $I_y$: 512 in⁴

#### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4

#### Confinement type
- **Type**: Tied

#### Structural Data
- **Total steel area, $A_s$**: 0.80 in²
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in
6.5. **MM at P=101 [kip]**

### General Information
- **Project**: SLAD
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Sidereness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

### Materials
- $f_y = 3$ ksi
- $E_c = 3122.02$ ksi
- $f_y = 40$ ksi
- $E_m = 29000$ ksi

### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_p = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #4
- **Confinement type**: Tied
- **Total steel area, $A_s$**: 0.89 in$^2$
- **Rho**: 0.83 %
- **Min. clear spacing**: 3.25 in

### Table

<table>
<thead>
<tr>
<th>No.</th>
<th>$P_x$</th>
<th>$M_x$</th>
<th>$M_{xy}$</th>
<th>$\phi P_x$</th>
<th>$\phi M_x$</th>
<th>$\phi M_{xy}$</th>
<th>Capacity</th>
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<tbody>
<tr>
<td>1</td>
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<td>16.6</td>
<td>3.3</td>
<td>101.00</td>
<td>21.70</td>
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<td>0.77</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.77
6.6. PM+ at θ=11 [deg] [User]

<table>
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</tr>
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<tbody>
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<td>Ext Col 1</td>
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<tr>
<td>Engineer</td>
<td>ECL</td>
</tr>
<tr>
<td>Code</td>
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<td>Bar Set</td>
<td>ASTM A615</td>
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<tr>
<td>Units</td>
<td>English</td>
</tr>
<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>Biaxial</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
</tr>
<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
</tr>
</tbody>
</table>

**Materials**

- $f_y =$ 3 ksi
- $E_s =$ 3122.02 ksi
- $f_y =$ 40 ksi
- $E_s =$ 29000 ksi

**Section**

- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_y =$ 96 in²
- $I_y =$ 1152 in⁴
- $I_y =$ 512 in⁴

**Reinforcement**

- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #4

**Confinement type**: Tied

- Total steel area, $A_s =$ 0.80 in²
- Rho: 0.83 %
- Min. clear spacing: 3.25 in

### Table: Lateral Section

<table>
<thead>
<tr>
<th>No.</th>
<th>$P_{x}$</th>
<th>$M_{yx}$</th>
<th>$M_{yy}$</th>
<th>$\phi M_{yx}$</th>
<th>$\phi M_{yy}$</th>
<th>$\phi M$</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>101.0</td>
<td>16.6</td>
<td>3.3</td>
<td>101.00</td>
<td>21.70</td>
<td>4.37</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.77
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1. General Information

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<td>Investigation</td>
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</tr>
<tr>
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<tr>
<td>Column Type</td>
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</tr>
<tr>
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<td>Moment capacity</td>
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2. Material Properties

2.1. Concrete

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f'_c$</td>
<td>3 ksi</td>
</tr>
<tr>
<td>$E_c$</td>
<td>3122.02 ksi</td>
</tr>
<tr>
<td>$f_c$</td>
<td>2.55 ksi</td>
</tr>
<tr>
<td>$\varepsilon_u$</td>
<td>0.003 in/in</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.85</td>
</tr>
</tbody>
</table>

2.2. Steel

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_y$</td>
<td>40 ksi</td>
</tr>
<tr>
<td>$E_s$</td>
<td>29000 ksi</td>
</tr>
<tr>
<td>$\varepsilon_{y,t}$</td>
<td>0.00137931 in/in</td>
</tr>
</tbody>
</table>

3. Section

3.1. Shape and Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>8 in</td>
</tr>
<tr>
<td>Depth</td>
<td>12 in</td>
</tr>
<tr>
<td>$A_g$</td>
<td>96 in²</td>
</tr>
<tr>
<td>$I_x$</td>
<td>1152 in⁴</td>
</tr>
<tr>
<td>$I_y$</td>
<td>512 in⁴</td>
</tr>
<tr>
<td>$r_x$</td>
<td>3.4641 in</td>
</tr>
<tr>
<td>$r_y$</td>
<td>2.3094 in</td>
</tr>
<tr>
<td>$X_o$</td>
<td>0 in</td>
</tr>
<tr>
<td>$Y_o$</td>
<td>0 in</td>
</tr>
</tbody>
</table>
3.2. Section Figure

![Section Figure](image)

Rectangular 8 x 12 in 1.83% reinf.

Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Bar</th>
<th>Diameter in</th>
<th>Area in²</th>
<th>Bar</th>
<th>Diameter in</th>
<th>Area in²</th>
<th>Bar</th>
<th>Diameter in</th>
<th>Area in²</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>0.38</td>
<td>0.11</td>
<td>#4</td>
<td>0.50</td>
<td>0.20</td>
<td>#5</td>
<td>0.63</td>
<td>0.31</td>
</tr>
<tr>
<td>#6</td>
<td>0.75</td>
<td>0.44</td>
<td>#7</td>
<td>0.88</td>
<td>0.60</td>
<td>#8</td>
<td>1.00</td>
<td>0.79</td>
</tr>
<tr>
<td>#9</td>
<td>1.13</td>
<td>1.00</td>
<td>#10</td>
<td>1.27</td>
<td>1.27</td>
<td>#11</td>
<td>1.41</td>
<td>1.56</td>
</tr>
<tr>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
<td>#18</td>
<td>2.26</td>
<td>4.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2. Confinement and Factors

<table>
<thead>
<tr>
<th>Confinement type</th>
<th>Tied</th>
</tr>
</thead>
<tbody>
<tr>
<td>For #10 bars or less</td>
<td>#3 ties</td>
</tr>
<tr>
<td>For larger bars</td>
<td>#4 ties</td>
</tr>
</tbody>
</table>

Capacity Reduction Factors

| Axial compression, (a) | 0.8               |
| Tension controlled φ, (b) | 0.9               |
| Compression controlled φ, (c) | 0.65           |

4.3. Arrangement

<table>
<thead>
<tr>
<th>Pattern</th>
<th>All sides equal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar layout</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Cover to</td>
<td>Transverse bars</td>
</tr>
<tr>
<td>Clear cover</td>
<td>1.5 in</td>
</tr>
<tr>
<td>Bars</td>
<td>4 #6</td>
</tr>
</tbody>
</table>
### Total steel area, $A_s$
- 1.76 in$^2$

### Rho
- 1.83 %

### Minimum clear spacing
- 2.75 in

#### 5. Factored Loads and Moments with Corresponding Capacity Ratios

**NOTE:** Calculations are based on "Moment Capacity" Method.

<table>
<thead>
<tr>
<th>No.</th>
<th>Demand</th>
<th>Capacity</th>
<th>Parameters at Capacity</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_u$</td>
<td>$M_{ux}$</td>
<td>$M_{uy}$</td>
<td>$\phi P_u$</td>
</tr>
<tr>
<td>1</td>
<td>-2.00</td>
<td>16.61</td>
<td>3.34</td>
<td>-2.00</td>
</tr>
</tbody>
</table>
6. Diagrams
6.1. PM at $\theta=0$ [deg]

---

**General Information**
- Project: SLAD
- Column: Ext Col 1
- Engineer: ECL
- Code: ACI 318-19
- Bar Set: ASTM A615
- Units: English
- Run Option: Investigation
- Run Axis: Biaxial
- Slenderness: Not Considered
- Column Type: Structural
- Capacity Method: Moment capacity

**Materials**
- $f_y$: 3 ksi
- $f_c$: 3122.02 ksi
- $f_y$: 40 ksi
- $f_c$: 29000 ksi

**Section**
- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_s$: 96 in$^2$
- $I_x$: 1152 in$^4$
- $I_y$: 512 in$^4$

**Reinforcement**
- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #6
- Confinement type: Tied

**Total steel area, $A_s$:** 1.76 in$^2$
- Rho: 1.83 %
- Min. clear spacing: 2.75 in
6.2. PM at $\theta=11$ [deg]

General Information
Project: SLAD
Column: Ext Col 1
Engineer: ECL
Code: ACI 318-19
Bar Set: ASTM A615
Units: English
Run Option: Investigation
Run Axis: Biaxial
Slenderness: Not Considered
Column Type: Structural
Capacity Method: Moment capacity

Materials
$f_y = 3$ ksi
$E_c = 31222.02$ ksi
$f_y = 40$ ksi
$E_y = 29000$ ksi

Section
Type: Rectangular
Width: 8 in
Depth: 12 in
$A_y = 96$ in$^2$
$I_y = 1152$ in$^4$
$I_y = 512$ in$^4$

Reinforcement
Pattern: All sides equal
Bar layout: Rectangular
Cover to: Transverse bars
Clear cover: 1.5 in
Bars: 4 #6

Confinement type: Tied
Total steel area, $A_s$: 1.76 in$^2$
Rho: 1.83 %
Min. clear spacing: 2.75 in

No. | $P_o$ | $M_{xx}$ | $M_{yy}$ | $\phi P_o$ | $\phi M_{xx}$ | $\phi M_{yy}$ | Capacity | Ratio
--- | --- | --- | --- | --- | --- | --- | --- | ---
1  | 2.0 | 16.6 | 3.3 | -2.00 | 22.28 | 4.48 | 0.75 |

Max. Capacity Ratio: 0.75
6.3. PM at $\theta=90$ [deg]

### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

### Materials
- $f_y = 3$ ksi
- $f_y = 3122.02$ ksi
- $f_y = 40$ ksi
- $f_y = 29000$ ksi

### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- $A_b = 96$ in$^2$
- $I_x = 1152$ in$^4$
- $I_y = 512$ in$^4$

### Reinforcement
- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #6
- **Confinement type**: Tied
- **Total steel area, $A_s$**: 1.76 in$^2$
- **Rho**: 1.83 %
- **Min. clear spacing**: 2.75 in
### APPENDIX: SP COLUMN OUTPUT

**WORST CASE SHEAR WALL COLUMN TENSION**

**FLEXURE DOMINATED**

---

**LATERAL SECTION**

---

**6.4. MM at P=-2 [kip]**

---

![Diagram showing MM at P=-2 [kip]](image)

---

**General Information**

- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: Biaxial
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

**Materials**

- **f_y**: 3 ksi
- **E_y**: 31222.02 ksi
- **f_a**: 40 ksi
- **E_a**: 29000 ksi

**Section**

- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 12 in
- **A_y**: 96 in²
- **I_x**: 1152 in⁴
- **I_y**: 512 in⁴

**Reinforcement**

- **Pattern**: All sides equal
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: 1.5 in
- **Bars**: 4 #6
- **Confinement type**: Tied

**Total steel area, A_s**: 1.76 in²

**Rho**: 1.83 %

**Min. clear spacing**: 2.75 in

---

### Table: Summary of Results

<table>
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<tr>
<th>No.</th>
<th>P_x</th>
<th>M_x</th>
<th>M_y</th>
<th>( \phi P_x )</th>
<th>( \phi M_x )</th>
<th>( \phi M_y )</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>16.6</td>
<td>3.3</td>
<td>-2.00</td>
<td>22.28</td>
<td>4.48</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.75
6.5. MM at P=0 [kip]

**General Information**
- Project: SLAD
- Column: Ext Col 1
- Engineer: ECL
- Code: ACI 318-19
- Bar Set: ASTM A615
- Units: English
- Run Option: Investigation
- Run Axis: Biaxial
- Slenderness: Not Considered
- Column Type: Structural
- Capacity Method: Moment capacity

**Materials**
- $f_y$: 3 ksi
- $E_c$: 3122.02 ksi
- $f_y$: 40 ksi
- $E_s$: 29000 ksi

**Section**
- Type: Rectangular
- Width: 8 in
- Depth: 12 in
- $A_y$: 96 in$^2$
- $I_x$: 1152 in$^4$
- $I_y$: 512 in$^4$

**Reinforcement**
- Pattern: All sides equal
- Bar layout: Rectangular
- Cover to: Transverse bars
- Clear cover: 1.5 in
- Bars: 4 #6

**Confinement type**: Tied
- Total steel area, $A_s$: 1.76 in$^2$
- Rho: 1.83 %
- Min. clear spacing: 2.75 in
APPENDIX: SP COLUMN OUTPUT
WORST CASE SHEAR WALL COLUMN TENSION
FLEXURE DOMINATED

LATERAL SECTION

6.6. PM+ at θ=11 [deg] [User]

<table>
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<th>M_{yy}</th>
<th>φP_x</th>
<th>φM_{xx}</th>
<th>φM_{yy}</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-2.0</td>
<td>16.6</td>
<td>3.3</td>
<td>-2.00</td>
<td>22.28</td>
<td>4.48</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.75

General Information
Project: SLAD
Column: Ext Col 1
Engineer: ECL
Code: ACI 318-19
Bar Set: ASTM A615
Units: English
Run Option: Investigation
Run Axis: Biaxial
Sidereness: Not Considered
Column Type: Structural
Capacity Method: Moment capacity

Materials
f_y 3 ksi
E_c 3122.02 ksi
e_y 40 ksi
E_e 29000 ksi

Section
Type: Rectangular
Width: 8 in
Depth: 12 in
A_y 96 in^2
I_y 1152 in^4
I_y 512 in^4

Reinforcement
Pattern: All sides equal
Bar layout: Rectangular
Cover to: Transverse bars
Clear cover: 1.5 in
Bars: 4 #6

Confinement type: Tied
Total steel area, A_s: 1.76 in^2
Rho: 1.83 %
Min. clear spacing: 2.75 in
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<td>Engineer</td>
<td>ECL</td>
</tr>
<tr>
<td>Code</td>
<td>ACI 318-19</td>
</tr>
<tr>
<td>Bar Set</td>
<td>ASTM A615</td>
</tr>
<tr>
<td>Units</td>
<td>English</td>
</tr>
<tr>
<td>Run Option</td>
<td>Investigation</td>
</tr>
<tr>
<td>Run Axis</td>
<td>X - axis</td>
</tr>
<tr>
<td>Slenderness</td>
<td>Not Considered</td>
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<tr>
<td>Column Type</td>
<td>Structural</td>
</tr>
<tr>
<td>Capacity Method</td>
<td>Moment capacity</td>
</tr>
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</table>

2. Material Properties

2.1. Concrete

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f'_c$</td>
<td>3 ksi</td>
</tr>
<tr>
<td>$E_c$</td>
<td>3122.02 ksi</td>
</tr>
<tr>
<td>$f_c$</td>
<td>2.55 ksi</td>
</tr>
<tr>
<td>$\varepsilon_u$</td>
<td>0.003 in/in</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.85</td>
</tr>
</tbody>
</table>

2.2. Steel

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_y$</td>
<td>40 ksi</td>
</tr>
<tr>
<td>$E_s$</td>
<td>29000 ksi</td>
</tr>
<tr>
<td>$\varepsilon_{y_t}$</td>
<td>0.00137931 in/in</td>
</tr>
</tbody>
</table>

3. Section

3.1. Shape and Properties

<table>
<thead>
<tr>
<th>Type</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>8 in</td>
</tr>
<tr>
<td>Depth</td>
<td>18 in</td>
</tr>
<tr>
<td>$A_g$</td>
<td>144 in²</td>
</tr>
<tr>
<td>$I_x$</td>
<td>3888 in⁴</td>
</tr>
<tr>
<td>$I_y$</td>
<td>768 in⁴</td>
</tr>
<tr>
<td>$r_x$</td>
<td>5.19615 in</td>
</tr>
<tr>
<td>$r_y$</td>
<td>2.3094 in</td>
</tr>
<tr>
<td>$X_o$</td>
<td>0 in</td>
</tr>
<tr>
<td>$Y_o$</td>
<td>0 in</td>
</tr>
</tbody>
</table>
3.2. Section Figure

![Column Section Diagram](image)

Figure 1: Column section

4. Reinforcement

4.1. Bar Set: ASTM A615

<table>
<thead>
<tr>
<th>Bar #</th>
<th>Diameter (in)</th>
<th>Area (in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>0.38</td>
<td>0.11</td>
</tr>
<tr>
<td>#6</td>
<td>0.75</td>
<td>0.44</td>
</tr>
<tr>
<td>#9</td>
<td>1.13</td>
<td>1.00</td>
</tr>
<tr>
<td>#14</td>
<td>1.69</td>
<td>2.25</td>
</tr>
</tbody>
</table>

4.2. Confinement and Factors

<table>
<thead>
<tr>
<th>Confinement type</th>
<th>Tied</th>
</tr>
</thead>
<tbody>
<tr>
<td>For #10 bars or less</td>
<td>#3 ties</td>
</tr>
<tr>
<td>For larger bars</td>
<td>#4 ties</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity Reduction Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial compression, (a)</td>
<td>0.8</td>
</tr>
<tr>
<td>Tension controlled ϕ, (b)</td>
<td>0.9</td>
</tr>
<tr>
<td>Compression controlled ϕ, (c)</td>
<td>0.65</td>
</tr>
</tbody>
</table>

4.3. Arrangement

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Sides different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar layout</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Cover to</td>
<td>Transverse bars</td>
</tr>
<tr>
<td>Clear cover</td>
<td>---</td>
</tr>
<tr>
<td>Bars</td>
<td>---</td>
</tr>
</tbody>
</table>
Total steel area, $A_s$ 2.64 in$^2$
Rho 1.83 %
Minimum clear spacing 2.75 in

4.4. Bars Provided

<table>
<thead>
<tr>
<th></th>
<th>Bars</th>
<th>Clear cover</th>
<th>in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>2</td>
<td>#6</td>
<td>1.5</td>
</tr>
<tr>
<td>Bottom</td>
<td>2</td>
<td>#6</td>
<td>1.5</td>
</tr>
<tr>
<td>Left</td>
<td>1</td>
<td>#6</td>
<td>1.5</td>
</tr>
<tr>
<td>Right</td>
<td>1</td>
<td>#6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

5. Factored Loads and Moments with Corresponding Capacity Ratios

NOTE: Calculations are based on "Moment Capacity" Method.

<table>
<thead>
<tr>
<th>No.</th>
<th>Demand</th>
<th>Capacity</th>
<th>Parameters at Capacity</th>
<th>Capacity Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_u$</td>
<td>$M_{ux}$</td>
<td>$\phi P_u$</td>
<td>$\phi M_{ux}$</td>
</tr>
<tr>
<td>1</td>
<td>32.40</td>
<td>66.69</td>
<td>32.40</td>
<td>74.18</td>
</tr>
</tbody>
</table>
6. Diagrams

6.1. PM at $\theta=0$ [deg]

### General Information
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: X - axis
- **Stiffness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

### Materials
- $f_y$: 3 ksi
- $E_y$: 312,020 ksi
- $f_y$: 40 ksi
- $E_y$: 29,000 ksi

### Section
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 18 in
- $A_p$: 144 in$^2$
- $I_x$: 3,888 in$^4$
- $I_y$: 768 in$^4$

### Reinforcement
- **Pattern**: Sides different
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: ---
- **Bars**: ---
- **Confinement type**: Tied
- **Total steel area, $A_p$**: 2.64 in$^2$
- **Rho**: 1.83 %
- **Min. clear spacing**: 2.75 in

### Table

<table>
<thead>
<tr>
<th>No.</th>
<th>$P_{n}$</th>
<th>$M_{n}$</th>
<th>$\phi P_{n}$</th>
<th>$\phi M_{n}$</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.4</td>
<td>66.7</td>
<td>32.40</td>
<td>74.18</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.90
6.2. PM+ at \( \theta=0 \) [deg] [User]

**General Information**
- **Project**: SLAD
- **Column**: Ext Col 1
- **Engineer**: ECL
- **Code**: ACI 318-19
- **Bar Set**: ASTM A615
- **Units**: English
- **Run Option**: Investigation
- **Run Axis**: X - axis
- **Slenderness**: Not Considered
- **Column Type**: Structural
- **Capacity Method**: Moment capacity

**Materials**
- \( f_y \): 3 ksi
- \( E_c \): 3122.02 ksi
- \( f_y \): 40 ksi
- \( E_y \): 29000 ksi

**Section**
- **Type**: Rectangular
- **Width**: 8 in
- **Depth**: 10 in
- \( A_p \): 144 in²
- \( I_x \): 3888 in⁴
- \( I_y \): 786 in⁴

**Reinforcement**
- **Pattern**: Sides different
- **Bar layout**: Rectangular
- **Cover to**: Transverse bars
- **Clear cover**: ---
- **Bars**: ---
- **Confinement type**: Tied

**Table**

<table>
<thead>
<tr>
<th>No.</th>
<th>( P_a )</th>
<th>( M_{ax} )</th>
<th>( \phi P_a )</th>
<th>( \phi M_{ax} )</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.4 kip</td>
<td>66.7 k-ft</td>
<td>32.4 kip</td>
<td>74.18 k-ft</td>
<td>0.90</td>
</tr>
</tbody>
</table>

Max. Capacity Ratio: 0.90
1. ALL JOISTS (J1) ARE 25 CM X 45 CM UNLESS NOTED OTHERWISE
2. SEE TRUSS SCHEDULE ON SHEET S.4 FOR SIZING

STRUCTURAL NOTES

DEVELOPER:

SEAL:

PROJECT:

SITE:

REVISIONS

DESCRIPTION:

DATE:

DRAWN BY:

CHECKED BY:

PLOT DATE:

SHEET NAME:

SCALE:

SHEET NO.:

FREETOWN, SIERRA LEONE

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SALVATION ACADEMY SCHOOL FOR DISADVANTAGED CHILDREN

DRAWINGS TO BE REVIEWED BY IN COUNTRY ARCHITECT AND ENGINEER

DRAWINGS NOT FOR CONSTRUCTION.

ECL

6/10/2021 10:44:32 PM

1:50

Checker

ROOF PLAN

S.3
<table>
<thead>
<tr>
<th>TRUSS NAME</th>
<th>L</th>
<th>Web Size</th>
<th>Chord Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUSS 1</td>
<td>13.06 M</td>
<td>3.05 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>6.46 M</td>
<td>7.17 M</td>
<td>15 CM X 15 CM</td>
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<td>3.91 M</td>
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<tr>
<td></td>
<td>0.91 M</td>
<td>0.51 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td>TRUSS 2</td>
<td>13.06 M</td>
<td>2.56 M</td>
<td>15 CM X 15 CM</td>
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<tr>
<td></td>
<td>5.93 M</td>
<td>3.14 M</td>
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<tr>
<td></td>
<td>4.12 M</td>
<td>0.63 M</td>
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</tr>
<tr>
<td></td>
<td>10.4 M</td>
<td>2.02 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td>TRUSS 3</td>
<td>10.4 M</td>
<td>1.1 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>6.2 M</td>
<td>3.1 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>4.81 M</td>
<td>0.71 M</td>
<td>15 CM X 15 CM</td>
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<tr>
<td></td>
<td>6.61 M</td>
<td>0.73 M</td>
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</tr>
<tr>
<td></td>
<td>4 M</td>
<td>0.99 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>4 M</td>
<td>0.57 M</td>
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</tr>
<tr>
<td></td>
<td>4 M</td>
<td>0.85 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td>TRUSS 4</td>
<td>2.8 M</td>
<td>1.2 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>10.2 M</td>
<td>2.2 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>10.2 M</td>
<td>1.3 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>5 M</td>
<td>0.89 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>5.35 M</td>
<td>0.85 M</td>
<td>15 CM X 15 CM</td>
</tr>
<tr>
<td></td>
<td>5.35 M</td>
<td>1.3 M</td>
<td>15 CM X 15 CM</td>
</tr>
</tbody>
</table>
15 CM CONCRETE SLAB OVER 25 CM X 45 CM CONCRETE BEAM

FLOOR SLAB REINFORCEMENT SEE PLAN

6 CM EQ EQ

(2) #4
(3) #4
(2) #6
(3) #6

15 CM CONCRETE SLAB OVER 25 CM X 45 CM CONCRETE BEAM

ROOF SLAB REINFORCEMENT SEE PLAN

6 CM EQ EQ

(2) #4
(3) #4
(2) #6
(3) #6

SPLICE PER SCHEDULE

120 CM TYP.

DEVELOPER:

SEAL:

PROJECT:

SALVATION ACADEMY

SCHOOL FOR

DISADVANTAGED

CHILDREN

SITE:

FREETOWN, SIERRA LEONE

SHEET NAME:

TYP SLAB AND BEAM DETAILS

SCALE:

As indicated

SHEET NO.:

S.5
15 CM CONCRETE SLAB OVER 30 CM X 45 CM CONCRETE BEAM
SLAB REINFORCEMENT SEE PLAN
6 CM EQ EQ
(2) #6
(4) #6

TYPICAL GIRDER
DETAILS
S.6

INTERIOR GIRDER SECTION AT MIDSPAN
INTERIOR GIRDER SECTION AT SUPPORT
EXTERIOR GIRDER SECTION AT MIDSPAN
EXTERIOR GIRDER SECTION AT SUPPORT

DEVELOPER:
SEAL:
PROJECT:
SITE:

REVISIONS
DESCRIPTION DATE:

DRAWN BY: ECL
CHECKED BY:

PLOT DATE: 6/10/2021 10:44:33 PM
SHEET NAME: TYPICAL GIRDER DETAILS
SCALE: 1:10
SHEET NO.: S.6
VALUES IN TABLE TYP. FOR f'c = 3000 psi & fy = 40000 psi ONLY

NOTES:
1. USE THE EMBEDMENT AND LAP SPLICE LENGTHS SHOWN IN SCHEDULE MULTIPLIED BY ALL APPLICABLE FACTORS AS DEFINED IN NOTES BELOW, U.N.O. ON DRAWINGS.
2. MULTIPLY THE Lh AND Ld LENGTHS BY 1.3 FOR TOP BARS WHICH ARE DEFINED AS HORIZONTAL BARS WITH 12" OR MORE CONCRETE CAST BELOW THEM.
3. WHEN BARS OF DIFFERENT SIZES ARE LAPPED, Lsp SHALL BE DETERMINED BY THE SMALLER BAR.
4. USE THIS TABLE UNLESS NOTED OTHERWISE ON DRAWINGS.

FOOTING DEVELOPMENT SCHEDULE

<table>
<thead>
<tr>
<th>BAR</th>
<th>DEVELOPMENT LENGTH (Lh)</th>
<th>DEVELOPMENT LENGTH (Ld)</th>
<th>LAP SPLICE LENGTH (Lsp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>40 cm</td>
<td>40 cm</td>
<td>38 cm</td>
</tr>
<tr>
<td>72</td>
<td>60 cm</td>
<td>60 cm</td>
<td>50 cm</td>
</tr>
<tr>
<td>80</td>
<td>60 cm</td>
<td>60 cm</td>
<td>50 cm</td>
</tr>
<tr>
<td>36</td>
<td>27 cm</td>
<td>27 cm</td>
<td>35 cm</td>
</tr>
<tr>
<td>47</td>
<td>36 cm</td>
<td>36 cm</td>
<td>35 cm</td>
</tr>
</tbody>
</table>

TYPICAL CONCRETE COVER

SLAB-ON-GRADE:
- FROM TOP: 2" (for EXPOSED TO EARTH)
- FROM SIDES: 2" (for EXPOSED TO EARTH)

FOOTING:
- FROM TOP: 150 cm (for EXPOSED TO EARTH)
- FROM SIDES: 45 cm (for EXPOSED TO EARTH)

BEAMS & COLUMN BARS:
- CLEAR COVER: 1" - 1 1/2" (for EXPOSED TO EARTH)
- EXPOSED TO EARTH: 2" (#6 OR LARGER)
- OVER VAPOR BARRIER: 1 1/2" (#5 OR SMALLER)

FINISH GRADE:
- SLAB-ON-GRADE: 15 cm

TYPICAL SLAB-ON-GRADE:
- OVER 5 CM SAND OVER 10 CM GRAVEL
CONTROL JOINT, TYP AT EACH FLOOR

COLUMN SCHEDULE

COLUMN TYPE LOCATION

ALL COLUMNS

CONTROL JOINT, TYP AT EACH FLOOR

TIES AT EACH BEAM, TYP

COLUMN DOWEL TO MATCH SIZE AND SPACING OF COLUMN VERTICAL REINFORCEMENT

LONGITUDINAL REINFORCEMENT
SEE COLUMN SCHEDULE

LENGTH OF EACH COLUMN RCP

COLUMN SCHEDULE

Roof 2nd Floor

T.O.F

Ld

Ld

5 CM

20 CM TYP.

BARS PER COLUMN SCHEDULE

EQUALY SPACED AROUND PERIMETER

#3 TIES

S1=#3 @ 20 CM O.C.

S1=#3 @ 20 CM O.C.

S1=#3 @ 20 CM O.C.

REVISIONS

DESCRIPTION DATE:

DRAWN BY ECL

CHECKED BY:

PLOT DATE:

6/10/2021 10:44:33 PM

SHEET NAME:

TYPICAL COLUMN DETAILS

SCALE:

As indicated

SHEET NO.:

S.8
SALVATION ACADEMY FOR DISADVANTAGED CHILDREN

CALIFORNIA POLYTECHNIC STATE UNIVERSITY, SAN LUIS OBISPO

JOURNEYMAN INTERNATIONAL

PRESENTED BY: EMMA LAMBERT

ADvised BY: JAMES MWANGI
FREETOWN, SIERRA LEONE
MATERIAL SPECIFICATIONS

TIMBER TRADE ROUTES

[Map showing timber trade routes]

[Images of timber and timber processing]
GRAVITY ANALYSIS

RIGID FLOOR DIAPHRAGM
GRAVITY ANALYSIS

FLEXIBLE ROOF DIAPHRAGM
FLEXIBLE ROOF DIAPHRAGM TRUSS CONFIGURATION
SEISMIC & WIND DESIGN
CONFINED MASONRY CONSTRUCTION
LATERAL ANALYSIS

SHEAR WALL LOCATION AND DRAG LINES
ETABS MODEL

RIGID DIAPHRAGM

FLEXIBLE DIAPHRAGM

2ND FLOOR PLAN

ROOF PLAN
WORK CITED

RENDERINGS CREATED BY:
ANITA WESONGA

CONFINED MASONRY PHOTOS PROVIDED BY:

TIMBER PHOTOS AND TRADE MAPS PROVIDED BY:
THANK YOU!

ARCE DEPARTMENT:
  JAMES MWANGI

JOURNEYMAN INTERNATIONAL:
  SLAD TEAM
  DANIEL WIENS
  CARLY ALTOFF