CASE STUDY: EPOCH ESTATE WINE PRODUCTION FACILITY

A Senior Capstone Project by: Kevin C. Marx

Architectural Engineering Department
California Polytechnic State University, San Luis Obispo
June 2016
© 2016 Kevin Marx
Introduction:

The project will be a case study performed on Epoch Estate Wines Production Facility in Templeton California. The building is a cut and cover project which was designed to hug the existing oak trees on site. The building serves as a capstone to the Architectural Engineering curriculum because it seamlessly combines the four main structural building materials: steel, concrete, masonry and timber, while also including every lateral force resisting system into one succinct project. During the design of the project, meetings with the architecture of record and client representative occurred where discussion about design procedure and client’s needs took place. After these discussions, the calculation and drawing package were finalized and submitted to the architect and advisor. The packages were then returned to the student with proposed changes to the drawings and calculations in order to meet the needs of the architect of record and client. All changes were made and the project was re submitted to a standard of 75% Construction Documents phase.

The Project:

The project as stated above is a Wine Production Facility which consists of many different programmed spaces: Administration Building, Case Storage, Fermentation Room, Tank Room, Meeting Room, Barrel Aging Room and Barrel Vaulting Room. The Administration Building is used for logistics such as analyzing production, and
paperwork regarding finance. The Case Storage is used for storing finished bottles. Fermentation Room will be used for producing the wine while the Tank Room stores the equipment associated with producing wine. Above the Fermentation Room is a Meeting Room, which is used for meetings and conferences. Once the wine is made, it is forklifted down the ramp into the Barrel Aging Room or Barrel Vaulting Room which is where the wine is stored in barrels for the aging process. Project type is defined by the International Building Code 2015 as a F-2 Factory building class. The building is located in San Luis Obispo county, specifically on 7505 York Mountain Rd, Templeton, CA 93465.

The Architect and Client:

The architect is Brian Korte who worked for Lake Flato Architects at the time. Brian Korte designs a lot of high end residential buildings and is known for his exposure of structure. This exposure of structure results in a meticulous care for the detailing, which comes from a history of furniture design. The Client is Bill Armstrong, a Colorado native, who is CEO of Armstrong Oil and Gas Inc. He started out as a geologist who would locate oil reserves within the soil and then buy the property to develop it and take the oil out of it. The relationship between Brian Korte and Bill Armstrong started when Bill Armstrong had Lake Flato Architects design his house in Colorado which was handled by Brian Korte. Soon after, Bill Armstrong had Lake Flato Architects design his new headquarters for his company. Once Bill Armstrong wanted to convert his winemaking passion into a business, he turned to Brian Korte again to design the production facility. Bill Armstrong role in the project other than financing was his picking
of the site. Bill used his knowledge of geology to pick a good site specific to wine making.

The Site:

The site was originally an old school house from the late 1800’s for children who lived in the agricultural regions and could not commute to the cities. The schoolhouse was later converted into a winery which used the space known as the Case Storage, Fermentation Room and Tank Room. The existing winery was then demolished and set up for a newer winery project (Epoch Estate Wines). The project is located on the top of a hill which has a windy road leading up to the entrance. The project is cut and cover meaning that the Barrel Aging and Barrel Vaulting area is cut into the landscape and after construction the spaces are covered with about ten feet of dirt which was removed. The project footprint is designed to avoid the existing oak trees on site.

The Materials:

The materials of each programmed space were chosen on architectural and clientele factors. The Administration Building was chosen to be made out of timber with minor architectural finishes because it is light-weight construction which would adhere to the client’s wishes. The Case Storage building was chosen to be Vulcraft open web joists because it would be cheaper to run MEP systems through the joists, while the masonry bearing walls were selected in order to handle the impact loading which can result from sloppy forklift usage but is also gives good thermal resistance for keeping the wine bottles at a constant temperature. The Fermentation Room was chosen to be non structural masonry walls near the fermentation equipment because of corrosion
caused by the wine making. While the steel roof framing was chosen because of the long spans, constructability and cost advantage. The Tank Room and Meeting Room rely on either masonry or concrete walls, which are necessary because they are used as retaining walls. The concrete used for the Barrel Aging and Barrel Vaulting Rooms are chosen because of the thermal efficiency. Wine should be kept a constant temperature and thus the concrete is adequate for keeping the thermal mass of the room constant, while also resisting the out of plane loading. The framing at the roof was chosen to be concrete because the loading at the roof is large because of the high soil loading and large live load which results from it being a cut and cover project.

The Design Challenges:

The Administration Building was timber framing with timber stud walls. The framing that was chosen was engineered lumber, Truss Joist TJI primary framing and Truss Joist LVL as rim joists and headers. This was chosen because the engineered lumber is generally cheaper than sawn lumber. The rim joists and headers are also engineered lumber to keep the ceiling heights consistent. While the TJI Framing was chosen to allow easier calculations for the holes due to MEP systems. All the primary framing was designed for loading due to wind from Chapter 30 of ASCE 7-10 (Components and Cladding). The building was governed by wind and primary lateral force resisting system was timber stud walls which uses plywood sheathing to handle the shear loading.

The Fermentation Room design was dictated by site and architectural conditions. The details at the Fermentation Room were chosen as stacked framing to limit shear tabs and because the extra cost due to ceiling height increase was not crippling to the
owner. Also the windy road would limit the size of girder members which could be hauled out to site. Although splices could have been an option to allow bigger girders, but with an exposed structure, the architect did not want to have any unnecessary shear tabs to splice the girder. For the lateral system in the East-West direction, the architect did not want to have large H.S.S. and instead requested to use small cable in an “X” orientation detailed as Ordinary Steel Concentric Braced Frames. Similarly to the gravity constraints, the detailing of the Ordinary Steel Moment Frames in the North-South direction were detailed to have minor shear tabs exposed.

The Barrel Aging Room used a one way N.W. reinforced concrete slab poured continuously with N.W. reinforced concrete beams which would frame into either a reinforced concrete column, spiral or wall. Because the programmed space was part of the cut and cover construction, the shear reinforcement on the beams would need to be extensive because of the large loading of the soil, 100 psf yards and terraces live load and the design for fire truck loading because the loading above was near the oak trees which the site was excavated around. The walls and beam depth would also be limited because of the owner and architectural constraints, which would become troublesome because of the large loading on the gravity members and the out of plane loading acting on the reinforced concrete walls.

The Coordination Challenges:

Once the building was designed and detailed, the project was reviewed by the architect and the advisor. Soon after, the calculation and drawing packages were sent back with proposed changes. Changes not stated above included: narrower column spacing at fermentation room, decreasing depth of the barrel aging room beams,
changing the interior mechanical unit walls from concrete to masonry, changing the connections at fermentation room to stacked framing to eliminate shear tabs, downsizing the column depths of the fermentation room moment frames which resulted in a downsizing of the girders and joists to match constructibility and the changing the Truss Joist TJIs in the case storage to Vulcraft open web joists. Once the proposed changes were presented to the engineering student, a strict deadline was set by the client (advisor). After all the proposed changes were followed through with, the calculation and drawing packages were updated and submitted to a “plan checking” phase. After submitting, the drawings and calculations were returned back because they were not consistent with the existing footing which exists in the Fermentation Room. The drawings and calculations were updated and finally re submitted for the final approval phase.

The Experience:

On top of being a capstone to the Architectural Engineering curriculum, the project had a lot of positive experience. The project forwarded the ability to build Engineer to Client/Architect relationships. This was important because no class within the Architectural Engineering helps build architecture or clientele relationships, which is arguably the most important aspect of the structural engineering discipline. The project also allowed the engineer to visit the site during occupancy which would be extremely beneficial to understanding the programming of the space. In comparison to every design lab, most of the buildings are office buildings in the Architectural Engineering curriculum, and it was worthwhile to visit the project to understand the winemaking process. The most important experience from the project was the task of working on
multiple projects at the same time. The daily agenda of a structural engineer involves multiple projects which could force you to change projects as soon as the phone rings. So this project, and the project from my ARCE 452 class would give strict deadlines which were independent of each other. Although this could make some weeks rougher than others, it also provided great preparations for daily agenda of a structural engineer.
GENERAL NOTES

1. THE FOLLOWING NOTES, TYPICAL DETAILS AND SHADOWSTUDY DRAWINGS MAY NOT APPLY TO THE PROJECT UNLESS OTHERWISE SHOWN ON THE CONTRACT DOCUMENTS.

2. THE CONTRACTOR'S PERFORMANCE. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

3. ALL MATERIALS AND BRAZING OF ALL METAL WORK TO MEET THE REQUIREMENTS OF LOCAL CODES AND NATIONAL CODES (AS REQU...}

SHOP DRAWING AND CONTRACTOR SUBMITTAL REVIEW

1. SHOP DRAWINGS OR CONTRACTOR SUBMITTALS PRESENTED FOR REVIEW AND APPROVAL, SUCH AS DETAILS FOR WOOD FRAME CONSTRUCTION, ARE NOT TO INCLUDE INSTRUCTIONS, DRAWINGS, SPECIFICATIONS, TECHNIQUES OR METHODS, ANY SUPPORT SERVICES PERFORMED BY ARCHITECT OR ENGINEER DURING ANY PHASE OF CONSTRUCTION, SHALL BE DESTROYED OR REMOVED FROM THE JOB SITE PRIOR TO THE INSPECTION REPORTS. THE CONTRACTOR SHALL PROVIDE TEMPORARY SHORING AND BRACING PRIOR TO BACKFILLING AND COMPACTION.

2. ALL FOUNDATION EXCAVATIONS SHALL BE CARRIED TO REQUIRED DEPTHS, NAVIGATE THROUGH THE STRUCTURAL INTEGRITY OF THE EXISTING FOUNDATION. THESE "CONTRACT OR CONSTRUCTION DOCUMENTS" AND SHALL BE OF THE SAME CHARACTER AS FOR SIMILAR OPERATION IS COMPLETE.

3. WHERE ANY CONFLICT OCCURS BETWEEN THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

4. ARCHITECT OR ENGINEER OF ANY DISCREPANCIES BETWEEN THE ACTUAL SITE CONDITIONS AND INFORMATION SHOWN ON OR IN THE "CONTRACT OR CONSTRUCTION DOCUMENTS" AND SHALL NOT BE CONSIDERED AS SUPPLEMENT TO CONTRACT DOCUMENTS.

5. PROVIDE OPENINGS AND SUPPORTS AS REQUIRED. TYPICAL DETAILS AND NOTES FOR MACHINERY, PLUMBING AND ELECTRICAL EQUIPMENT, HEAT, DUCTS, PIPING, ETC. ALL MECHANICAL, PLUMBING AND ELECTRICAL EQUIPMENT SHALL BE PROPERTY SHIPPED AND RASIED AGAINST LATERAL FORCES.

6. REFER TO ARCHITECTURAL DRAWINGS TO COORDINATE WITH STRUCTURAL DRAWINGS. ANY GENERIC DRAWING THAT IS TO BE COORDINATED OR CLARIFIED BEFORE START OF CONSTRUCTION.

7. SHOP DRAWINGS OR CONTRACTOR SUBMITTALS PRESENTED FOR REVIEW AND APPROVAL, SUCH AS DETAILS FOR WOOD FRAME CONSTRUCTION, ARE NOT TO INCLUDE INSTRUCTIONS, DRAWINGS, SPECIFICATIONS, TECHNIQUES OR METHODS, ANY SUPPORT SERVICES PERFORMED BY ARCHITECT OR ENGINEER DURING ANY PHASE OF CONSTRUCTION, SHALL BE DESTROYED OR REMOVED FROM THE JOB SITE PRIOR TO THE INSPECTION REPORTS. THE CONTRACTOR SHALL PROVIDE TEMPORARY SHORING AND BRACING PRIOR TO BACKFILLING AND COMPACTION.

8. THE CONTRACTOR SHALL PROVIDE TEMPORARY SHORING AND BRACING PRIOR TO BACKFILLING AND COMPACTION.

9. PROVIDE SUPPORT AND BRACING AS REQUIRED. TYPICAL DETAILS AND NOTES FOR MACHINERY, PLUMBING AND ELECTRICAL EQUIPMENT, HEAT, DUCTS, PIPING, ETC. ALL MECHANICAL, PLUMBING AND ELECTRICAL EQUIPMENT SHALL BE PROPERTY SHIPPED AND RASIED AGAINST LATERAL FORCES.

10. REFER TO ARCHITECTURAL DRAWINGS TO COORDINATE WITH STRUCTURAL DRAWINGS. ANY GENERIC DRAWING THAT IS TO BE COORDINATED OR CLARIFIED BEFORE START OF CONSTRUCTION.

11. THE ARCHITECT TO PROVIDE A COPY OF PROJECT SPECIFICATIONS FOR THE CONTRACTOR AND CONSTRUCTION MANAGER TO REVIEW THE CONTRACT DOCUMENTS.

12. THE CONTRACTOR IS RESPONSIBLE FOR ADEQUATE DESIGN AND CONSTRUCTION OF ALL FORMS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL WORK NOT INCLUDED IN THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

13. ALL FOUNDATION EXCAVATIONS SHALL BE CARRIED TO REQUIRED DEPTHS, NAVIGATE THROUGH THE STRUCTURAL INTEGRITY OF THE EXISTING FOUNDATION. THESE "CONTRACT OR CONSTRUCTION DOCUMENTS" AND SHALL BE OF THE SAME CHARACTER AS FOR SIMILAR OPERATION IS COMPLETE.

14. BACKFILLING AND COMPACTION MAY BE PERFORMED IN COMPLIANCE WITH LOCAL CODES AND REGULATIONS, THE MOST STRINGENT SHALL APPLY TO THE CONTRACTOR.

15. THE CONTRACTOR SHALL HAVE A COPY OF THE CBC ON HIS CONSTRUCTION FACILITY SITE FOR REFERENCE.

16. ADDITIONAL ADEQUATE CONSTRUCTION INFORMATION SHOWN ON THE WORK IS OBSOLETE AND ARE NOT PERMITTED ON THE JOB SITE.

17. THE CONTRACTOR SHALL PROVIDE TEMPORARY SHORING AND BRACING PRIOR TO BACKFILLING AND COMPACTION.

18. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

19. ALL MATERIALS AND WORKSHOPS SHALL MEET THE REQUIREMENTS OF LOCAL CODES AND NATIONAL CODES (AS REQUIRED). THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

20. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

21. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

22. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

23. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

24. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

25. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

26. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

27. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

28. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

29. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

30. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

31. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

32. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

33. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

34. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

35. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

36. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

37. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

38. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

39. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

40. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

41. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

42. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

43. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

44. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

45. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

46. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

47. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

48. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

49. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

50. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

51. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

52. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

53. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

54. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

55. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

56. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

57. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

58. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

59. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

60. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

61. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.

62. THE CONTRACTOR SHALL REFER TO THE CONTRACT DOCUMENTS FOR INFORMATION NOT COVERED ON THIS SHEET OR SHOWING CONFORMANCE WITH THE CONTRACT DOCUMENTS.
ALL CONCRETE SHALL HAVE A MINIMUM TOTAL U.S. CONCRETE PRESSURE (PR) OF 3,000 P.S.I. AT 28 DAYS. ALL CONCRETE SHALL BE PLACED BEHIND "P" 3/4" - 1/2" EXPOSED TO EARTH OR WEATHER: 1-1/2".

2. ALL CONCRETE SHALL BE CLEAN OF RUST, STAGGER SPLICES IN REINFORCING STEEL, UNLESS SPECIFICALLY DETAILED OR NOTED OTHERWISE.

3. EPOXY-COATED REINFORCEMENT (WHERE SPECIFICALLY NOTED OR DETAILED) SHALL BE SECURED TO THE REINFORCING STEEL IN ACCORDANCE WITH TMS 602-08/ACI 530.1-08/ASCE 6-08.

5. ALL REINFORCEMENT SHALL BE IN PLACE PRIOR TO POURING OF CONCRETE.

7. STAGGER SPACES IN REINFORCING STEEL, UNLESS SPECIFICALLY NOTED OR DETAILED.

9. ALL REINFORCING BARS前に登録され、この文は以下に続く。

A. CONCRETE MASONRY UNITS.

B. CONCRETE MASONRY UNITS.

C. CONCRETE MASONRY UNITS.

D. CONCRETE MASONRY UNITS.

E. CONCRETE MASONRY UNITS.

F. CONCRETE MASONRY UNITS.

G. CONCRETE MASONRY UNITS.

H. CONCRETE MASONRY UNITS.

I. CONCRETE MASONRY UNITS.

J. CONCRETE MASONRY UNITS.

K. CONCRETE MASONRY UNITS.

L. CONCRETE MASONRY UNITS.

M. CONCRETE MASONRY UNITS.

N. CONCRETE MASONRY UNITS.

O. CONCRETE MASONRY UNITS.

P. CONCRETE MASONRY UNITS.

Q. CONCRETE MASONRY UNITS.

R. CONCRETE MASONRY UNITS.

S. CONCRETE MASONRY UNITS.

T. CONCRETE MASONRY UNITS.

U. CONCRETE MASONRY UNITS.

V. CONCRETE MASONRY UNITS.

W. CONCRETE MASONRY UNITS.

X. CONCRETE MASONRY UNITS.

Y. CONCRETE MASONRY UNITS.

Z. CONCRETE MASONRY UNITS.
6. NO FIELD WELDING PERMITTED, UNLESS SPECIFICALLY NOTED OTHERWISE.

7. WHERE WOOD STUDS ARE BEARING AT INTERIOR PARTITIONS OR BEARING WALLS: #2 OR BETTER

8. PLATES SHALL BE STAINLESS STEEL, SILICON BRONZE, COPPER-OXIDE OR 3" MINIMUM HOT DIP GALVANIZED STEEL.

9. STEEL DECKING SHALL BE COLD ROLLED STEEL.

10. STEEL DECKING SHALL BE PLACED ON THE SUPPORTING STRUCTURAL SHEET STEEL AND GIRDERS MANUFACTURER. STEEL DECKING SHALL BE PAINTED ONE COAT OF ZINC-COATED FASTENERS SHALL BE PROVIDED CONTINUOUS DOUBLE 2x WALL WIDTH (2x4, 2x6). FOUNDATION SILL PLATES SHALL BE CALIFORNIA WELDER QUALIFICATION REQUIREMENTS. WELDING SHALL COMPLY WITH CURRENT 'AWS D1.1 AND 05/01/16 STRUCTURAL STEEL EMBEDDED INTO CONCRETE OR NAILING FOR FRAMING SHALL BE WITH 'COMMON TRACKS.'

11. BUILDING PRODUCTS, USA, INC. TYPE B-36, OR APPROVED EQUAL.

12. A. APPROPRIATE MASONRY SHALL BE UNPAINTED.

13. CEG REVISION 05/17/16

14. STEEL DECK SHALL BE WELDED TO THE SUPPORTS WITH BLOCK OF SAME MATERIAL AND MEMBER TYPE:

15. BASE METAL THICKNESS IN MILLIS:

16. FROM THE TOP OF THE SUPPORTING STRUCTURAL SHEET STEEL AND GIRDERS MANUFACTURER. STEEL DECKING SHALL BE PAINTED ONE COAT OF ZINC-COATED FASTENERS SHALL BE PROVIDED CONTINUOUS DOUBLE 2x WALL WIDTH (2x4, 2x6). FOUNDATION SILL PLATES SHALL BE CALIFORNIA WELDER QUALIFICATION REQUIREMENTS. WELDING SHALL COMPLY WITH CURRENT 'AWS D1.1 AND 05/01/16 STRUCTURAL STEEL EMBEDDED INTO CONCRETE OR NAILING FOR FRAMING SHALL BE WITH 'COMMON TRACKS.'

17. BUILDING PRODUCTS, USA, INC. TYPE B-36, OR APPROVED EQUAL.
17. FRAMING AROUND FLUES AND CHIMNEYS SHALL CONFORM TO CBC SECTION 2308.8

18. PIPES IN WALLS SHALL CONFORM TO CBC SECTION 2308.8

2. PRE-FABRICATED COMPOSITE LUMBER AND TRUSSES

1. ALL STRUCTURAL COMPOSITE LUMBER OR TIMBER SHALL BE OF THE FOLLOWING:

A. STANDARD LAMINATED VENEER LUMBER (LVL) MATERIAL SHALL CONFORM TO ASTM D2047:

   - Fb = 2,600 P.S.I.
   - Fv = 285 P.S.I.
   - E = 1,550,000 P.S.I.

2. STANDARD LVL MATERIAL SHALL BE REDMARK LABRABE LUMBER AS MANUFACTURED BY REDMARK (ICC ESR-2993).

3. BEAMS SHALL BE END SEALED AGAINST THE ELEMENTS/WEATHER AND LOAD WRAFED FOR PROTECTION DURING SHIPMENT.

4. BEAMS SHALL HAVE STANDARD CAMBER UNLESS SPECIFICALLY CALLED OUT OTHERWISE ON DRAWINGS.

5. BEAMS SHALL NOT BE NOTCHED OR HAVE HOLES DRILLED THROUGH UNLESS SPECIFICALLY NOTED OTHERWISE.

6. ALL PRE-FABRICATED WOOD TRUSSES (I-JOISTS) SHALL CONFORM TO ASTM D5456:

A. PLYWOOD WEB TRUSSES SHALL BE INSTALLED AS MANUFACTURED WITHOUT ALTERING THE SPACING OF THE TRUSSES.

B. ALL BEARING POINTS.

7. EACH TRUSS SHALL BE LEGIBLY BRANDED, MARKED OR OTHERWISE PERMANENTLY ATTACHED TO THE FOLLOWING:

A. THE TRUSS MANUFACTURER'S TRADEMARK.

B. THE IDENTIFICATION OF THE COMPANY MANUFACTURING THE TRUSS.

C. THE NAME OF THE COMPANIES.

8. TRUSSES SHALL BE INSTALLED WITH ALL BEARING PLATES OR BEVELED BEARING PLATES AS PER MANUFACTURER'S RECOMMENDATIONS AND THESE DRAWINGS. THE PRECEDING ITEMS SHALL BE INSTALLED PRIOR TO ANY TRUSS LOADS.

9. TRUSSES SHALL BE INSTALLED WITH ALL BEARING POINTS.

10. INTERIOR NON-BEARING WALLS SHALL BE ISOLATED FROM VERTICAL TRUSS LOADS. TRUSSES SHALL BE BLOCKED AS PER MANUFACTURER'S RECOMMENDATIONS IN ADDITION TO:

A. ALL BEARING POINTS.

B. RIDGE.

C. THE SPACING OF THE TRUSSES.

11. TRUSSES SHALL BE INSTALLED WITH ALL BEARING HARDWARE, BRIDGING, BRACING, PRE-NOTCHED BEARING PLATES OR BEVELED BEARING PLATES AS PER MANUFACTURER'S RECOMMENDATIONS AND THESE DRAWINGS. THE PRECEDING ITEMS SHALL BE INSTALLED PRIOR TO ANY TRUSS LOADING.

12. TRUSSES SHALL BE INSTALLED WITH ALL BEARING HARDWARE, BRIDGING, BRACING, PRE-NOTCHED BEARING PLATES OR BEVELED BEARING PLATES AS PER MANUFACTURER'S RECOMMENDATIONS AND THESE DRAWINGS. THE PRECEDING ITEMS SHALL BE INSTALLED PRIOR TO ANY TRUSS LOADING.

13. BEAMS SHALL BE END SEALED AGAINST THE ELEMENTS/WEATHER AND LOAD WRAFED FOR PROTECTION DURING SHIPMENT.

14. TEMPORARY CONSTRUCTION LOADS SHALL NOT BE PLACED ON TRUSSES UNTIL TRUSSES ARE SECURED AND ALL ERECTION HARDWARE, BRIDGING, BRACING, BEARING HARDWARE, ETC. HAS BEEN PLACED. TEMPORARY CONSTRUCTION LOADS SHALL NOT EXCEED ROOF LIVE LOAD.

15. IF ERECTION BRACING IS SPECIFIED, THEN BRACING SHOWN ON THESE DRAWINGS IS REQUIRED. TRUSSES SHALL NOT BE STORED UNLESS SPECIFICALLY NOTED.

16. MAXIMUM MOISTURE CONTENT FOR ALL LUMBER MATERIAL SHALL BE MAINTAINED WHEN MEMBER DEPTH IS ALTERED.

17. GRAVITY LOADING:

A. LIVE LOAD:

   - DL (ADMIN): 19 PSF
   - DL (FERMENTATION ROOM): 20 PSF
   - DL (BARREL AGING): 890 PSF
   - LL (BARREL AGING): 100 PSF
   - RLL (ADMIN) : 20 PSF
   - RLL (CASE STORAGE) : 20 PSF
   - RLL (FERMENTATION ROOM) : 20 PSF
   - R = 3.25
   - CS = 0.245

B. GRAVITY LOAD:

   - Fb = 2,900 P.S.I.
   - Fc (PERPENDICULAR) = 750 P.S.I.
   - Fv = 285 P.S.I.

18. WIND LOADING:

A. BASIC WIND SPEED: 85 MPH

B. PRESSURE COEFFICIENT: -0.18

C. Pressures for Component and Cladding: 45 PSI

19. EARTHQUAKE LOADING:

A. WIND IMPORTANCE FACTOR: 1.0

B. WIND EXPOSURE: C

C. PRESSURE FOR COMPONENT AND CLADDING: 16 PSI

20. SEISMIC LOADING:

A. GRAVITY LOADING:

   - DL (ADMIN): 19 PSF
   - DL (FERMENTATION ROOM): 20 PSF
   - DL (BARREL AGING): 890 PSF
   - LL (BARREL AGING): 100 PSF
   - R = 3.25
   - CS = 0.245

B. GRAVITY LOAD:

   - Fb = 2,900 P.S.I.
   - Fc (PERPENDICULAR) = 750 P.S.I.
   - Fv = 285 P.S.I.

21. MAXIMUM MOISTURE CONTENT FOR ALL LUMBER MATERIAL SHALL BE MAINTAINED WHEN MEMBER DEPTH IS ALTERED.

22. GRAVITY LOADING:

A. LIVE LOAD:

   - DL (ADMIN): 19 PSF
   - DL (FERMENTATION ROOM): 20 PSF
   - DL (BARREL AGING): 890 PSF
   - LL (BARREL AGING): 100 PSF
   - R = 3.25
   - CS = 0.245

B. GRAVITY LOAD:

   - Fb = 2,900 P.S.I.
   - Fc (PERPENDICULAR) = 750 P.S.I.
   - Fv = 285 P.S.I.

23. WIND LOADING:

A. BASIC WIND SPEED: 85 MPH

B. PRESSURE COEFFICIENT: -0.18

C. Pressures for Component and Cladding: 45 PSI

24. EARTHQUAKE LOADING:

A. GRAVITY LOADING:

   - DL (ADMIN): 19 PSF
   - DL (FERMENTATION ROOM): 20 PSF
   - DL (BARREL AGING): 890 PSF
   - LL (BARREL AGING): 100 PSF
   - R = 3.25
   - CS = 0.245

B. GRAVITY LOAD:

   - Fb = 2,900 P.S.I.
   - Fc (PERPENDICULAR) = 750 P.S.I.
   - Fv = 285 P.S.I.
CONCRETE TYP. STEP IN SLAB

CONCRETE TYP. REBAR BEND

CONCRETE STEP TO SLAB ON GRADE

CONCRETE TYP. REBAR BEND

ENGINEERING FILL

CONCRETE TYP. REBAR BEND

ENGINEERING FILL

NOTES:
1. 1500 PSI LEAN-MIX CONCRETE FILL TO BE PLACED BEFORE FTG
2. STEP FTG DOWN TO MAINTAIN PIPE IN MIDDLE 1/3 OF TOTAL DEPTH OF FOOTING
3. STEP FTG IF PIPE OCCURS IN LOWER THIRD OF ORGINAL FTG
4. NO PIPES SHALL BE PLACED BELOW SPREAD FTGS OR WITHIN 2 TO 1 BEARING ZONE AROUND SPREAD FTG
5. IF PIPE IS IN PLACE PRIOR TO CASTING CONCRETE WRAP PIPE W/ 1" STYRO-FOAM INSULATION IN LIEU OF SLEEVE
6. PIPES OR CONDUITS ARE NOT ALLOWED PARALLEL IN FOOTING
1. General Typical Notes: See General Structural Notes
   A. Concrete footings and slabs on grade shall be 3,000 psi compressive strength at 28 days
   B. Concrete for building walls, retaining walls and columns shall be 4,000 psi compressive strength at 28 days
   C. See Architectural Drawings for all embedded items and non-structural components associated with concrete work
   D. See typical concrete details

2. 6" Slab on grade w/ #4 bars @ 16" c.c.
   A. See concrete details for typical slab section

3. 4" Exterior concrete slab on grade w/ #3 bars @ 16" c.c. each way
   A. See concrete details for typical slab section

4. Ramp up at 10%

5. Slope up at 1/4" per foot

6. 1" Thick concrete building wall, Typical at Barrel Aging Room
   A. Reinforcement per reinforcement schedule

7. 1" Thick concrete building wall, Typical at Barrel Vaulting Room
   A. Reinforcement per reinforcement schedule

8. 6" Slab on grade masonry interior building wall
   A. #4 bars @ 16" c.c. vertical (u.n.o.) located at center of wall. #4 bars @ 16" c.c. horizontal
   B. See architectural for openings
   C. See structural details for masonry corners

9. 1" Clay concrete spiral centered below concrete beams
   A. Reinforcement per reinforcement schedule

10. 1" Square concrete column centered below concrete beam
    A. Reinforcement per reinforcement schedule

11. 11' Square shallow concrete isolated footing @ 32" deep
    A. (10) #8's Both ways

12. 11' Square shallow concrete isolated footing @ 40" deep
    A. (14) #9's Both ways

13. 8" Solid grouted masonry interior building wall
    A. #5 bars @ 16" c.c. vertical (U.N.O.) located at center of wall. #4 bars @ 16" c.c. horizontal
    B. See architectural for openings
    C. See structural details for masonry corners

14. 18" dia. concrete spiral centered below concrete beam
    A. Reinforcement per reinforcement schedule

15. 18" Square concrete isolated footing @ 32" deep
    A. Reinforcement per reinforcement schedule

16. 18" Square concrete isolated footing @ 40" deep
    A. Reinforcement per reinforcement schedule

17. 18" Sq. rectangular concrete column centered below concrete beam
    A. Reinforcement per reinforcement schedule

18. 11' Square shallow concrete isolated footing @ 32" deep
    A. (10) #8's Both ways

19. 11' Square shallow concrete isolated footing @ 40" deep
    A. (14) #9's Both ways

20. 5" Continuous concrete shear wall footing @ 24" deep
    A. (3) #6's per longitudinal foot
    B. (5) #7's as temp. steel

21. 4" Continuous concrete shear wall footing @ 18" deep
    A. (3) #6's per longitudinal foot
    B. (4) #6's as temp. steel

GENERAL FOUNDATION NOTES

1. The foundation design is based on the minimum requirements outlined in the Project Geotechnical Engineering Report prepared by Geotechnical Engineers Inc.

2. Prior to the Contractor requesting a Building Department Foundation Inspection, the Soils Engineer shall advise the Building Official in writing that:
   a. The building pad was prepared in accordance with the Soils Engineer's recommendations
   b. The utility trenches have been properly backfilled and compacted
   c. The foundation excavations comply with the Soils Engineer's recommendations
   d. The soil expansion index is verified in field

3. Hold downs, anchor bolts, tie down anchors, foundation straps, etc. shall be in place held by templates or wire ties, prior to concrete inspection

4. All fasteners and anchor bolts into preservative-treated and fire retardant treated wood that are highly corrosive, shall be hot dipped into coated galvanized, stainless steel, silicon bronze. Standard galvanized connectors (G60) may be used for low corrosive still plate materials
1. General Typical Notes: See General Structural Notes
   A. Concrete footings and slabs on grade shall be 3,000 psi compressive strength at 28 days
   B. See Architectural Drawings for all embedded items and non-structural components
   C. See typical concrete details

2. Existing slab on grade will remain the same

3. New 12" Sq. Concrete Pilaster below W12x106 Steel Column

4. Shearwall Schedule Notes
   A. Common type nails
   B. Fasteners in pressure-treated lumber shall be stainless steel, silicon bronze, copper or hot dip zinc coated galvanized steel fasteners
   C. Zinc-coated fasteners shall conform to A.S.T.M. A153

5. Simpson HD type holdown to wood post at end of each shear wall

6. S-CAM solid ground wall at Case Storage

7. C-CAM solid ground wall at Tank Room

8. Continue sheathing and nailing over side of post at end of shearwall

9. #4 bars @ 16" c.c. horizontal (U.N.O.) located at center of wall. #5 bars @ 16" c.c. vertical

10. Stagger nailing at sill/bottom plate

11. Continue sheathing and nailing over side of header or beam directly above shearwall

12. No penetrations allowed in shearwalls unless specifically detailed

13. HSS 46x4xS A360 Gr. B steel column at Tank Room

14. 14" Sq. Concrete Plaster below W12x106 Steel Column

15. W12 x 106 A360 Steel Column

16. 4' Sq. x 12" deep shelf-reinforced concrete footing

17. Special inspection is required

18. Concrete footings and slabs on grade shall be 3,000 psi compressive strength at 28 days

19. See Architectural Drawings for all embedded items and non-structural components

20. HSS 4x4x1/8 A500 Gr. B steel column at Tank Room

21. Special inspection is required

22. Concrete footings and slabs on grade shall be 3,000 psi compressive strength at 28 days
1. General Typical Notes: See General Structural Notes
   A. Concrete for building walls, retaining walls and columns shall be 4000 psi compressive strength at 28 days.
   B. See Architectural Drawings for all embedded items and non-structural components associated with concrete work.
   C. See typical concrete details.

2. 12" Thick slab with #6's at 6" c.c. at top and #7's at 12" c.c. at bottom and #4's at 10" c.c. as temp. steel.

3. 12" Thick slab with #7's at 9" c.c. at top and #9's at 9" c.c. at bottom and #4's at 10" c.c. as temp. steel.

4. 18" Thick concrete building wall. Typical at Barrel Aging Room.
   A. Reinforcement per reinforcement schedule.

5. 12" Thick concrete building wall. Typical at Barrel Vaulting Room.
   A. Reinforcement per reinforcement schedule.

6. 8" Solid grouted masonry interior building wall
   A. #5 bars @ 16" c.c. vertical (U.N.O.) located at center of wall. #4 bars @ 16" c.c. horizontal.
   B. See architectural for openings.
   C. See structural details for masonry corners.

7. 36" x 18" Conc. Beam with (5) #8's at bottom and (3) #10's at top.
   A. Check concrete details for reinforcement details.

8. 18" Dia. concrete spiral centered below concrete beam.
   A. Reinforcement per reinforcement schedule.

9. 18" Sq. rectangular concrete column centered below concrete beam.
   A. Reinforcement per reinforcement schedule.
FLOOR FRAMING PLAN REFERENCE NOTES

1. General Typical Notes: See General Structural Notes
   A. Refer to Architectural Floor Plans for non-structural walls, soffits, eave details and misc.
      non-structural details and requirements

2. Roof Sheathing: 5/8" Structural 1 Plywood
   A. Panel Index 32/16
   B. Glued and Nailed with 8d @ 4:6:12 c.c.
   C. Lay with face grain perpendicular to grain
   D. Stagger Sheets

3. Roof Sheathing: 5/8" Structural 1 Plywood
   A. Panel Index 32/16
   B. Glued and Nailed with 8d @ 6:6:12 c.c.
   C. Lay with face grain perpendicular to grain
   D. Stagger Sheets

4. 2x Stud bearing wall
   A. 2x6 DF No. 2 Studs at 16" c.c.
   B. 5-1/4 x 14 TJ LVL as header
   C. Balloon frame walls at all vaulted areas or sloped roof areas

5. Existing masonry wall will remain the same

6. Existing CMU to be removed

7. 8" Solid-grooved masonry wall at Case Storage
   A. Special inspection is required
   B. #4 bars @ 16" c.c. horizontal (U.N.O.) located at center of wall. #5 bars @ 16" c.c. vertical

8. 8" Solid-grooved masonry wall at Fermentation Room
   A. Special inspection is required
   B. #4 bars @ 16" c.c. horizontal (U.N.O.) located at center of wall. #5 bars @ 16" c.c. vertical

9. 8" CMU solid-grooved masonry wall at Fermentation Room
   A. Special inspection is required
   B. #4 bars @ 16" c.c. horizontal (U.N.O.) located at center of wall. #5 bars @ 16" c.c. vertical

10. 10" Redbuilt Red-145 Joists at 24" c.c.
    A. Provide Simpson ITS Type hanger at suspended conditions

11. 11.875" Redbuilt Red-145 Joists at 24" c.c.
    A. Provide Simpson ITS Type hanger at suspended conditions

12. Verso-B-Deck at exposed areas

13. W12x106 A992 steel column

14. 6" W3 Verso Formlok, 6" total depth concrete fill

15. B Verso Formlok 4" total depth concrete fill

16. HSS 6x4x1/8 A992 Gr. B steel column

17. 2" 3x3x3/8 AS16 steel outrigger

18. HSS 12x4x1/2 A992 Gr. B steel beam

19. W12x106 A992 steel column

20. W3 Verco Formlok, 6" total depth concrete fill

21. B Verso Formlok 4" total depth concrete fill

22. HSS 6x4x1/8 A992 Gr. B steel column

23. 2" 3x3x3/8 AS16 steel outrigger

24. HSS 12x4x1/2 A992 Gr. B steel beam

25. W12x106 A992 steel column

26. W3 Verco Formlok, 6" total depth concrete fill

27. B Verso Formlok 4" total depth concrete fill

28. HSS 6x4x1/8 A992 Gr. B steel column

29. 2" 3x3x3/8 AS16 steel outrigger

30. HSS 12x4x1/2 A992 Gr. B steel beam

31. W12x106 A992 steel column

32. W3 Verco Formlok, 6" total depth concrete fill

33. B Verso Formlok 4" total depth concrete fill

34. HSS 6x4x1/8 A992 Gr. B steel column

35. 2" 3x3x3/8 AS16 steel outrigger

36. HSS 12x4x1/2 A992 Gr. B steel beam

37. W12x106 A992 steel column

38. W3 Verco Formlok, 6" total depth concrete fill

39. B Verso Formlok 4" total depth concrete fill

40. HSS 6x4x1/8 A992 Gr. B steel column

41. 2" 3x3x3/8 AS16 steel outrigger

42. HSS 12x4x1/2 A992 Gr. B steel beam

43. W12x106 A992 steel column

44. W3 Verco Formlok, 6" total depth concrete fill

45. B Verso Formlok 4" total depth concrete fill

46. HSS 6x4x1/8 A992 Gr. B steel column

47. 2" 3x3x3/8 AS16 steel outrigger

48. HSS 12x4x1/2 A992 Gr. B steel beam

49. W12x106 A992 steel column

50. W3 Verco Formlok, 6" total depth concrete fill

51. B Verso Formlok 4" total depth concrete fill

52. HSS 6x4x1/8 A992 Gr. B steel column

53. 2" 3x3x3/8 AS16 steel outrigger

54. HSS 12x4x1/2 A992 Gr. B steel beam

55. W12x106 A992 steel column

56. W3 Verco Formlok, 6" total depth concrete fill

57. B Verso Formlok 4" total depth concrete fill

58. HSS 6x4x1/8 A992 Gr. B steel column

59. 2" 3x3x3/8 AS16 steel outrigger

60. HSS 12x4x1/2 A992 Gr. B steel beam

61. W12x106 A992 steel column

62. W3 Verco Formlok, 6" total depth concrete fill

63. B Verso Formlok 4" total depth concrete fill

64. HSS 6x4x1/8 A992 Gr. B steel column

65. 2" 3x3x3/8 AS16 steel outrigger

66. HSS 12x4x1/2 A992 Gr. B steel beam

67. W12x106 A992 steel column

68. W3 Verco Formlok, 6" total depth concrete fill

69. B Verso Formlok 4" total depth concrete fill

70. HSS 6x4x1/8 A992 Gr. B steel column

71. 2" 3x3x3/8 AS16 steel outrigger

72. HSS 12x4x1/2 A992 Gr. B steel beam

73. W12x106 A992 steel column

74. W3 Verco Formlok, 6" total depth concrete fill

75. B Verso Formlok 4" total depth concrete fill

76. HSS 6x4x1/8 A992 Gr. B steel column

77. 2" 3x3x3/8 AS16 steel outrigger

78. HSS 12x4x1/2 A992 Gr. B steel beam

79. W12x106 A992 steel column

80. W3 Verco Formlok, 6" total depth concrete fill

81. B Verso Formlok 4" total depth concrete fill

82. HSS 6x4x1/8 A992 Gr. B steel column

83. 2" 3x3x3/8 AS16 steel outrigger

84. HSS 12x4x1/2 A992 Gr. B steel beam
NOTES:
1. SEE FRAMING/Foundation PLAN AND NOTES

8) NO. 8 LONG. REINFORCEMENT
NO. 3'S AT 24" C.C.
1 1/2" CLR.

NOTES:
1. TYPICAL AT BARREL AGING ROOM

L/W (24" min.)
3" CLR

FOOTING REINFORCEMENT PER PLAN

BEAM PER PLAN

INTERIOR CMU WALL

FOOTING DIMENSIONS PER PLAN

KEY FROM BEV 2x6 PLATE

INTERIOR CMU WALL

INTERIOR CMU WALL TO FOOTING

CONCRETE SPiral SECTION

CONCRETE SHEAR WALL PLAN

CONCRETE WALL TO FOOTING

SLAB ON GRADE

#4 DOWELS AT 16" c.c.

KEY FROM BEV 2x6 PLATE

INTERIOR CMU WALL

INTERIOR CMU WALL TO FOOTING
OFFSET RODS OUT OF PLANE TO AVOID CONFLICT OF CROSSING RODS

WIDE FLANGE STEEL BEAM

GIRDER PER PLAN

ROOF DECKING PER PLAN

BEAM PER PLAN

A035-0875 HIGH STRENGTH TRI PYRAMID ROD:
DIA: 0.875"

2x2x1/4 A500 Gr. B HSS STEEL BEAM

SCALE:

DATE:

"CHECKED" BY:

DRAWN BY:

SHEET NUMBER:

SHEET NAME:

PROJECT NAME:

REVISION NUMBER:

REVISION DATE:

KEVIN MARX

M. PAROLINI

03/01/15

05/01/16

MARX

UNREGISTERED ENGINEERS

3/8" = 1'-0"
Epoch Estate Wines Production Facility Case Study

Kevin Marx
ARCE 453
Instructor: Michael Parolini, SE, LEED AP
Project Description:

**Code Used:**

- 2010 Minimum Design Loads for Buildings and Other Structures (ASCE 7-10)
- 2011 Building Code Requirements for Masonry Structures (TMS 402-11)
- Steel Design Manual for Structural Steel Buildings (AISC 360-10)
- Building Code Requirements for Structural Concrete (ACI 318-14)

**Size of Building:**

Building Sub Floor Area: 20,000 SF

Building Height:
- Administration Building: 12' - 0" Tall
- Case Storage: 20' - 0" Tall
- Fermentation Room: 26' - 0" Tall
- Barrel Ageing Room: 16' - 0" Tall (Subgrade)

**Type of Building:**

Gravity:
- Administration Building: Engineered Lumber Framing, Timber Stud Framing
- Case Storage: Vulcraft Steel Open Web Joists, Reinforced Masonry Walls
- Fermentation Room: Verco Roof Decking, Wideflange Steel A992 Joist, Vulcraft Open Web Joist, Wideflange Steel A992 Girder, Wideflange Steel A992 Column, Reinforced N.W. Concrete Pilaster
- Tank Room: Verco Composite Decking, HSS Steel A500 Gr. B. Beam, HSS Steel A500 Gr. B. Column
- Meeting Room: Verco Composite Decking, Wideflange Steel A992 Beam, Reinforced Masonry Wall
- Barrel Ageing Room: Reinforced N.W. Concrete Slab, Reinforced N.W. Concrete Beam, Reinforced N.W. Concrete Column, Reinforced N.W. Concrete Wall
Type of Building:

Lateral:

Administration Building: Plywood CDX Diaphragm
Timber Double Sided Shear Walls

Case Storage: Verco Decking
Special Reinforced Masonry Shear Walls

Fermentation Room: Verco Decking
Ordinary Steel Brace Frames
Ordinary Steel Moment Frames

Tank Room: Verco Decking
Special Reinforced N.W. Concrete Shear Walls

Meeting Room: Verco Decking
Special Reinforced Masonry Shear Walls

Barrel Ageing Room: Reinforced N.W. Concrete Slab
Reinforced N.W. Concrete Shear Walls

Foundations:

Administration Building: Reinforced N.W. Concrete Continuous Footing

Case Storage: Reinforced N.W. Concrete Continuous Footing

Fermentation Room: Reinforced N.W. Concrete Isolated Footing

Tank Room: Reinforced N.W. Concrete Continuous Footing

Meeting Room: Reinforced N.W. Concrete Continuous Footing

Barrel Ageing Room: Reinforced N.W. Concrete Continuous Footing

Location of Building

7505 York Mountain Rd, Templeton, CA 93465

Building Info.

Factory (F-2)
Risk Category II
Site Class C
SDS = 0.69g
SD1 = 0.40g
Exposure C
<table>
<thead>
<tr>
<th>Key Plan</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td></td>
</tr>
<tr>
<td>Administration Room</td>
<td>2</td>
</tr>
<tr>
<td>Case Storage</td>
<td>13</td>
</tr>
<tr>
<td>Fermentation Room / Tank Room / Meeting Room</td>
<td>19</td>
</tr>
<tr>
<td>Barrel Aging Room</td>
<td>61</td>
</tr>
<tr>
<td>Lateral</td>
<td></td>
</tr>
<tr>
<td>References</td>
<td>94</td>
</tr>
<tr>
<td>Administration Room</td>
<td>112</td>
</tr>
<tr>
<td>Case Storage</td>
<td>130</td>
</tr>
<tr>
<td>Fermentation Room</td>
<td>153</td>
</tr>
<tr>
<td>Barrel Aging Room</td>
<td>182</td>
</tr>
</tbody>
</table>
Gravity: Administration Room
## Dead Load (Admin. Building)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Wall (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verco Stl. Deck</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5/8&quot; Plywood Diaphragm</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>2X4 D.F. No. 2 Furring</td>
<td>N/A</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Spray on insulation</td>
<td>N/A</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>18&quot; Deep Truss Joist TJI</td>
<td>N/A</td>
<td>N/A</td>
<td>4.5</td>
</tr>
<tr>
<td>5/8&quot; Gyp. Board</td>
<td>N/A</td>
<td>N/A</td>
<td>2.0</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>0.5</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.5</strong></td>
<td><strong>12.5</strong></td>
<td><strong>19</strong></td>
</tr>
</tbody>
</table>

## Live Load @ Roof (Admin. Building)

Live Load (Roof) : 20 psf
TYP. STEEL DECK DESIGN

TYP. DECK SPAN: 8'-0" O.C. (IN TRIGGERS)

DEMAND: 20psf + 7.5psf = 27.5psf

9psf = 27.5psf

i. TYPE PLN-24 + 3" DEEP ROOF DECK
(GALVANIZED) IS ADEQUATE
CAPACITY: 300psf

TYPICAL JOIST DESIGN (OPTION 1)

DEMANDS:

LOAD TAKEOFF

\[ W_d = 9psf \times 24" \times 2' = 264lb \]

\[ W_{le} = (20psf)(2') = 40lb \]

\[ P_{eff} = 0.89 \]

\[ W_w = (16psf)(2') = 32lb \]

COMBINE LOADS:

\[ 1) \ W = 0.6W_d + 1.0W_{le} + 1.0W_w = 0.6(264lb) + 1.0(40lb) + 1.0(32lb) = 452lb \]

\[ 2) \ W = 1.0W_d + 1.0W_{le} = 264lb + 40lb = 304lb \]

\[ 3) \ W = 1.0W_d + 0.3W_{le} + 0.2W_w = 264lb + 0.3(40lb) + 0.2(32lb) = 294lb \]

\[ 4) \ W = 0.6W_d + 0.3W_{le} + 0.2W_w = 0.6(264lb) + 0.3(40lb) + 0.2(32lb) = 278lb \]

TRUSS JOIST

TJI 117/8" DEEP (110) IS ADEQUATE
FOR A W/A = 60 P/LF W/A. AN ALLOWABLE
OF A NON-SNOW LOAD 125% = 77 P/LF &
LIVE LOAD 1/2" DEFLECTION LIMIT @ 68 P/LF
W/A SPAN OF 26'-0" & SPACING @ 24" O.C.
TIMBER SAWN LUMBER J1 (OPTION 2)

\[ W = 70.4 \text{ kips} \] (Same 24" c.o. spacing)

\[ V = \frac{W_L}{2} = \frac{70.4}{2} = 35.2 \text{ kips} \]

\[ M = \frac{W_L^2}{8} = \frac{(70.4^2)}{8} = 3.526 \text{ kips-ft} \]

DeadLoad: Larch No. 1: \[ f_b = 10000 \text{ psi} \]

Check for shear:

\[ \frac{V}{A} = \frac{704}{16.88} = 41.7 \text{ psi} \]

\[ f_v = 225 \text{ psi} > 41.7 \text{ psi} = f_{v, \text{act}} \]

NDS 4.3.1

Try 2 x 12:

\[ A = 16.88 \text{ in}^2 \]

\[ \frac{5X}{31.64 \text{ in}^2} = 31.64 \text{ in}^2 \]

NDS Supplement

\[ f_b = 10000 \text{ psi} \times (1.25) \times (1.15) \times (1.0) \]

\[ f_b = 1437.5 \text{ psi} \]

\[ f_{b, \text{act}} = \frac{Mx}{5x} = \frac{31.64 \times 1437.5}{31.64 \text{ in}^2} \]

\[ f_{b, \text{act}} = 1335 \text{ psi} < 1437.5 \text{ psi} = f_b \]

Check for shear:

\[ \frac{V}{A} = \frac{704}{16.88} = 41.7 \text{ psi} \]

\[ f_v = 225 \text{ psi} > 41.7 \text{ psi} = f_{v, \text{act}} \]
Check deflection: 

\[ \Delta_D = \frac{5W_4}{384EI} = \frac{5(2\text{,}500\text{ lb})(2.40)^4}{384(1,000,000\text{ lb} \cdot \text{in}^2)(178\text{ in}^3)} \]

IBC 2015:

\[ \Delta_D = 0.3287 \text{ in} < \frac{L}{240} = 1 \text{ in} \]

AISC 360:

\[ \Delta_{D+L} = \frac{5(600\text{ lb})(2.40)^4}{384(1,000,000\text{ lb} \cdot \text{in}^2)(178\text{ in}^3)} = 0.834 \text{ in} \]

IBC 2015:

\[ \Delta_{D+L} = 0.834 \text{ in} < \frac{L}{180} = \frac{240}{180} = 1.3 \text{ in} \]

Timber sawn lumber design (option 3):

D.F. Larch No. 2 4x4 frame @ 24" O.C.

Check flexure: (try 4x8)

\[ f_v = C_d C_r f_v = (1.25)(1.15)(1.3)(900 \text{ psi}) \]

\[ f_v = 1681.9 \text{ psi} \]

\[ f_{b,act} = \frac{f_v}{3x} = \frac{(3.520 + E)12}{30,000,000} = 137.7 \text{ psi} \]

\[ f_{b,act} = 137.7 \text{ psi} < 1681.9 \text{ psi} = f_v \]
Reference:

CHECK SHEAR

\[ f_v = f_v C_D = (180 \text{ psi})(1.25) = 225 \text{ psi} \]

\[ f_{v,act} = \frac{V}{A} = \frac{204 \text{ ft}}{25.28 \text{ in}^2} = 27.7 \text{ psi} \]

\[ f_{v,act} = 225 \text{ psi} > 27.7 \text{ psi} = f_{v,act} \]

CHECK DEFLECTION

\[ \Delta_D = \frac{5wD^4}{384EI} = \frac{5(40 \text{ lb}) (240) ^4}{384(1,600,000 \text{ psi}) (111,161 \text{ in}^4)} = 0.53'' \]

\[ \Delta_{D,act} = \frac{L}{240} = \frac{240}{240} = 1'' \]

\[ 20.53'' = \Delta_{D,act} \]

\[ \Delta_{D+L} = \frac{5(40 \text{ lb}) (240) ^4}{384(1,600,000 \text{ psi}) (111,161 \text{ in}^4)} = 1.334'' \]

\[ \Delta_{D+L,act} = \frac{L}{180} = \frac{240}{180} = 1.334'' \]

\[ \Delta_{D+L} = 1.334'' > 1.334'' = \Delta_{D+L,act} \]

D.F. LARCH NO.2 9X10 IS ADEQUATE
DUE TO INSPECTION, W/ SPAN OF 20'-0"
& SPACING OF 24"
<table>
<thead>
<tr>
<th>Reference</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPICAL HEADER DESIGN</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SPAN</strong>: 24' 0&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>LOAD TAKEOFF</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DL</strong>: 12.5 psf</td>
<td></td>
</tr>
<tr>
<td><strong>LL</strong>: 20.0 psf</td>
<td></td>
</tr>
<tr>
<td><strong>W</strong> = 16.0 psf</td>
<td></td>
</tr>
</tbody>
</table>

**COMBINE LOADING**

\[
q_v = 1.0q_o + 0.75q_L + 0.25(0.75)q_w
\]

\[
q_v = 12.5 \text{ psf} + 0.75(20 \text{ psf}) + 0.25(0.75)16 \text{ psf}
\]

\[
q_v = 34.7 \text{ psf}
\]

**TRUSS JOIST**

\[
W = (34.7 \text{ psf}) \times 10 = 347 \text{ kips}
\]

**CATALOG**

- **5\(\frac{1}{4}\) x 4\(\frac{1}{4}\) TRUSS JOIST LVL 15**
  - ADEQUATE FOR SHEAR & FLEXURE

\[
347 \text{ kips} < 475 \text{ kips} \text{ TOTAL LOAD}
\]

\[
347 \text{ kips} > 372 \text{ kips} \text{ DEFLECTION MIN. BEARING: } 1.5
\]
Reference:

**DESIGN OUTRIGGER @ ADMIN**

\[ W_D = (12.5 \text{ psf})(8') = 100 \text{ kips} \]

\[ W_L = (80 \text{ psf})(8') = 640 \text{ kips} \]

\[ W_W = (12 \text{ psf})(8') = 96 \text{ kips} \]

**COMBINE LOADS**

\[ W = 0.5 W_D + 0.6 W_L + 0.1 W_W = 1.2(100) + 0.6(640) + 0.1(96) \]

\[ W = 424 \text{ kips} \]

\[ V = \frac{W}{2} = 212 \text{ kips} \]

\[ M = \frac{W}{2} \times 8' = 896 \text{ kips-ft} \]

**DESIGN DEFLECTION**


\[ I_x = 2.11 \text{ in}^4 \]

\[ \Delta_{DL} = \frac{L^2}{180} = 0.65 \times 12^2 = 725 \text{ in} \]

\[ \Delta_{ALL} = 180 \frac{0.5 \times 12}{180} = 10.8 \text{ in} \]
Reference:

\[ \Delta_{\text{act}} = \frac{w_0 l^4}{8 E I} \left( \frac{0.24 + 0.12}{6} \right) \]

\[ \Delta_{\text{all}} = 0.315 \text{ in} < \Delta_{\text{act}} \text{ ALL} \]

\[ \Delta_{\text{all}} = \frac{l^2}{240} \left( \frac{0.65}{240} \right) = 0.65 \text{ in} \]

\[ \Delta_{\text{act}} = \frac{w_0 l^4}{8 E I} \left( \frac{(0.15)^4}{8} \right) = 0.315 \text{ in} \]

\[ \Delta_{\text{act}} = 0.315 < \Delta_{\text{all}} \]

*FLEXURE & SHEAR WILL BE ADEQUATE DUE TO INSPECTION*

SEE PC4

2.1 3 x 3 x 9/16 is ADEQUATE FOR A SPAN OF 2'-6" & A TRIB. WIDTH OF 8'-0"

\[ M_u = 896 \text{ ft-lb} \]

\[ V_u = 274 \text{ kips} \]

\[ \Delta_{\text{act}} = 0.315 \]

\[ \Delta_{\text{all}} = 0.82 \text{ in} \]
**DESIGN BEARING WALL @ ADMIN BUILDING**

**2X4 P.E. LARCH NO. 2 IS ADEQUATE?**

\[
\frac{e}{d} = \frac{12''}{3.5''} = 4.14 < 5.0
\]

\[
F_c^* = F_c \cdot c_{w} \cdot c_{r} = (1380 \text{ psi}) \cdot (1.75) \cdot (1.15)
\]

\[
F_c = 2531.25 \text{ psi}
\]

\[
F_o = \frac{0.822 \cdot F_{min}}{(0.8)^2} = \frac{0.822 \cdot (580,000 \text{ psi})}{(41.14)^2}
\]

\[
F_o = 281.7 \text{ psi}
\]

\[
\frac{F_c}{F_o} = 0.111
\]

\[
C_o = \frac{1 + \frac{F_c}{F_o}}{2} = \frac{1 + 0.111}{2} = 0.556
\]

\[
C_p = \frac{1}{2(0.556)} = 0.8
\]

\[
C_p = 0.1086
\]

\[
F_p = F_c \cdot C_p = (2531.25 \text{ psi}) \cdot (0.1086)
\]

\[
F_p = 275 \text{ psi}
\]

\[
F_{act} = \frac{P}{A} = \frac{704 \#}{5.25''} = 134 \text{ psi} < 275 \text{ psi}
\]

2X4 P.E. LARCH NO. 2 IS ADEQUATE FOR STUD MATERIAL WITH BEAM LENGTH OF 12'' F_{act} = 134 \text{ psi}
Gravity: Case Storage
## Dead Load @ Roof (Case Storage)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Wall (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2&quot; Gravel</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>1-1/2&quot; Foam Roofing</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5/8&quot; Plywood Diaphragm</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Spray Foam Insulation</td>
<td>N/A</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>18&quot; Deep Truss Joist TJI</td>
<td>N/A</td>
<td>N/A</td>
<td>2.0</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>0.5</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>7.5</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

## Live Load @ Roof (Case Storage)

Live Load (Roof) : 20 psf
Reference:

Typ. Steel Deck Design

Typ. Deck Span: 2'-0"

-Yello Delking Catalog

Demand is Same as Fermentation
- By Inspection Previous Deck is Adequate

Type PLN-24 1/3" Deep Roof Deck
(Galvanized) is adequate.

Capacity = 300 psf > 27.33 psf = Demand

Design of Timber Joist

Ref Pg. 89

W = 20.46 k f (from last problem)

V = \frac{W \cdot L}{2} = \frac{(20.46)(28)}{2} = 295.6 k f

Load Taking

M = \frac{W \cdot L^2}{8} = \frac{(20.46)(28)^2}{8} = 6,900 k f \cdot "

Design for Deflection

IBC 2015

\Delta = \frac{5 \cdot W \cdot L^4}{384 \cdot E \cdot I_{pl}} = \frac{5 \cdot (60 \cdot 10^6)(28 \cdot 12)^4}{384 \cdot (1,600,000) \cdot (1,86)}

I_{pl} = 30.5 \cdot 6 \text{ in}^4

Try 4" x 12" D.F. Larch No. 2 I = 415.3 \text{ in}^4

\Delta_H = \frac{5 \cdot W \cdot L^2}{384 \cdot E \cdot I} = \frac{5 \cdot (60 \cdot 10^6)(28 \cdot 12)}{384 \cdot (1,600,000) \cdot (415.3)} = 1.37"
Reference:

**DESIGN OF TIMBER JOIST (OPTION 2)**

\[ W = 70.4 \text{ plf} \]

**USE TRUSS JOIST TJ1 14 (560)**

\[ W_{ALL} = 100 \text{ plf} > 70.4 \text{ plf} \]

\[ W_{ALL} = 85 \text{ plf} > 70.4 \text{ plf} \]

**TRUSS JOIST CATALOG**

TRUSS JOIST TJ1 14" DEEP (560)
IS ADEQUATE FOR A SPAN OF
28'-6" & 24" C.C. SPACING

**DESIGN OF TIMBER JOIST (OPTION 3)**

\[ W = 70.4 \text{ plf} \]

**USE TRUSS JOIST LVL 13/4" X 14"**

\[ W_{ALL} = 96 \text{ plf} > 70.4 \text{ plf} \]

\[ W_{ALL} = 78 \text{ plf} > 70.4 \text{ plf} \]

**TRUSS JOIST CATALOG**

TRUSS JOIST 13/4" X 14"
IS ADEQUATE FOR A SPAN OF
28'-6" & A SPACING OF 24" C.C.
Reference: 180.2505

\[ \Delta_{D_{\text{all}}} = \frac{L}{240} \left( \frac{28}{240} \right) = 1.4'' \]

\[ \Delta_{D_{\text{all}}} < 1.4'' \text{ or } \Delta_{D} \leq 1.4'' = \Delta_{D_{\text{all}}} \]

**DESIGN FLEXURE**

NDSTBL 4.12.1

\[ f_{b} = f_{b} \cdot c_{b} \cdot c_{o} \cdot f_{p} = 900 \text{ psi} \cdot (1.25)(1.15)(1.0) \]

\[ f_{b} = 1293.8 \text{ psi} \]

\[ f_{b_{\text{act}}} = \frac{m_{c}}{s_{x}} = \frac{(6900 \# f_{b})^{1/2}}{73.83 \, 1.3} = 1121.4 \text{ psi} \]

\[ f_{b_{\text{act}}} = 1121.4 < 1293.8 \text{ psi} = f_{b_{\text{all}}} \]

**DESIGN SHEAR**

NDSTBL 4.3.1

\[ f_{v} = C_{D} \cdot f_{v} = 1.25 (160 \text{ psi}) = 225 \text{ psi} \]

\[ f_{v_{\text{act}}} = \frac{V}{A} = \frac{935 \#}{39.38 \#} = 25 \text{ psi} \]

\[ f_{v_{\text{act}}} = 225 > 25 \text{ psi} = f_{v_{\text{act}}} \]

4X12 NO. 2 D.F. LATCH IS ADEQUATE FOR A SPAN OF 28'-0" & A SPACING OF 24" O.C.
Gravity: Fermentation Room
Meeting Room
Tank Room
### Dead Load @ Roof (Fermentation Room)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Girder (psf)</th>
<th>Column (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2&quot; Gravel</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>1-1/2&quot; Foam Roofing</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Verco Steel Decking</td>
<td>N/A</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>2x6 D.F. No. 2 Furring</td>
<td>N/A</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Spray on Insulation</td>
<td>N/A</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>5/8&quot; Plywood Sheathing</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Steel Panel</td>
<td>N/A</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>W16x31</td>
<td>N/A</td>
<td>N/A</td>
<td>5.6</td>
<td>5.4</td>
</tr>
<tr>
<td>W18x35</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>1.8</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>0.5</td>
<td>0.7</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.5</strong></td>
<td><strong>20.5</strong></td>
<td><strong>26.5</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>

### Live Load @ Roof (Fermentation Room)

Live Load (Roof) : 20 psf
## Dead Load (Meeting Room)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Wall (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3&quot; Conc. Topping</td>
<td>36.25</td>
<td>36.25</td>
<td>36.25</td>
</tr>
<tr>
<td>Verco Composite Slab</td>
<td>N/A</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>5/8&quot; Plywood Diaphragm</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Spray Foam Insulation</td>
<td>N/A</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Wide Flange Steel Beam</td>
<td>N/A</td>
<td>N/A</td>
<td>2.0</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>0.5</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>37</strong></td>
<td><strong>85</strong></td>
<td><strong>90</strong></td>
</tr>
</tbody>
</table>

## Live Load @ Roof (Meeting Room)

Live Load: 50 psf
### Dead Load (Tank Room)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Column (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil (1.5 ft deep)</td>
<td>165</td>
<td>165</td>
<td>165</td>
</tr>
<tr>
<td>2&quot; Rigid Insulation</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Drainage Membrane</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Verco Composite Deck</td>
<td>N/A</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Approximate Stl. HSS Bm.</td>
<td>N/A</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>N/A</td>
<td>N/A</td>
<td>2.5</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>0.5</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>170</strong></td>
<td><strong>244.5</strong></td>
<td><strong>247</strong></td>
</tr>
</tbody>
</table>

### Live Load @ Roof (Fermentation Room)

Live Load (Yards and Terraces): 100 psf
DESIGN OF DECK

TYP. DECK SPAN: (5'-6") C.C.

DEMAND: \( LL + DL = 20 \text{psf} + 7.5 \text{psf} \)

\( q_{u} = 27.5 \text{psf} \)

VERCO ROOF DECK CATALOG

TYPE P1N-24 ~ 3" DEEP ROOF DECK (GALVANIZED) IS ADEQUATE

CAPACITY = 300psf > 27.5psf = \( q_{u} \)

DESIGN OF WIDE FLANGE STL. BEAM

DECK CONTINUOUSLY BRACES BEAM

\( f_0 = 0 \Rightarrow \text{DESIGN FOR}_M \)

DEMAND:

\[ W_0 = \frac{9.0 \cdot W_t}{20.5 \text{psf}} \]
\[ W_t = 7-6" \]
\[ W_0 = 1153, 75 \text{pF} \]

ASCE 7-10
EQ 4.8-1

\[ A_t = 112 \Phi \leq 200 \Phi \] NO UL REDUCTION

\[ W_{LR} = 9.0 \cdot W_t - (20 \text{psf})(7.5') \]
\[ W_{LR} = 150 \text{psf} \]
DEMAND:

\[ V_0 = \frac{w_0 \cdot L}{2} = \frac{(153.75 \text{ psf})(20)}{2} \]

\[ V_0 = 1.537 \text{ KIPS} \]

\[ M_0 = \frac{w_0 \cdot L^2}{8} = \frac{(153.75 \text{ psf})(20)^2}{8} = 7.69 \text{ K-ft} \]

\[ M_L = \frac{w_L \cdot L^2}{2} = \frac{(150 \text{ psf})(20)^2}{2} = 11.5 \text{ K-ft} \]

\[ W = 0.6 \cdot w_L \cdot (10 \text{ ft})(7.5) = 120 \text{ psf} \]

\[ V_w = \frac{W_L \cdot L}{2} = (120 \text{ psf})(20) \cdot \frac{1}{2} = 1,200 \text{ ft-lb} \]

\[ M_w = \frac{W_L \cdot L^2}{8} = (120 \text{ psf})(20)^2 \cdot \frac{1}{8} = 1,200 \text{ K-ft} \]

**COMBINED LOADS:** *LOAD COMBO 3 GOVERNS*

\[ V_w = 1.2V_0 + 1.6V_L + \frac{1}{2}V_w = 1.2(1.54) + 1.6(1.5) + \frac{1}{2}(1.2) \]

\[ V_w = 4.85 \text{ K} \]

\[ M_w = 1.2M_0 + 1.6M_L + \frac{1}{2}M_w = 1.2(7.69) + 1.6(11.5) + \frac{1}{2}(1,200) \]

\[ M_w = 24.24 \text{ K-ft} \]

**DESIGN FOR DEFLECTION**

\[ \Delta_{DL} = \frac{L}{180} \Rightarrow \text{SUPPORTING NONPLASTER CEILING} \]

\[ \frac{L}{180} = \frac{12'' \cdot 20\text{''}}{180} = 1.3'' \]

\[ I_{req} = \frac{5(303.75 \text{ psf})(1000)(240)^4}{384(1.3)} = 29,000 \text{ K-ft}^3 \]

\[ I_{req} = 339.4 \text{ in}^4 \]
Reference:

DESIGN DEFLECTION:

\[ \Delta_D + L = 1.329'' \leq 1.23 = \Delta_{\text{DEL}} \]

Answer:

\[ \Delta_D = 0.611'' \leq 1.0'' = \Delta_{\text{DEL}} \]

CHECK FLEXURE:

Beam is continuously braced by deck

M_p = 203 K - FC

\[ M_p = \Phi M_N \Rightarrow \frac{L_0}{L} = 0 \ (\text{cont. braced}) \]

M_u = 21.3 K - FC

\[ M_N = 203 K - FC > 21.3 K - FC \]

CHECK SHEAR

\[ \Phi V_N = 131 \text{ Kips} \]

\[ V_u = 412.4 \text{ Kips} \]

\[ \Phi V_N = 131 K > 4.85 K = V_u \]

W16x31 is adequate for a span of 20'-0" & a spacing C.C. 7'-6"

\[ M_u = 24.3 K - FC, V_u = 4.85 K, \Delta_D + L = 1.3'' \]

\[ \Delta_D = 1'' \]
Reference:

**DESIGN OF WIDE FLANGE GIRDER**

**GIRDER IS BRACED AT COMPRESSION EDGE BY BEAMS @ (5'-7") C.C.**

\[ L_0 = 5\text{'-6"} \]

**DEMANDS**

\[ D_1 \] \[ D_2 \] \[ D_3 \] \[ D_4 \] \[ D_5 \]

**COLUMN TO COLUMN SPACING: 42'-0"**

**TOTAL BEAM LENGTH: 53'-6"**

\[ E.O. = 5\text{'-6"} \]

**AXIAL LOADS**

\[ A_0 = (59.3')(14.5') = 860 \text{ k} \text{ with } 800 \text{ k} \text{ Eq.} \]

\[ P = qv_k A_0 \Rightarrow q_v = 1.2 D + 1.6 C + 0.3 W \]

\[ P_1 = (50 \text{ ksf})(20')(5.5') = 6,490 \text{ k} \text{ Eq.} \]

\[ P_2 = (50 \text{ ksf})(20')(5.5'){1^2 \over 2} = 7,380 \text{ k} \text{ Eq.} \]

\[ P_3 = (50 \text{ ksf})(20')(5.5'){1^2 \over 2} = 5,310 \text{ k} \text{ Eq.} \]

**P1D = 2,915 \text{ k}, \ P_{2D} = 1,320 \text{ k}, \ P_{3D} = 1,760 \text{ k}**

**P2D = 3,313 \text{ k}, \ P_{2L} = 1,5 \text{ k}, \ P_{2W} = 2,0 \text{ k}**

**P3D = 2,391 \text{ k}, \ P_{3L} = 1,081 \text{ k}, \ P_{3W} = 1,441 \text{ k}**
Basic Load Cases

<table>
<thead>
<tr>
<th>BLC Description</th>
<th>Category</th>
<th>X Gravity</th>
<th>Y Gravity</th>
<th>Joint</th>
<th>Point</th>
<th>Distributed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>RLL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>WL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Load Combinations

<table>
<thead>
<tr>
<th>Description</th>
<th>Solve</th>
<th>PDelta</th>
<th>SRSS</th>
<th>BLC</th>
<th>Factor</th>
<th>BLC</th>
<th>Factor</th>
<th>BLC</th>
<th>Factor</th>
<th>BLC</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serviceability w/ camber (L)</td>
<td>✔</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic Tension</td>
<td>✔</td>
<td></td>
<td></td>
<td>1</td>
<td>1.729</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seismic Compression</td>
<td>✔</td>
<td></td>
<td></td>
<td>1</td>
<td>1.371</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serviceability (D)</td>
<td>✔</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serviceability (D+L)</td>
<td>✔</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td>✔</td>
<td></td>
<td></td>
<td>1</td>
<td>1.2</td>
<td>2</td>
<td>1.6</td>
<td>3</td>
<td>.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Live Load

-2.39k
-3.13k
-2.91k
-2.91k
-2.91k
-2.91k
-2.91k
-2.91k
-3.13k
-2.39k

Dead Load

-1.08k
-1.5k
-1.32k
-1.32k
-1.32k
-1.32k
-1.32k
-1.32k
-1.5k
-1.08k

Wind Load

-1.44k
-2k
-1.76k
-1.76k
-1.76k
-1.76k
-1.76k
-1.76k
-2k
-1.44k
Deflection due to Dead Load (Camber)

Member M1, LC 4: Serviceability (D)

Member M2, LC 4: Serviceability (D)

Member M3, LC 4: Serviceability (D)
Deflection due to Dead + Live

Member M1, LC 1: Serviceability w/ camber (L)

Member M2, LC 1: Serviceability w/ camber (L)

Member M3, LC 1: Serviceability w/ camber (L)
Reference:

**FACTORED DEMANDS**

\[ M_u = 220k\text{-kips} \]
\[ V_u = 216.9\text{kips} \]

TRY A W 16\times 40\in : \quad I_x = 5.18\text{in}^4

△ @ N1

RISA

\[ \Delta_p = 11.09'' \quad \text{CAMBER}=+1'' \]
\[ \Delta_{p+L} = 0.470'' \]
\[ \Delta_{p+L,\text{acc}} = \frac{2L}{180} = \frac{5.5\cdot 12}{180} = 0.73'' \]

△ @ N3

\[ \Delta_{D} = 7.60'' \quad \text{CAMBER}=+2.5'' \]
\[ \Delta_{p+L} = \Delta_{p+L,\text{acc}} + 0.11'' = -1.24'' \]
\[ \Delta_{D+L,\text{acc}} = \frac{L}{180} = \frac{42\cdot 12}{180} = -2.8'' \]

△ ONB

RISA

\[ \Delta_0 = 11.3410'' \quad \text{CAMBER}=+1.25'' \]
\[ \Delta_{p+L} = 0.574'' \]
\[ \Delta_{p+L,\text{acc}} = \frac{2L}{180} = \frac{2(7)(12)}{180} = 0.93'' \]
DEFLECTION SUMMARY

N1

$\Delta_{DFL} = [0.462(4)(0.73)] = \Delta_{DFL_{ALL}}$

N3

$A_{DHL} = [\begin{array}{c} -1.125'' \leq -2.8'' = \Delta_{DFL_{ALL}} \end{array}]$

N5

$\Delta_{DFL} = \begin{bmatrix} -0.565'' & 0.93'' \end{bmatrix} = \Delta_{DFL_{ALL}}$

CHECK FLEXURE

Assume $C_B = 1.0$ (conservative)

$W18 \times 35 \Rightarrow \phi M_N = 210K - f_G$

$Q = 7.5''$ (S.W. reduces moment)

$\phi M_N = 258K > 230K - f_G = M_u$

CHECK SHEAR

$A_{SC} = 300$

$\phi V_u = 159.1K$

$V_u = 23.4K$

$\phi V = 146K > 26.9K = V_u$

W18 x 35 is adequate as a typ. girder (see key plan)

Typically spaced @ 20'-0'' C.C.

$M_u = 230K - f_G$

$V_u = 26.9K$

$\Delta_{DHL} = \begin{bmatrix} 1.125'' \end{bmatrix}$,

$\Delta_{DHL_{ALL}} = \begin{bmatrix} 0.463'' \end{bmatrix}$
Reference:

FERMENTATION ROOF OUTRIGGER

\[
\begin{align*}
\mu &= \frac{30.5 \text{ psi}}{2} \\
\phi &= 2.0 \text{ psi} \\
\gamma &= 1.2 \text{ psi}
\end{align*}
\]

Answer:

\[
\begin{align*}
W_0 &= \frac{1}{2} \cdot 30.5 \text{ psi} \\
W_0 &= 15.25 \text{ psi} \\
W_0 &= 10
\end{align*}
\]

\[
\begin{align*}
W &= \frac{1}{2} \cdot 20 \text{ psi} \\
W &= 10 \text{ psi}
\end{align*}
\]

COMBINE LOADING

\[
\begin{align*}
W &= W_0 + W_1 + W_2 \\
W &= 15.25 + 10 + 12 = 37.25 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
W_{eq} &= \frac{1}{2} \cdot 37.25 \text{ psi} \\
W_{eq} &= 18.625 \text{ psi}
\end{align*}
\]

ASCE 7

2.3.2

\[
\begin{align*}
W &= 1.2 \cdot 10 + 0.5 \cdot 10 + 0.2 \cdot 12 = 24 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
W &= 62.6 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
V &= W_{eq} \cdot 1.5 = 27.938 \text{ psi}
\end{align*}
\]

\[
\begin{align*}
M &= \frac{W \cdot 1.5^2}{2} = 3.835 \text{ ksi}
\end{align*}
\]
Reference:  DESIGN BEAM FOR SHEAR

\[ \phi V_n = 0.9 \left( \frac{A_{yw}}{A_{yw} + A_{w}} \right) \]

TR 22x2x1/8

\[ A_{yw} = 2(2)\left( \frac{0.125}{4} \right) = 0.5 \text{ in}^2 \]
\[ V_n = 1.0 \]
\[ V_{bw} = 16 \text{ kips} \]
\[ f_{yw} = 36 \text{ kips/in}^2 \]

\[ \phi V_n = 0.9 \left( 0.6 \times f_{yw} A_{yw} \right) \]
\[ \phi V_n = 0.9 \left( 0.6 \left( 36 \text{ kips/in}^2 \right) \times 0.5 \text{ in}^2 \text{ } \times 1.0 \right) = 9.7 \text{ kips} \]

\[ \phi V_n = 9.7 \text{ kips} > 2.2 \text{ kips} = V_{bw} \]

Reference:  DESIGN FOR FLEXURE

CHECK YIELD:

\[ M_n = M_o = f_y Z_x \leq M_y \]
\[ M_o = 2 \times f_y \left( 0.22 \text{ in}^3 \right) \times 2 \times 36 \text{ kips} \]
\[ \phi M_o = (0.9 \times 168 \text{ kip-ft}) = 149 \text{ kip-ft} \]

CHECK LTB:

\[ \frac{M_n}{M_{cr}} = \frac{A_y E I_y G_0}{k \phi} \left( B_x \sqrt{1 + B^2} \right) \]

\[ B = 2.3 \]
\[ \frac{d}{L} = 0.87 \text{ in} \]

Page 30 of 70
Prepared By: Kevin Marx
Checked By: Kevin Marx
Date: 5/31/16
Reference:

\[ M_{cF} = \frac{N_F G_t}{L_b} \left( \frac{B}{B^2 + \sqrt{11B^2}} \right) \]

\[ I_b = 2(0.189\text{in}^4) = 0.378\text{ in}^4 \]

\[ G = 11,200\text{ ksi} \]

\[ G = 2(0.00293) = 0.00586\text{ in}^4 \]

\[ M_{cF} = \frac{11,200(0.00293)(0.378\text{ in}^4)(11,200\text{ ksi})}{3.8\times12^2} = \frac{11,717\text{ ft-lb}}{1.12} = M_{cF} \]

\[(0.378\text{ in}^4 + 0.00586\text{ in}^4) = 11,717\text{ ft-lb} = M_{cF} \]

CHECK LOCAL FLANGE BUCKLING:

\[ d_w = \frac{2.5}{2}(0.125) = 0.3125 \text{ in} \]

\[ 0.54\sqrt{E/\sigma_f} = 0.54\sqrt{29,000(ksi)/(20,000(ksi))} = 10.8 \]

\[ \frac{d_w}{b/2} < \frac{1}{\pi} \rightarrow \text{FLANGE LOCAL BUCKLING DOES NOT APPLY} \]

LOCAL BUCKLING OF JEE SEAM:

\[ d_w = 8 < 0.84\sqrt{E/\sigma_f} \rightarrow \text{Flange = G} \]

\[ M_{n} = 11.7\text{ k-ft} \]

\[ (0.9)(11.7\text{ k-ft}) = 10.5\text{ k-ft} \]
Reference: CHECK DEFLECTION

\[ \Delta_D = \frac{L}{240} = \frac{(3.5) 12}{240} = 0.35'' \]

\[ \Delta_D = \frac{L^2}{240} = \frac{(3.5)^2 12}{240} = 0.35'' \]

\[ \Delta_D = \frac{w_D L^2}{8 E I} = \frac{0.100(3.5)^2 12}{8(29000)(324)} = \Delta_D_{ACT} \]

\[ \Delta_D = 0.423'' < 0.35'' \]

\[ \Delta_D = \frac{w_D L^2}{8 E I} = \frac{(0.205)(3.5)^2 (2.5)^2}{8(29000)(324)} = \Delta_D_{ACT} \]

\[ \Delta_D = 0.214'' < 0.35'' \]

2.5 2.5 x 2.5 x 3/16 is ADEQUATE FOR A CANTILEVER BEAM 3'-0" & A TRIBUTARY WIDTH OF 0'-0".

\[ M_u = 234 k-F \cdot \text{in} \]

\[ V_u = 2.2 k \]

\[ \Delta_D = 0.214'' \]

\[ \Delta_D = 0.423'' \]
Reference: STEEL COLUMN DESIGN (WORST CASE)

\[ K = 1.0 \quad (P_I - P_{II}) \]
\[ L = 22'' - 9'' \]

\[ A_0 = \left( \frac{45^2 + 20^2}{2} \right) \left( 9.5 + \frac{42'}{2} \right) = 915,114,14 \quad L_r = 12 \text{ psf} \]

\[ q_v = 1.2 q_0 + 1.6 q_0 + 0.5 q_0 = 1.2 (900) + 160 (1200) + \frac{1}{2} (120) \]

\[ q_u = 60 \text{ psf} \]

\[ P_u = q_u \cdot A_t = 60 \text{ psf} \cdot 915,114,14 = 54,994 \]

TRY W8 x 24

\[ f_y = 1,661 \quad A_g = 7.08''^2 \]

\[ \frac{K}{I} = \frac{1.0(2.5)(12''^3)}{1.00''^4} = 169.6 < 200 \checkmark \]

\[ \frac{K}{L} = \frac{4.7}{7''} = 0.67 < \frac{5}{3} \quad \text{required} = 1.13 \]

\[ F_c = \frac{11^2 E}{(K/L)^4} = \frac{11^2 (29,000 \text{ psi})}{(169.6)^2} = 9.95 \text{ ksi} \]

\[ F_{cr} = 0.977 F_c = (0.977)(9.95 \text{ ksi}) = 9.73 \text{ ksi} \]

\[ \phi P_n = \phi A_g F_{cr} = 0.9 (7.08''^2) (9.73 \text{ ksi}) = 55.63 \text{ kips} \]

\[ \phi P_n < P_u \quad \text{W8 x 24 IS ADEQUATE FOR AN UNGRADED LENGTH OF 22''-9''} \]

\[ P_u = 54,994 \text{ kips} \]
<table>
<thead>
<tr>
<th>Reference</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SIZE</strong></td>
<td><strong>PILASTER</strong></td>
</tr>
<tr>
<td><strong>DEMAND:</strong></td>
<td>$P_u = 54.9k$</td>
</tr>
<tr>
<td><strong>X CONSIDERING A d = 8' FROM THE WIDE FLANGE BEAM:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>- CHOOSE 10 X 10 SQ. COLUMN TO LEAVE ROOM FOR BASEPLATE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SR COLUMN RESULTS</strong></td>
<td>$P_{Pa} = 266.6k &gt; 54.9k$</td>
</tr>
<tr>
<td><strong>TRANSVERSE REINFORCEMENT</strong></td>
<td></td>
</tr>
<tr>
<td><strong>USE NO. 3's</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ACIA 9/18</strong></td>
<td>$k = \frac{d}{2} = \frac{10''}{2} = 5''$</td>
</tr>
<tr>
<td><strong>TOTAL 101.12</strong></td>
<td>$k = 8.0''$</td>
</tr>
</tbody>
</table>

10 X 10 CONC. PILASTER IS ADEQUATE FOR A LOAD OF 55k. USE (4) NO. 5'S AS LONGITUDINAL REINFORCEMENT AND NO. 3's @ 3'' C.C. AS TRANSVERSE REINFORCEMENT.
General Information:

File Name: u:\3. 4th year\senior project\1. gravity\risatopbeam\pilestal.col
Project: EPOCI Winery
Column: Pilestal
Code: AGC 318-11
Engineer: KCM
Units: English
Run Option: Investigation
Run Axis: X-axis
Slenderness: Not considered
Column Type: Structural

Material Properties:

- f'c = 4 ksi
- Ec = 3605 ksi
- Ultimate strain = 0.003 in/in
- Betal = 0.85
- fy = 60 ksi
- EK = 29000 ksi

Section:

- Rectangular: Width = 10 in
- Depth = 10 in
- Gross section area, Ag = 100 in²
- Ix = 838.333 in⁴
- Ky = 838.333 in⁴
- Ex = 2.88678 in
- X0 = 0 in
- Y0 = 0 in

Reinforcement:

<table>
<thead>
<tr>
<th>Bar Set: ASTM A615</th>
<th>Size Dia. (in)</th>
<th>Area (in²)</th>
<th>Size Dia. (in)</th>
<th>Area (in²)</th>
<th>Size Dia. (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>0.60</td>
<td>0.20</td>
<td>0.63</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>1.00</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>1.41</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>
</tr>
</tbody>
</table>

Confined: Tied; #3 ties with #10 bars, #4 with larger bars,
\(\phi(a) = 0.8, \phi(b) = 0.9, \phi(c) = 0.65\)

Layout: Rectangular
Pattern: All Sides Equal (Cover to transverse reinforcement)
Total steel area: As = 1.24 in² at rho = 1.24%
Minimum clear spacing = 5.00 in

4 #5 Cover = 1.5 in

Control Points:

<table>
<thead>
<tr>
<th>Bending about</th>
<th>Axial Load P (kip)</th>
<th>X-Moment k-ft</th>
<th>Y-Moment k-ft</th>
<th>NA depth in</th>
<th>Dc depth in</th>
<th>eps_x</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Max compression</td>
<td>-0.00</td>
<td>-0.00</td>
<td>25.17</td>
<td>7.81</td>
<td>-0.00207</td>
<td>0.650</td>
</tr>
<tr>
<td></td>
<td>Allovable comp.</td>
<td>213.3</td>
<td>15.63</td>
<td>0.00</td>
<td>9.83</td>
<td>7.81</td>
<td>0.00207</td>
</tr>
<tr>
<td></td>
<td>zf = 0.0</td>
<td>169.6</td>
<td>25.89</td>
<td>0.00</td>
<td>7.81</td>
<td>7.81</td>
<td>0.00207</td>
</tr>
<tr>
<td></td>
<td>zf = 0.8*fy</td>
<td>117.5</td>
<td>30.65</td>
<td>0.00</td>
<td>5.81</td>
<td>7.81</td>
<td>0.00103</td>
</tr>
<tr>
<td></td>
<td>Balanced point</td>
<td>79.8</td>
<td>31.64</td>
<td>0.00</td>
<td>4.62</td>
<td>7.81</td>
<td>0.00207</td>
</tr>
<tr>
<td></td>
<td>Tension control</td>
<td>53.1</td>
<td>34.13</td>
<td>0.00</td>
<td>3.85</td>
<td>7.81</td>
<td>0.00000</td>
</tr>
<tr>
<td></td>
<td>Pure bending</td>
<td>-0.0</td>
<td>21.17</td>
<td>0.00</td>
<td>1.75</td>
<td>7.81</td>
<td>0.01098</td>
</tr>
<tr>
<td></td>
<td>Max tension</td>
<td>-67.0</td>
<td>-0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.81</td>
<td>9.99999</td>
</tr>
</tbody>
</table>

- X               | Max compression    | -0.00         | -0.00         | 25.17       | 7.81        | -0.00207 | 0.650|
|                 | Allovable comp.    | 213.3         | -15.63        | -0.00       | 9.83        | 7.81   | -0.00062 | 0.650|
|                 | zf = 0.0           | 169.6         | -25.89        | -0.00       | 7.81        | 7.81   | 0.00000 | 0.650|
|                 | zf = 0.8\*fy       | 117.5         | -30.65        | -0.00       | 5.81        | 7.81   | 0.00103 | 0.650|
|                 | Balanced point     | 79.8          | -31.64        | -0.00       | 4.62        | 7.81   | 0.00207 | 0.650|
|                 | Tension control    | 53.1          | -34.13        | 0.00        | 3.85        | 7.81   | 0.00000 | 0.650|
|                 | Pure bending       | -0.0          | -21.17        | -0.00       | 1.75        | 7.81   | 0.01098 | 0.650|
|                 | Max tension        | -67.0         | -0.00         | 0.00        | 0.00        | 7.81   | 9.99999 | 0.900|
Reference: CONCRETE ISOLED FERMENTATION
ROOM FOOTING

Answer:

\[ A_{F1G} = \frac{P_D + P_L}{q_{w1}} \]

\[ P_D = (2.9 \text{ psf})(915 \text{ ft}) + (150 \text{ psf})(10 \text{ ft}) \times 12 \]

\[ P_D = 27.8 \text{ k} \]

\[ P_L = (12 \text{ psf})(915 \text{ ft}) = 10.98 \text{ k} \]

\[ q_{w1} = 3 \text{ ksf} \]

\[ A_{F1G} = P_D + P_L = \frac{27.8 \text{ k} + 10.98 \text{ k}}{3 \text{ ksf}} = 12.93 \text{ ft} \]

USE A 4'x4' CONCRETE FOOTING

DETERMINE THICKNESS

A) CHECK ONE-WAY SHEAR

\[ V_u = q_{w1} \left[ \frac{4 - d}{2} - d \right] \]

\[ q_{w1} = 1.2 P_D + 1.6 P_L + 0.5 P_w \]

\[ q_{w1} = 1.2(27.8 \text{ k}) + 1.6(10.98 \text{ k}) + 0.5(3 \text{ ksf}) \]

\[ q_{w1} = 353 \text{ ksf} \]
Check shear capacity

\[ \phi V_u = \phi (2 \frac{f_c}{f_p} \cdot b_d) = 0.75 \left( \frac{2 \times 4000}{70000} \right) (2 \cdot 0.7) \]

\[ \phi V_u = (1.28 \cdot 9.2 \cdot 70) \cdot \gamma \]

\[ V_u = \frac{9}{4000} \cdot 9.2 \cdot \gamma = (3.53 \times 10^3) \left[ \frac{4}{9} \cdot \gamma \cdot 0 \right] \]

\[ V_u = 5.589 + 0.2942 \gamma = 1.38 \gamma \]

\[ d = 3.9'' \quad \text{Use} \quad b = 9'' \]

\[ V_u = 5.589 + 0.2942 \gamma = 1.38 \gamma \]

\[ \phi V_u = 11.28 \gamma \left( \frac{9}{40} \right) \]

\[ V_u = 5'7" \gamma \frac{4}{12} \]

\[ V_u = 3.53 \times 10^3 \left[ \frac{\gamma - 0.7}{4} \cdot \gamma \right] = 4.17 \gamma \frac{4}{12} \]

Check 2 way

\[ L_0 = H_d + 2 \left( \frac{b_c \cdot c_o \gamma}{b \cdot c_o \gamma} \right) = (5') + 2 \left( \frac{10''}{16''} \right) \]

\[ L_0 = 16'' \]

Interior col. \( \gamma = 40 \)

Total col. \( \gamma = 1 \)

* By inspection

\[ \phi V_u = \phi 4 \cdot \frac{f_c^2}{f_p^2} \cdot b_d \cdot \gamma = 0.75 \left( 4 \right) \left( \frac{4000}{70000} \right) \left( 0.7 \right) \left( 5 \right) \]

\[ \phi V_u = 56.9 \gamma \]

\[ V_u = \frac{9}{4000} \left( \frac{L_0^2 - (b_c \cdot b \gamma^2)}{b} \right) = 3.53 \gamma \left( \frac{L_0^2 - (b \gamma^2)}{b} \right) \]

\[ V_u = 52.3 \gamma \]
CHECK FLEXURE

\[ Q_{\text{min}} = 6'' \quad \text{CHANGE} \quad h = 12'' \quad d = 8'' \]

\[ M_{u} = \frac{Q_{\text{min}} l^2}{2} = 3.53 \times 10^3 \times \left[ \frac{4 - \frac{12''}{2}}{2} \right]^\frac{1}{2} \]

\[ M_{u} = 4.42 \text{ k-ft} \]

\[ A_{c} = \frac{M_{u}}{f_{y} (\frac{12''}{8''})} = 0.147 \frac{\text{in}^2}{\text{ft}} \]

TRY (1) NO. 4 @ 12'' C.C.

\[ S = \frac{A_{s}}{b d} = \frac{12'' \times 8''}{12'' \times 8''} = 2.11\% \]

\[ A_{s, \text{min}} = \frac{3.53 \times 10^3}{f_{y}} - b w d = \frac{3.53 \times 10^3}{60,000} \times 12'' \]

\[ A_{s, \text{min}} = 0.083 \text{ in}^2/\text{ft} \]

**UP TO (1) NO. 9 @ 18'' C.C.**

*ADEQUATE DUE TO INSPECTION*

\[ 0.017 = \epsilon_{c} > 0.005 \quad \text{TENSION CONTROLLED} \]

\[ f_{\text{temp}} = \frac{0.0018 \times 60,000}{60,000} = 0.19\% \]

\[ A_{s, \text{temp}} = 0.259 \text{ in}^2/\text{ft} \]

USE (1) NO. 6 SPACED @ 18'' O.C.

4' x 4' x 1' CONCRETE FOOTING

W/ NO. 9'S @ 18'' O.C. SPACING (LONG. BAR)

W/ NO. 6'S @ 18'' O.C. SPACING (TEMP. & SHINING)


**BEAM TO GIRDER**

\[ V_u = 4.85k \quad M_u = 24.24k-ft \]

**BOLT CAPACITY**

\[ \phi R_{N} = \phi F_{n} A_b \]

\[ F_{n} = 90k \text{ksi} \]

\[ A_b = 0.397 in^2 \]

\[ \phi R_{N} = 0.75 \left( \frac{90k}{ksi} \right) \left( 0.397 \text{in}^2 \right) = 15.605k/ft \]

**USE (2) 5/8" BOLT: 31.3 k > 4.85k**

**BOLT BEARING**

\[ \phi R_{N} = 0.75 \frac{d E}{f_{u}} \leq 0.75 d E \]

\[ d = 5/8" \]

\[ E = 29,360 \text{ksi} \]

\[ \phi R_{N} = (0.75)(5/8)(29,360) = 29,360 \]

\[ \phi R_{N2} = (0.75)(5/8)(1.625)(29,360) = 21,200 \]

\[ d E = (2.4)(5/8)(29,360) = 160,312 \]

\[ \phi R_{N} = 2(160,312) = 320,624 > 4.85k \]
PLATE CHECK

\[ \Phi R_n = \Phi (0.6) f_y \cdot \frac{A_y}{t} = (1)(0.6)(58 \text{ksi})(0.25 \text{"}) \]

USE \( t = \frac{1}{4} \text{"} \) BECAUSE MIN. WELD = 3/16".

\[ \Phi R_n = 37.8 \text{ k} > 4.85 \text{ k} = V_u \checkmark \]

YIELD LIMIT STATE IS ADEQUATE

RIPURE

\[ \Phi R_n = \Phi (0.6) f_y \cdot \frac{A_y}{t} = (0.75)(0.6)(58 \text{ksi})(0.25 \text{"}) \]

\[ \Phi R_n = 35.9 \text{ k} > 4.85 \text{ k} = V_u \checkmark \]

RIPURE LIMIT STATE IS ADEQUATE

\[ \Phi R_n = \Phi (0.6) f_u \cdot \frac{A_t}{t} \pm \frac{U_b (f_u - f_y)}{f_y} \]

\[ \Phi R_n = 0.75 \left( \frac{5}{4} \right) (0.96875 \text{ ksi}) \]

\[ f_y = 58 \text{ ksi}, f_u = 30 \text{ ksi}, U_b = 1.0 \]

\[ A_t = \left[ \frac{2}{3} - (3/4) \right] (0.25 " ) = 0.40625 " \]

\[ \Phi R_n = 0.75 \left( \frac{5}{4} \cdot \frac{30 \text{ ksi}}{58 \text{ ksi}} \right) \left( 0.96875 \text{ ksi} \right) \]

\[ \Phi R_n = 0.75 \left( 0.6 \cdot \frac{0.96875 \text{ ksi}}{0.96875 \text{ ksi}} \right) + 1.0 \left( 58 \text{ ksi} \right) (0.40625 \text{ ksi}) \]

\[ \Phi R_n = 0.691 \text{ k} \leq 42.95 \text{ k} \]

\[ \Phi R_n = 42.95 \text{ k} \leq 46.0 \text{ k} \]

\[ \Phi R_n = 42.95 \text{ k} \leq 46.0 \text{ k} \]

\[ \Phi R_n = 42.95 \text{ k} \leq 46.0 \text{ k} \]

\[ \Phi R_n = 42.95 \text{ k} \leq 46.0 \text{ k} \]
**BEAM CHECK**

*UPSIZE W 16X31 TO A W 10X68 FOR CONSTRUCTIBILITY*

**BEAM IS CEPED, SO CHECK SHEAR**

\[ \phi V_{n} = \phi (0.6) F_{y} A_{w} C_{v} \]

\[ h/2w = \frac{10.7}{2.32} \leq 2.25 \sqrt{\frac{E_{f}}{F_{y}}} = 2.70 \]

\[ \phi V_{n} = 1 (0.6) (50ksi)(0.47)(10.4 - 0.774) \]

\[ \phi V_{n} = 121.68 k \geq 4.75 k = V_{u} \]

**MOMENT IN BOLT**

\[ \theta = 2.75^\circ + (3/4) 12^\circ = 2.875^\circ = \theta \]

\[ \phi A_{n} = 24.9k \]

\[ 4.85k = C_{x} (24.9k) \quad \therefore C_{x} = 0.19 \]

\[ C_{x} = 0.19 > 0.19 = C_{x,req} \]

**REQUIRED WELD**

\[ \theta = 7^\circ \]

\[ K = \frac{0.75}{2} \]

\[ C_{x} = 0.75 + 2.75 = 2.94 \]

\[ a = 2.94/\frac{1}{7} = 0.419 \]

\[ C = 2.06 \]
<table>
<thead>
<tr>
<th>Reference:</th>
<th>Answer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_{min} = \frac{P_u}{4.58k} = \frac{1.2}{0.75} - (0.75)(2.75)(7) = 0.33''$</td>
<td></td>
</tr>
<tr>
<td>$\phi = 3/16&quot;$ FILLET WELD</td>
<td></td>
</tr>
<tr>
<td>PLATE FLEXURE CHECK</td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{6} = \frac{2.75'}{0.25'}$</td>
<td>308</td>
</tr>
<tr>
<td>$0.06E/fy = 64.4$</td>
<td></td>
</tr>
<tr>
<td>$1.9E/fy = 1530$</td>
<td>VCE (F11-2)</td>
</tr>
<tr>
<td>$\phi M_{in} = \phi C_k \left[1.52 - 0.274 \frac{k_k}{k} \left(\frac{L}{d}\right) M_y\right]$</td>
<td></td>
</tr>
<tr>
<td>$M_y = F_y S_x = (36k)(0.25')(7')^2 = 73.5 \text{k-in}$</td>
<td></td>
</tr>
<tr>
<td>$M_p = F_y Z_x = (36k)(0.25')(7')^2 = 110.25 \text{k-in}$</td>
<td></td>
</tr>
<tr>
<td>$0.9 \left[1.52 - 0.274 \left(\frac{308}{3000}\right)\right] 73.5 \text{k-in} = 93.62 \text{k-in}$</td>
<td></td>
</tr>
<tr>
<td>$93.62 \text{k-in} &lt; 110.25 \text{k-in}$</td>
<td></td>
</tr>
<tr>
<td>$M_u = V_u \cdot c = (4.85k)(2.75') = 13.4 \text{k-in}$</td>
<td></td>
</tr>
<tr>
<td>$\phi M_n = 93.62 \text{k-in} &gt; 13.4 \text{k-in} = M_u$</td>
<td></td>
</tr>
<tr>
<td>Reference:</td>
<td>Answer:</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>BEAM SPICE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>J6:</strong> PLATE SHALL CARRY LOADS ON SMALLER BEAM AT POINT OF SPICE,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 x 4&quot; x 1/4&quot; W (2) 5/8&quot; O BOLTS</td>
</tr>
<tr>
<td></td>
<td>IS ADEQUATE FOR SIMILAR LOADS TO THE BEAM TO GIRDERS CONNECTION</td>
</tr>
</tbody>
</table>
**DESIGN OF FERMENTATION ROOF TRUSS**

**VULCRAFT CATALOG**

- **12' FAN:** 24'11/16' / 20'6" = 20'6" = 
- **W_d = (P_s * W_o) / 20'6" = (20'6" / 20'6") * 20'6" = 20'6"**
- **W_o = 162' 8"/16**
- **W_o = 10'12" / 8 = 1'12"**

- \[ W_u = \frac{1}{2} W_o + 1.6 W_i = 1.7 (10'12") + 1.6 (10'12") \]
- \[ W_u = 250' 41/2" \]

**SPAN: 40'-0"**

**VULCRAFT K SERIES 24K OR IS**

- ADEQUATE WITH A STRENGTH CAPACITY OF 304 KSF & A DEFLECTION LIMIT OF (0.05L) b = 2G2-51/2" FOR A SPAN OF 40'-0" & SPACING OF 4'-0" O.C.

**DESIGN MEETING ROOM DECK**

**VERCO CATALOG**

- \[ q_p = 900 psf \]
- \[ q_w = 50 psf \]
- \[ q_n = 900 psf + 50 psf = 900 psf \]

**USE W2 FORMOK CAGE 20 WI 4" TOTAL SLAB DEPTH: ADEQUATE FOR SPAN OF 7'-6" CAN I: 37" R"" PSF**
Reference: DESIGN MEETING ROOM BEAM

SPAN: 14'-6"
SPACING: 7'-0"

\( q_v = 80 \, \text{psf} \)
\( q_v' = 50 \, \text{psf} \)

\( a_{q_u} = 1.29q + 1.69q' = 1.2(80 \, \text{psf}) + 1.6(50 \, \text{psf}) \)
\( a_{q_u} = 176 \, \text{psf} \)

\( w_u = a_{q_u} \cdot w' = (176 \, \text{psf}) \cdot (r) = 17.23 \, \text{k/ft} \)

\( v_u = w_u \cdot \frac{(1.23 \, \text{k/ft}) (14.6)}{2} = 8.92 \, \text{k} \)

\( M_u = \frac{w_u \cdot L^2}{8} - \frac{(1.23 \, \text{k/ft}) (14.6)^2}{8} = 32.3 \, \text{k-ft} \)

Answer:

DESIGN FOR FLEXURE:

\( M_u = 32.3 \, \text{k-ft} \)

AISI360
TOL 3-2

\( 2b = 0 \) (CONT. BRAZED) \\
\( \phi M_p = \phi M_n \)

USE W8x13 \( \Rightarrow \phi M_n = 42.8 \, \text{k-ft} \)

CHECK SHEAR:

\( \phi V_n > V_u \)

\( V_u = 8.9 \, \text{k} \)
\( \phi V_n = 55.1 \, \text{k} \)

\( \phi V_n > V_u \) \( \checkmark \)
Reference:

CHECK DEFLECTION

\[ \Delta_{\text{all}} = \frac{L}{240} \left(14.5 \text{ (in)}\right) = 0.725'' \]

**Answer:**

\[ \Delta_{\text{all}} = 0.725'' < \Delta_{D} \]

**Answer:**

\[ \Delta_{\text{all}} = 0.728'' < 0.96'' \]

**WNB is adequate for a span of:**

14'-0'' & P = 32 kips & V = 8.7 kips

\[ \Delta_{D} = 0.485'' \]

\[ \Delta_{D+I} = 0.79'' \]
Reference:

\[ \begin{align*}
V_u &= 8.92 \text{k} \\
M_u &= 24.24 \text{k-ft}
\end{align*} \]

**Bolt Capacity**

\[ \begin{align*}
&\phi R_n = 15.03 \text{k/bolt} \quad \sim \text{USE (2) 5/8" bolt} \\
&\phi R_n = 31.3 \text{k} > 8.92 \text{k}
\end{align*} \]

**Bolt Bearing**

\[ \begin{align*}
&\phi F_n = 29.30 \text{k} \\
&\phi F_n = 21.2 \text{k} \\
&\phi F_n = 2.4 \text{at} \; \phi F_u = 16.3 \text{k}; \quad \phi F_n = 32.62 \text{k} > 28 \text{kip}
\end{align*} \]

**Check Plate**

\[ \begin{align*}
&\phi F_n = 37.8 \text{k} \quad \text{YIELD} \\
&\phi F_n = 35.9 \text{k} \quad \text{RUPTURE} \\
&\phi F_n = 42.9 \text{k} \quad \text{BLOCK} \; \text{SHEAR}
\end{align*} \]

**Beam Check**

\[ \begin{align*}
&W8 \times 31 \text{ beam} \\
&\phi V_n = \phi (0.6) F_y A_w C_r \\
&h/\phi F_n = 29.9 < 2.24 \sqrt{F_y} \\
&\phi V_n = (1.0)(0.6)(50 \times 5)(0.23)(7.91 - 0.250 \times 10)^{-1.0} \\
&\phi V_n = 46.3 \text{k} > 8.92 \text{k} = V_u
\end{align*} \]
Reference:

MOMENT IN BOLTS

\[ e = 2.75 + 3/4 \times 1/2 = 2.375 \approx 3'' \]

\[ \phi R_n = 24.9 \text{k} \]

\[ 2.92k = C_x \times 24.9k = 0.358 = C_x \times \text{min} \]

\[ e = 3'', \ 2 \text{ BOLTS} \]

\[ C_x = 0.358 > 0.258 \]

WELD DETAILED

\[ e = 1'', \ \kappa = \frac{0.75}{2} = 0.375 \]

\[ C_x = 0.75, \ 2.75 = 2.94 \]

\[ \alpha = 2.94 / 3'' = 0.419, \ \beta = 2.06 \]

\[ \alpha_{min} = \frac{C_x}{4C_x + \alpha} = \frac{8.92}{0.692} = 0.638 \]

USE A 1\frac{1}{16}'' FILLET WELD

PLATE FLEXURE CHECK

\[ f_x = 308, \ \frac{1}{f_y} = 61.4, \ \frac{1}{f_y} = 1530 \]

\[ M_y = F_y x = 73.5 \text{k-n} \]

\[ M_y = F_y (2.75'' \times 110.25 \text{k-n} \times 2.75'') = 9367 \text{k-n} \]

\[ M_y = V_x e = (892 \text{k}) (2.75'') = 24.58 \text{k-n} \]

\[ \phi M_y = 98.62 \text{k-n} = 24.58 \text{k-n} = M_y \]
Reference:

STEEL DECK DESIGN

\[ D + C = q_{DL} + q_{LL} = 170 \text{psf} + 100 \text{psf} = 270 \text{psf} \]

VELLO DECK CATALOG

GAGE 18 PLWZ 5 1/2" TOTAL DEPTH

GALVANIZED FORMWORK. VELLO COMPOSITE DECK (1 WOOL) IS ADEQUATE

\[ q_{U} = 330 \text{psf} > 270 \text{psf} = q_{L} \]

DESIGN STEEL BEAM (H.S.S.)

LOAD PANEl

\[ q_{D} = 230 \text{psf}, \quad q_{U} = 100 \text{psf} \]

\[ A_U = (6.6 \times 110) \text{in}^2 = 666 \text{in}^2 \]

: NO LIVELOAD REDUCTION

ACUTE:

1.2(230psf) + 1.0(100psf) = 430psf

\[ V_u = \frac{W_u L}{2} = \frac{q_u w_c l}{2} = \frac{(430 \text{psf})(6.6 \text{in})(20 \text{in})}{2} \]

\[ V_u = 29.1 \text{k} \]

\[ M_u = q_u w_c l^2 (930 \text{psf})(6.6 \text{in})(20 \text{in})^2 = 149.3 \text{k-ft} \]

DESIGN FLEXURE

AISC 310

TOL 3-12 USE H.S.S. 12 x 4 x 1/2" CAPACITY = 161 k-ft

CAPACITY = 161 k-ft > 149.3 k-ft = DEMAND
**CHECK SHEAR**

\[ \phi V_n = \phi \left( \frac{0.6 (fy \cdot Aw) C_y}{E_I} \right) \]

\[ \frac{b}{h} = 0.6, \quad \frac{h}{b} = 2.22 \]

\[ 1.1 \cdot K \cdot E / k_y = 1.1 \cdot 5 \cdot \frac{2400}{80} = 69.76 \]

\[ 0.6 \cdot w \cdot 1.1 \cdot K \cdot E / k_y = 0.6 \cdot 69.76 = 41.86 \]

\[ \phi V_n = \phi \cdot 0.6 \left( \frac{49000 \cdot (1.4 \cdot 0.465)}{1.4 \cdot 59000 \cdot 2100 \cdot 10^6} \right) = 0.8 \]

\[ \phi V_n = 92.4 \rightarrow 29.1 K \]

**DESIGN DEFLECTION**

\[ I_p = 2.1 \text{in}^4 \]

\[ 18C20 \frac{5}{8} \]

\[ \Delta_{\text{-all}} = \frac{L}{240} \cdot 10^{-6} = 0.5 \]

\[ \Delta_p = \frac{5wL^4}{24EI} = \frac{5 \cdot (240 + 5L) \cdot (1.0) \cdot (120)^4}{284 \cdot (2.5 \cdot 10^6 \text{in}^4) \cdot (2100 \text{in}^6)} = 0.05 \]

\[ 0.05 > 0.03 = \Delta_{\text{all}} \]

\[ 18C20 \frac{5}{8} \]

\[ \Delta_{t+\text{all}} = \frac{L}{180} = \frac{120}{180} = 0.66 \]

\[ \Delta_{\text{all}} = \frac{5wL^4}{24EI} = \frac{5 \cdot (240 + 5L) \cdot (1.0) \cdot (120)^4}{284 \cdot (2.5 \cdot 10^6 \text{in}^4) \cdot (2100 \text{in}^6)} = 0.00 \]

\[ 0.00 < 0.166 = \Delta_{t+\text{all}} \]
Reference:

HSS 12x4x1/4 is adequate for a span of 10.0' with a spacing of 6.0'

\[ M_u = 115.3 \text{ k} \cdot \text{ft}, \ V_u = 20.1 \text{ k} \]
\[ A_0 = 6.05", \ A_0 = 0.08" \]

Answer:

DESIGN COLUMN

\[ P_D = 9.2 \cdot A_t = \left(295 \text{ ksf}\right)\left(6.0"\right)\left(10.0/2\right) = 8.16 \text{ k} \]
\[ P_t = a_t \cdot A_t = \left(1000 \text{ ksf}\right)\left(6.0"\right)\left(10/2\right) = 3.3 \text{ k} \]

1) \[ 1.2P_D + 1.6P_t = 1.2\left(8.16 \text{ k}\right) + 1.6\left(3.3 \text{ k}\right) = 15.13 \text{ k} \]

Use HSS 4x4x1/8 is adequate for a \( \theta = 40^\circ \) and a demand of \( 15.13 \text{ k} \)

\[ P_D = 9.17 \text{ k} \]
Design Tank Room Isolated Footing

\[ A_{\text{fig}} = \frac{P_0 + P_1}{q_{\text{unit}}} = \frac{(8.10K + 3.8K)}{3K\text{sf}} = 4.17\]  

Use 2x2 SD Footing

\[ q_{\text{unit}} = \frac{P_1}{A_{\text{fig}}} = \frac{15.2K}{4.17} = 3.65K\text{sf} \]

**Determine Thickness**

\[ V_u = q_{\text{unit}} \left( \frac{1 - \frac{d}{2}}{2 - \frac{d}{2}} \right) \]  

\[ V_u = 3.65K\text{sf} \left( \frac{1 - 0.64}{2 - 0.64} \right) \]

\[ V_u = 3.16K - 3.8K \]

\[ \phi V_u = 0.6 (2.15) (0.139d) = 0.139d = 3.16K - 3.8K \]

\[ d = 0.64" \]

\[ \delta_{\text{min}} = 8" \]  

**One Way Shear is Adequate Due To Inspection**

**Check 2 Way**

\[ d_0 = 4\left(\frac{8}{2}\right) + 2\left(\frac{10}{2}\right) = 4(8") + 2(10") \]

\[ d_0 = 48" \]

**Interior**: \( N = 40 \)

**Eqn 31 for 2 Way Shear Will Govern**
$\phi V_c = 0.75 \sqrt[6]{4''} \sqrt[6]{48''} = 72.86 k$

$V_m = 0.9 \left( \frac{1}{L} \right) \left( \frac{h_c + d}{2} \right) = 3.8 k \left( \frac{2''}{\frac{1}{2}'' + \frac{3}{12}''} \right) = 11.4 k$

**CHECK FLEXURE**

$M_u = \frac{3}{2} \int_{\frac{1}{12}}^{\frac{1}{2}} \left[ \frac{Z}{2} - 4'' \right] \frac{1}{12} \left[ \frac{Z}{2} - 4'' \right] dz$

$M_u = 1.32 k-ft$

$P_{min} = \frac{V_c}{E} = 0.003162$

$A_s = (0.003162) (12'') (\frac{1}{12}) = 0.304 \Phi/ft$

*USE NO. 5 (6'') E.C.K. SPACING*

$A_g = (0.314) (60'') = 0.35$ ft

$e = \frac{A_g}{A_s} = 0.556$

$\varepsilon = \frac{P_{min}}{E} = \frac{0.003162 (160k/\Phi)}{6000 psi} = 0.04299$

$\phi = 0.9 \Rightarrow TENSION \ CONTROLLED$

$0.9 \mu A_s (d - a_k) = 0.9(0.314) (60'') (0.314) \frac{1}{6'' - 0.314''}$

$M_{min} = 10.84 k-ft > M_u$
Reference:

\[ \text{Stemp} = \frac{0.0018 \times 60000}{60000} = 0.0018 \]

\[ A_{\text{Stemp}} = 0.259 \text{ ft}^2 \]

Use No. 6 @ 18" C.C. Spacing

2x2x1 Isolated Col. Footing

W/ No. 5s @ 12" C.C. Spacing &

W/ No. 6s @ 18" C.C. Spacing
Gravity: Barrel Aging Room
Barrel Vaulting Room
## Dead Load (Barrel Aging)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Beam (psf)</th>
<th>Column (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil (4.5 ft deep)</td>
<td>495</td>
<td>495</td>
<td>495</td>
</tr>
<tr>
<td>2&quot; Rigid Insulation</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Drainage Membrane</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>12&quot; N.W. Conc. Slab</td>
<td>N/A</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>36&quot; Deep Beam</td>
<td>N/A</td>
<td>N/A</td>
<td>21</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>N/A</td>
<td>N/A</td>
<td>3.0</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>15.5</td>
<td>33.5</td>
<td>36.5</td>
</tr>
<tr>
<td>Total</td>
<td>515</td>
<td>685</td>
<td>715</td>
</tr>
</tbody>
</table>

## Live Load (Barrel Aging)

Live Load (Yards and Terraces): 100 psf
### Dead Load (Barrel Vaulting)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Deck (psf)</th>
<th>Wall (psf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil (6 ft deep)</td>
<td>660</td>
<td>660</td>
</tr>
<tr>
<td>2&quot; Rigid Insulation</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Drainage Membrane</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Vapor Barrier</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>12&quot; N.W. Conc. Slab</td>
<td>N/A</td>
<td>150</td>
</tr>
<tr>
<td>MEP</td>
<td>N/A</td>
<td>2.0</td>
</tr>
<tr>
<td>Sprinklers</td>
<td>N/A</td>
<td>3.0</td>
</tr>
<tr>
<td>Misc. + Slope Factor</td>
<td>25.5</td>
<td>32.5</td>
</tr>
<tr>
<td>Total</td>
<td>690</td>
<td>863</td>
</tr>
</tbody>
</table>

### Live Load (Barrel Vaulting)

Live Load (Yards and Terraces): 100 psf
Reference:

\[ t = \frac{L}{24} = \frac{20.5}{2.9} = 10.25" \]

Try 12" slab

Live Load Reduction

Yard & Terrace Loading: Use AISC 7.3.4.7

Load Takeoff

\[ a_t = \frac{20.5}{60} = 1230 \text{ psf} \]

\[ a_t \text{ shall not exceed } 1.5 \left( \frac{20.5}{20.5} \right) \]

\[ a_t = 1230 \text{ psf}, \quad k_{ul} = 1.0 \]

\[ L_p = 1.0 \left( 0.25 + \frac{15}{W_{LLAC}} \right) = 0.99 \left( 0.847 \right) \]

\[ L_c = 54.75 \text{ psf} \]

Combine Loads

1) \[ 1.4D = 1.4 \left( 515 \text{ psf} \right) = 721 \text{ psf} \]

2) \[ 1.2D + 1.6L = 1.2 \left( 515 \text{ psf} \right) + 1.6 \left( 54.75 \text{ psf} \right) \]

\[ q_{ul} = 753.6 \text{ psf} \quad (\text{from L.C. 2}) \]
ACI 318-14 TBL 6.5.2

\[ M_u = \frac{wL^2}{10} = \frac{753.6 \text{ ksf} (20.5) \text{ ft}}{10} = 15072 \text{ k-ft} \]

\[ M_u = 31.67 \text{ k-ft/ft} \]

\[ N_u = 1.15 (wL) = 1.15 (753.6 \text{ ksf}) (20.5) \]

\[ N_u = 16544 \text{ k-lbf} \]

\[ V_u = 0.88 \text{ k-lbf} \]

\[ M_{u,4} = \frac{wL^2}{14} = \frac{(753.6 \text{ ksf}) (20.5) \text{ ft}}{14} = 10142 \text{ k-ft} \]

\[ d_+ = 12'' - 0.75'' - \frac{0.75''}{2} = 10.875'' \]

\[ d_- = 12'' - 1.5'' - \frac{0.75''}{2} = 10.125'' \]
SIZING NEGATIVE MOMENT REIN.

\[ M_{u_1} = A_s f_y \left( d - \frac{d}{2} \right) \approx A_s f_y (d - \frac{d}{2}) \]

\[ A_s = \frac{M_{u_1}}{f_y \left( d - \frac{d}{2} \right)} = \frac{3167 \text{ kips}}{60 \text{ ksi} \cdot (10.125 - 5)} \]

\[ A_s = 0.75 \text{ ft}^2 \]

*TRY (1) NO. 6 @ 6" U.C. SPACING

\[ a = \frac{A_s f_y}{0.85 f_y b} = \frac{(0.75)(60 \text{ ksi})}{0.85(4 \text{ ksi})(12)} = 1.294 \]

\[ c = \frac{a}{b} = \frac{1.294}{12} = 0.12 \]

\[ \left( \frac{a}{c} \right)_{\text{cu}} = 0.0172 < 0.005 \]

TENSION CONTROLLED \( \Rightarrow \phi = 0.9 \)

\[ \phi M_a = 0.9 A_s f_y \left( d - \frac{d}{2} \right) = 0.9 (0.75)(60 \text{ ksi})(10.125 - 5) \]

\[ \phi M_a = 37.5 \text{ kips} < 31.67 \text{ kips} \]

SIZING POSITIVE MOMENT REIN.

\[ M_{u_1} = A_s f_y \left( d - \frac{d}{2} \right) \approx A_s f_y (d - \frac{d}{2}) \]

\[ A_s = \frac{22.63 \text{ kips}}{60 \text{ ksi} \cdot (10.125 - 5)} = 0.56 \text{ ft}^2 \]
TRY (1) NO. 7 @ 12" O.C.

\[ A_{\phi} = 0.6 \phi \Rightarrow \phi = \frac{A_{\phi}}{0.6 \phi} = \frac{60}{0.6 \phi} = 100 \phi \]

\[ a = 0.88'' \]

\[ c = a / 8 = 0.047'' / 8 = 0.006'' \]

\[ \frac{d - c}{c} (\epsilon_{cd}) = 0.029 > 0.005 \]

TENSION CONTROLLED \( \Rightarrow \phi = 0.3 \)

\[ \phi_{MN} = \phi_{R} \frac{f_{y} (d - a / 2)}{f_{c}} \]

\[ \phi_{MA} = 0.9 \frac{0.6 (d - 10.875'' / 2)}{0.88''} \]

\[ \phi_{MN} = 28.2 \text{ k-ft} > 22.63 \text{ k-ft} \]

CHECK SHEAR

\[ V_{w} = 8.88 \text{ k} \]

\[ (c) V_{c} = 0.2 \frac{2 \times 10^{4}}{f_{c}} b \omega d = 0.75 (2) (10) (4000) (12) \times 0.0125'' = 11.53 \text{ k} > 8.88 \text{ k} \]

CHECK REINF. FOR CRACKING @ TOP

\[ M_{\text{max}} = \text{LESSER OF} \]

\[ 18 \left( \frac{10000}{21.6 f_{y}} \right) - 2.5 \phi_{c} = 11.25'' \]

\[ M_{\text{max}} = 12 \left( \frac{40000}{21.6 f_{y}} \right) = 12'' \]

\[ M_{\text{max}} = a'' \phi_{c} \]

\[ M_{\text{max}} = a'' \phi_{c} @ \text{TOP} \]
CHECK REINF. FOR CRACKING @ BOTT.

\[ N_{\text{MAX}} = \text{LEESER OF} \]

- \[ 15 \left( \frac{0.125}{3.83} \right) - 2.5c_e = 13.1'' \]
- \[ 12\left( \frac{4.5}{1.35} \right) = 12'' \]

\[ N_{\text{MAX}} = 36'' \text{ or } 18'' \]

\[ N_{\text{MAX}} = 12'' \text{ at bottom} \]

SIZE TEMP STL.

\[ A_{\text{MIN}} = 0.0013(A_g) = 0.259 \# \]

\[ N_{\text{MAX}} = 51'' \text{ or } 18'' \Rightarrow 18'' = N_{\text{MAX}} \]

(1) NO. 4 @ 18'' SPACING IS ADEQUATE T&S STEEL.

12'' DEEP SLAB IS ADEQUATE WITH (1) NO. 6 @ 6'' C.C. SPACING FOR (2) MOM. REINFORCEMENT (1) NO. 7 @ 12'' C.C. SPACING FOR (4) MOMENT & NO. 4.5 @ 18'' C.C. SPACING FOR TEMP & SHEAR FORCE.
DESIGN OF TYP. BEAM (CONC.)

SPAN: 20'-0"

TRIB. WIDTH: 20'-6"

APPROXIMATE BEAM DEPTH

\[ t = \frac{2}{18.5} = \frac{(20')(12')}{18.5} = 13'' \]

\[ t = 13'' + 12'' \text{ (SLAB DEPTH)} \]

\[ t = 26'' \text{ DEEP} \]

TRY: 26'' DEEP \times 12'' WIDE

LOADING

LOAD TAKEOFF

\[ W_D = 0.9V_D, \quad W_U = (0.65 \text{psf})(20'' \cdot 6') \]

\[ W_D = 14,043 \text{ k/ft} \]

LIVE LOAD REDUCTION:

\[ L_L = L_0(0.25 + \frac{15}{2(410\text{/ft})}) \]

\[ L_0 = 100 \text{ psf}, \quad K_{LL} = 2.0, \quad f_t = (20')(20.5) \]

\[ L_L = 100 \text{ psf} \left( 0.25 + \frac{15}{2(410\text{/ft})} \right) A_t = 410\text{ft} \]

\[ L_L = 77.4 \text{ psf} \]
### Basic Load Cases

<table>
<thead>
<tr>
<th>BLC Description</th>
<th>Category</th>
<th>X Gravity</th>
<th>Y Gravity</th>
<th>Joint</th>
<th>Point</th>
<th>Dist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>DL</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>LL</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>LL</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Load Combinations

<table>
<thead>
<tr>
<th>Description</th>
<th>Solve</th>
<th>PDelta</th>
<th>SRSS</th>
<th>BLC</th>
<th>Factor</th>
<th>BLC</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>1.2</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>3</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>1</td>
<td>1.2</td>
<td>3</td>
<td>1.6</td>
</tr>
</tbody>
</table>

#### Dead Load

![Dead Load Diagram]

#### Live Load A

![Live Load A Diagram]

#### Live Load B

![Live Load B Diagram]
Maximum Positive Moment (LC 2)

Member M1

Maximum Negative Moment (LC 3)

Maximum Shear (LC 1)
\[ W_L = 9W_L \cdot W_B = (77.4\, \text{kips})(20.5') = 1587\, \text{kips} \]

**Factored: RISA Given Demands**

- \[ M_{uL} = 774.9\, \text{kips} \cdot \text{ft} \]
- \[ M_{uT} = 534.8\, \text{kips} \cdot \text{ft} \]
- \[ V_u = 220\, \text{kips} \]

**Modeling Information**

- Model all boundary conditions as fixed
- 12\, \text{x}\, 20\, \text{ft} Beam
- 12\, \text{in}. Diameter, Spiral
- \( h_{col} = 6\) (half of column height)
- Span = 20\, \text{ft}, \( h = 6\, \text{ft} \)
- Skip loading by AGI 315 $\phi(6.4.2)$
Reference:

**DESIGN LONGITUDINAL BARS (NEGATIVE)**

\[
M_u = 7.749 k\text{-feet}
\]

\[
M_u = \phi M_p = \phi f_y A_b \left( a - \frac{a}{b} \right)
\]

\[
A_{req'd} = \frac{M_u}{\phi f_y b d} = \frac{7.749 \text{-feet}}{0.9(60 \text{ksi})(5^\circ / 2)}
\]

\[
d = 2.3^\circ - 1.5^\circ - 0.375^\circ - 10'' = 23.025''
\]

\[
A_{req'd} = \frac{(7.749 \text{-feet})}{0.9(60 \text{ksi})(5^\circ / 2)} = 8.74\text{''}
\]

**TOO LARGE**

BUMP TO \(36^\circ \times 18''\)

\[
d = 36^\circ - 1.5^\circ - 0.375^\circ - 1.25^\circ = 33.5''
\]

\[
A_{req'd} = \frac{M_u}{\phi f_y b d} = \frac{5(1.237\text{ksi})(60 \text{kpsi})}{0.85(45 \text{kpsi})(18^\circ)}
\]

\[
A_{req'd} = 0.14\text{''}
\]

**TRY** (5) NO. 10's

\[
d = 36^\circ - 1.5^\circ - 0.375^\circ - 1.25^\circ = 33.5''
\]

\[
a = \frac{A_{req'd}}{0.85(45 \text{kpsi})(18^\circ)} = 6.22\text{''}
\]

\[
\alpha = \frac{a}{d} = \frac{6.22}{0.85} = 7.32''
\]

\[
E_{S} = \frac{a - \alpha}{c} (E_{01}) = \frac{33.5 - 7.32}{7.32}\text{(0.003)}
\]
\[ \varepsilon_s = 0.0167 > 0.005 \quad \Rightarrow \quad \text{TENSION CONTROLLED} \]
\[ \phi M_n = \phi F_y A_s (d - a/2) \]
\[ \phi M_n = 0.9 (600 k = \phi) (33.5625 - 5.88) \]
\[ \phi M_n = 820.8 k - \phi \]

TRY \((d, a) = 9.5\)

\[ A_s = 0.1 (d/a) = 6.7 \quad \Rightarrow \quad D = 26 - 1.5 \cdot 0.375 - 1.25 \]
\[ \alpha = \frac{A_s \phi_f}{0.85 f_y} = \frac{(6.7)(0.99)}{0.85(4.5)} = 5.88'' \]
\[ c = \sqrt{\frac{a}{D}} = 8.91'' / 0.85 = 6.91'' \]
\[ \varepsilon_s = \frac{(d-c)}{c} = \frac{33.5625 - 6.91}{6.91} \]
\[ \varepsilon_s = 0.0115 > 0.005 \quad \Rightarrow \quad \text{TENSION CONTROLLED} \]
\[ \phi M_n = 0.9 (600 k = \phi) (33.5625 - 5.88) \]
\[ \phi M_n = 820.8 k - \phi \]

TOLERANCE: \(18'' - 2(1.5'') - 2(0.375) - (6.125) - 5''\)

TOLERANCE: \(2.5'' \checkmark\)
TRY (7) NO. 8

\[ A_5 = 7(0.79\,\text{in}) = 5.53\,\text{in}^2 \]
\[ d = 30" - 1.5" - 0.375" - 1\frac{1}{2}" = 33.625" \]
\[ a = A_5/F_y \times (5.53\,\text{in})(60\,\text{ksi})/0.25(4\,\text{ksi})(18") \]
\[ a = 6.42" \]
\[ a/v_y = 0.42(4.85) = 6.378" \]
\[ \varepsilon_s = \frac{d - c}{c} \times \varepsilon_y = \frac{33.625 - 4.85}{4.85} = 0.003 \]
\[ \varepsilon_s = 0.028 > 0.005 \text{ in tension controlled} \]
\[ \phi m_0 = 0.9(0.85)(0.42) \]
\[ \phi m_0 = 0.7(0.85)(5.53)(33.625 - 6.42)/2 \]
\[ \phi m_0 = 769.3k - \text{FILS} \]

USE (a) NO. 9's AS NEGATIVE BENDING REIN.
Reference:

**DESIGN POSITIVE FLEXURE REINFORCING**

**Answer:**

\[ M_{w+} = 554.8 \text{ k-ft} \]

\[ \text{TREY (5) NO. 6's} \]

\[ A_s = \frac{5 \times 0.79}{30 - 15 - 0.375 - \frac{10}{2}} = 33.6 \text{ in}^2 \]

\[ b_{eff} = \frac{8(1.25)}{96} = 0.85 \text{ in} \]

\[ c_{min} = \frac{11}{20} = 0.55 \text{ in} \]

\[ \alpha = \frac{A_s f_y}{A_{eff} f_{y,ed}} = 0.89 \]

\[ \varepsilon_s = \frac{2340^2}{1.08} = 1.05 \]

\[ \varepsilon_s = 0.193 \times \varepsilon_{0} = 0.05 \text{ in} \]

\[ f_{m0} = 0.9(0.85)(2.85^2) = 589.7 \text{ k-ft} \]

\[ \varepsilon_{0} = \frac{d-C}{C} = \frac{33.6 - 27.5}{27.5} = 0.102 > 0.005 \]

\[ \phi = 0.9 \]

\[ \text{TREY (6) NO. 7's} \]

\[ A_s = 3.6 \text{ in}^2, \quad d = 36.5 \text{ in} \]

\[ R = \frac{A_s f_y}{0.85 f_{y,ed}} = \frac{(3.6)(60)}{0.85(46)} = 0.814 \]

\[ c = \frac{0.55}{0.85} = 0.65 \]

\[ \varepsilon_s = \frac{d-C}{C} = \frac{33.6 - 27.5}{27.5} = 0.102 > 0.005 \]

\[ \phi = 0.9 \]
Reference:

\[
OM_0 = \phi_f y A_s (a - 9\frac{1}{2}) = 0.9 (3.64) (0.625) (353,687.5 - \frac{0.144}{2})
\]

Answer:

\[
OM_0 = 539.14 \text{ k}\text{ft} \quad \text{UNDER CAPACITY}
\]

For ease of the consist,

USE (5) NO. 8'S AS POSITIVE REINFORCEMENT & (5) NO. 10'S AS NEGATIVE MOMENT REINFORCEMENT.

CHECK AS MIN

a) \( \frac{3.35'}{3600} - \frac{8.4000}{60,000} \)

As\(_{\text{min}} = 1.91\)

b) \( \frac{2.3'}{3600} - \frac{200}{60,000} \)

As\(_{\text{min}} = 2.01\)

ACI 318-08

(9.6.1.7)

\( A_{\phi} \geq A_{\text{min}} \)
CHECK SHEAR

\[ V_{n} = 226k \quad (TRY \ NO.4 \ TIES) \]

\[ V_{n,\text{design}} = 226k - (22.6k/\text{foot}) \times 33.625^1/2 = 163k \]

\[ \phi V_{c/2} = 0.75 \times \frac{2b}{h} = 0.75 \times \frac{2 \times 3}{4} = 0.75 \times 1.5 = 1.125 \]

\[ 0.72 < 1.125 \quad \text{STIRUPS ARE REQUIRED} \]

\[ N_{n,\text{reqd}} = \frac{V_{n,\text{design}} - V_{n}}{V_{n,\text{design}}} = \frac{163k - 57.4k}{163k} = 0.75 \]

\[ \sqrt{V_{n,\text{reqd}}} = 5.7'' \quad \text{and} \quad N = 4'' \]

*ADD INTERMEDIATE TIES TO REDUCE SPACING*

Diagram:

- (5) No. 10's
- No. 4 @ 8" spacing
- (5) No. 8's
- Section 18"
Reference:

\[ \text{Answer:} \]

\[ S_{reqv} = \frac{0.05(0.05)(0.45)(2.025)}{103k - 51.4k} = 0.3'' \]

\[ \alpha_{N} = 6º \]

**Option 1:** No. 4's @ 8" o.c. Av = 0.8#

**Option 2:** No. 3's @ 6" o.c. Av = 0.44#

\[ f_{max} = \frac{0.2}{2} \text{ or } \frac{0.1}{2} \Rightarrow f = \frac{1}{2} = 3.4'' \]

\[ \theta = f_{max} \Rightarrow M_{max} \geq N_{act} \]
Reference: ASCE-E 4.7-1

DESIGN CONC. COLUMN (SPIRAL)

\[ A_t = (21.5') 20' = 430 \text{ ft}^2 \]

\[ K_u = 4 \]

\[ L_t = 3.0 (0.25 + \frac{1}{\frac{24,000}{1,000}}) = 61.2 \text{ psf} \]

COMBINE LOADS

1) \[ 4.07 = (1.4)(75 \text{ psf}) = 100 \text{ psf} = q_{w1} = \text{ COVERING} \]

\[ P_{w1} = (100 \text{ psf})(430 \text{ ft}^2) \cdot \frac{1}{1,000} = 430,500 \text{ lbs} \]

*CHECK SP COLUMN FILE*

\[ \phi P_a = 458,200 \text{ K} > P_{w1} \]

DESIGN CONC. COLUMN (RECTANGLE)

\[ A_t = 20' \cdot 20' = 400 \text{ ft}^2 \]

\[ K_u = 4 \]

\[ L_t = 3.0 (0.25 + \frac{1}{\frac{24,000}{1,000}}) = 62.5 \text{ psf} \]

COMBINE LOADS

\[ q_{w1} = 1.4q_{w1} = 1.4(75 \text{ psf}) = 100 \text{ psf} \]

\[ P_{w1} = q_{w1} A_t = (100 \text{ psf})(430) = 400,400 \text{ lbs} \]

\[ \phi P_n = 440,160 \text{ K} \]
General Information:
- File Name: u:\13. 4th year\senior project\1. gravity\risajspcolun\sp column.col
- Project: Fermentation com cl (spiral)
- Column: Cl (spiral)
- Code: ACI 318-11
- Engineer: kcm
- Units: English
- Run Option: Investigation
- Column Type: Structural

Material Properties:
- f'c = 4 ksi
- fy = 60 ksi
- Ec = 3605 ksi
- Es = 29000 ksi
- Ultimate strain = 0.003 in/in
- Beta1 = 0.85

Section:
- Circular: Diameter = 12 in
- Gross section area, Ag = 113.097 in²
- Ez = 1017.88 in⁴
- Ex = 2 in
- Ey = 3 in
- Xc = 0 in
- Yc = 0 in

Reinforcement:
<table>
<thead>
<tr>
<th>Bar Set: ASTM A416</th>
<th>Size Diam (in)</th>
<th>Area (in²)</th>
<th>Size Diam (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>
</tr>
<tr>
<td>6</td>
<td>0.75</td>
<td>0.44</td>
<td>7</td>
<td>0.88</td>
</tr>
<tr>
<td>9</td>
<td>1.13</td>
<td>1.00</td>
<td>10</td>
<td>1.27</td>
</tr>
<tr>
<td>14</td>
<td>1.69</td>
<td>2.25</td>
<td>18</td>
<td>2.26</td>
</tr>
</tbody>
</table>

Confinement: Tied: #3 ties with #10 bars, #4 with larger bars. phi(a) = 0.8, phi(b) = 0.9, phi(c) = 0.65

Layout: Circular
- Pattern: All Sides Equal (Cover to longitudinal reinforcement)
- Total steel area: As = 4.60 in² at zbc = 4.24
- Minimum clear spacing = 1.95 in
- $ #7 Cover = 1.875 in

Control Points:

<table>
<thead>
<tr>
<th>Bending about</th>
<th>Axial Load P kip</th>
<th>X-Moment k-ft in</th>
<th>Y-Moment k-ft in</th>
<th>NA depth in</th>
<th>Dt depth in</th>
<th>eps_t</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 0 Max comp</td>
<td>426.5</td>
<td>-0.00</td>
<td>-0.00</td>
<td>31.22</td>
<td>9.69</td>
<td>-0.00207</td>
<td>0.650</td>
</tr>
<tr>
<td>0 Allowable comp</td>
<td>341.2</td>
<td>22.09</td>
<td>0.00</td>
<td>11.83</td>
<td>9.69</td>
<td>-0.00054</td>
<td>0.650</td>
</tr>
<tr>
<td>0 fs = 0.0</td>
<td>277.1</td>
<td>35.34</td>
<td>0.00</td>
<td>9.69</td>
<td>9.69</td>
<td>0.00000</td>
<td>0.650</td>
</tr>
<tr>
<td>0 fs = 0.5*fy</td>
<td>167.0</td>
<td>46.87</td>
<td>0.00</td>
<td>7.20</td>
<td>9.69</td>
<td>0.00103</td>
<td>0.650</td>
</tr>
<tr>
<td>0 Balanced point</td>
<td>78.7</td>
<td>50.97</td>
<td>0.00</td>
<td>5.73</td>
<td>9.69</td>
<td>0.00207</td>
<td>0.650</td>
</tr>
<tr>
<td>0 Tension control</td>
<td>-66.5</td>
<td>54.61</td>
<td>0.00</td>
<td>3.63</td>
<td>9.69</td>
<td>0.00500</td>
<td>0.900</td>
</tr>
<tr>
<td>0 Pure bending</td>
<td>-0.0</td>
<td>55.01</td>
<td>0.00</td>
<td>4.41</td>
<td>9.69</td>
<td>0.00359</td>
<td>0.779</td>
</tr>
<tr>
<td>0 Max tension</td>
<td>-259.2</td>
<td>0.00</td>
<td>0.00</td>
<td>4.41</td>
<td>9.69</td>
<td>9.99999</td>
<td>0.900</td>
</tr>
</tbody>
</table>

| -X 0 Max comp | 426.5            | -0.00            | -0.00            | 31.22       | 9.69        | -0.00207 | 0.650 |
| 0 Allowable comp | 341.2          | -22.09           | -0.00            | 11.83       | 9.69        | -0.00054 | 0.650 |
| 0 fs = 0.0     | 277.1            | -35.34           | -0.00            | 9.69        | 9.69        | 0.00000  | 0.650 |
| 0 fs = 0.5*fy  | 167.0            | -46.87           | -0.00            | 7.20        | 9.69        | 0.00103  | 0.650 |
| 0 Balanced point | 78.7             | -50.97           | -0.00            | 5.73        | 9.69        | 0.00207  | 0.650 |
| 0 Tension control | -66.5           | -54.61           | -0.00            | 3.63        | 9.69        | 0.00500  | 0.900 |
| 0 Pure bending | -0.0             | -55.01           | -0.00            | 4.41        | 9.69        | 0.00359  | 0.779 |
| 0 Max tension  | -259.2           | 0.00             | 0.00             | 4.41        | 9.69        | 9.99999  | 0.900 |
General Information:
- File Name: u:\4. 4th year\senior project\1. gravity\risaspolumn\sp column.col
- Project: Fermentation room c1 (Spiral)
- Column: ACI 318-11
- Engineer: kcm
- Units: English

Run Option: Investigation
- Slenderness: Not considered
- Column Type: Structural

Material Properties:
- $f'c = 4$ ksi
- $E_s = 3605$ ksi
- Ultimate strain = 0.003 in/in
- Beta 1 = 0.85

Section:
- Rectangular: Width = 14 in
- Depth = 14 in
- Gross section area, $A_g = 196$ in$^2$
- $I_x = 3201.33$ in$^4$
- $r_x = 4.04146$ in
- $x = 0$ in

Reinforcement:

<table>
<thead>
<tr>
<th>Size Diam (in)</th>
<th>Area (in$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.88</td>
</tr>
<tr>
<td>4</td>
<td>0.50</td>
</tr>
<tr>
<td>5</td>
<td>0.63</td>
</tr>
<tr>
<td>6</td>
<td>0.76</td>
</tr>
<tr>
<td>7</td>
<td>0.88</td>
</tr>
<tr>
<td>8</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>1.13</td>
</tr>
<tr>
<td>10</td>
<td>1.27</td>
</tr>
<tr>
<td>11</td>
<td>1.41</td>
</tr>
<tr>
<td>12</td>
<td>1.56</td>
</tr>
<tr>
<td>13</td>
<td>1.69</td>
</tr>
<tr>
<td>14</td>
<td>2.26</td>
</tr>
<tr>
<td>15</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Confined: Tied: #3 ties with #10 bars, #4 with larger bars.
- $\phi(a) = 0.8$, $\phi(b) = 0.9$, $\phi(c) = 0.6$

Layout: Rectangular
- Pattern: All Sides Equal (Cover to longitudinal reinforcement)

Total steel area: $A_s = 4.80$ in$^2$ at $f_{rc} = 2.45$
- Minimum clear spacing = 3.81 in

8 #7 Cover = 1.875 in

Control Points:

<table>
<thead>
<tr>
<th>Bending about</th>
<th>Axial Load P kip</th>
<th>X-Moment k-ft</th>
<th>Y-Moment k-ft</th>
<th>NA depth in</th>
<th>Dc depth in</th>
<th>$\varepsilon_{max}$ in</th>
<th>Phi</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 0 Max comp</td>
<td>609.8</td>
<td>0.00</td>
<td>0.00</td>
<td>37.66</td>
<td>11.69</td>
<td>-0.00207</td>
<td>0.650</td>
</tr>
<tr>
<td>0 Allowable comp.</td>
<td>487.8</td>
<td>40.50</td>
<td>0.00</td>
<td>14.27</td>
<td>11.69</td>
<td>-0.00054</td>
<td>0.650</td>
</tr>
<tr>
<td>0 $\phi = 0.0$</td>
<td>398.2</td>
<td>-77.94</td>
<td>0.00</td>
<td>8.69</td>
<td>11.69</td>
<td>0.00081</td>
<td>0.650</td>
</tr>
<tr>
<td>0 $\phi = 0.5^2$</td>
<td>270.2</td>
<td>-101.55</td>
<td>0.00</td>
<td>6.92</td>
<td>11.69</td>
<td>0.00005</td>
<td>0.650</td>
</tr>
<tr>
<td>0 Balanced point</td>
<td>174.7</td>
<td>-113.89</td>
<td>0.00</td>
<td>4.38</td>
<td>11.69</td>
<td>0.00000</td>
<td>0.900</td>
</tr>
<tr>
<td>0 Tension control</td>
<td>67.4</td>
<td>-130.13</td>
<td>0.00</td>
<td>3.38</td>
<td>11.69</td>
<td>0.00000</td>
<td>0.900</td>
</tr>
<tr>
<td>0 Pure bending</td>
<td>0.0</td>
<td>-110.24</td>
<td>0.00</td>
<td>0.00</td>
<td>11.69</td>
<td>9.399995</td>
<td>0.900</td>
</tr>
<tr>
<td>0 Max tension</td>
<td>-269.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>11.69</td>
<td>9.399995</td>
<td>0.900</td>
</tr>
</tbody>
</table>

- X 0 Max comp | 609.8            | -0.00         | -0.00         | 37.66       | 11.69       | -0.00207                | 0.650|
| 0 Allowable comp. | 487.8          | -49.50        | -0.00         | 14.27       | 11.69       | -0.00054                | 0.650|
| 0 $\phi = 0.0$ | 398.2           | -77.94        | -0.00         | 8.69        | 11.69       | 0.00081                 | 0.650|
| 0 $\phi = 0.5^2$ | 270.2           | -101.55       | -0.00         | 6.92        | 11.69       | 0.00005                 | 0.650|
| 0 Balanced point | 174.7           | -113.89       | -0.00         | 4.38        | 11.69       | 0.00000                 | 0.900|
| 0 Tension control | 67.4            | -130.13       | -0.00         | 3.38        | 11.69       | 0.00000                 | 0.900|
| 0 Pure bending    | 0.0              | -110.24       | -0.00         | 0.00        | 11.69       | 9.399995               | 0.900|
| 0 Max tension     | -269.2           | 0.00          | 0.00          | 0.00        | 11.69       | 9.399995               | 0.900|
Reference:

**SPIRAL**

USE A 14" φ CONC. SPIRAL W/ (8) NO. 3'S W/ NO. 3'S @ 24" C.C.

\[ P_u = 430.5 \text{ kN} \]

**RECT. COL.**

USE A 12" x 12" RECT. COLUMN W/ (8) NO. 8'S & NO. 3'S @ 24" C.C.

\[ P_u = 408.4 \text{ kN} \]

**DESIGN SPIRAL FOOTING**

\[ A_{FDG} = \frac{P_u + P_r}{f_{yd,CC}} = \frac{430.5 \text{ kN}}{2200 \text{ psi}} = 1.94 \text{ ft}^2 \]

\[ A_{FDG} = 111.3 \text{ in.}^2 \]

**TRY AN 11" x 11" FOOTING**

\[ q_u = P_u + 430.5 \text{ kN} = 8,560 \text{ kN/ft} \]

\[ A_{FDG} = 121 \text{ in.}^2 \]

**CHECK ONE WAY SHEAR**

\[ V_u = q_u \left( \frac{L - d_{cc}}{2} - d \right) = 3.50 \text{ kN/ft} \left( \frac{11 - 1.5/12}{2} - d \right) \]

\[ V_u = 17.75 - 3.5x \]

\[ \phi V_u = 0.75 f_{yd,CC} d = 0.75 \left( \frac{14000}{12} \right) (11) \]

\[ \phi V_u = 1.13 \phi \Rightarrow d = 3.73 \text{ in.} \]

\[ d_{min} = 12.2" \]
Reference:

\[ V_u = 3.50f_s\left(11^2 - \left(\frac{14}{12}\right)^2\right) = 13.35K \]
\[ \Phi V_u = 1.138\left(\frac{14}{12}\right) = 15.9K \]

**CHECK TWO WAY SHEAR**

\[ b_0 = (14'' + 14'') = 88'' \]
\[ a = 40 \text{ (INT. COLUMN)} \]
\[ A = 1.0 \text{ (SQ OR CIRCULAR)} \]

\[ V_u = a V_u \left(12 - (b_{00} + a + d)^2\right) = 3.50f_s\left(11^2 - \left(\frac{14}{12} + 14'\right)^2\right) \]
\[ V_u = 911.4K \]
\[ \Phi V_u = 0.75(4)\left(\frac{14.9}{1060}\right)88\left(\frac{14}{14}\right) \]
\[ \Phi V_u = 233.7K \]

**SOLVE FOR NEW A**

\[ \Phi V_u = \frac{3.50\left(11^2 - \left(\frac{14}{12}\right)^2\right)}{\Phi \text{ NEW A}} = \Phi V_u \]

\[ \text{USED } 11 = 12 \rightarrow d = 14.9'' \]
\[ h = 24'' \quad b_0 = 107'' \]
\[ \Phi V_u = 0.75(4)(14.9)(107)(20') = 4060K \]
\[ V_u = 3.50f_s\left(11^2 - \left(\frac{14}{12} + 20\right)^2\right) = 402.2K \]
\[ V_u < \Phi V_u \]
Reference: CHECK FLEXURE

\[ M_u = \frac{9 \omega l}{2} \left[ \frac{1.26}{2} \right]^{\frac{1}{2}} = 3.56 \text{ kips} \left[ \frac{11.4}{2} \right]^{\frac{1}{2}} \]

\[ M_u = 43 \text{ k-ft/ft} \]

USE \( f_{y} = \frac{345}{58} = 0.00216 \text{ in} \]

\[ A_s / f_y = f_{y} \cdot b / d = 1.06 \text{ in} \]

USE A NO. 10 @ 12" O.C. SPACING

\[ \alpha = \frac{A_s f_y}{0.83 (4.5)^{0.85 (4)(12)}} = 1.567 \text{ in} \]

\[ c = \alpha \beta = 2.7 \text{ in} \]

\[ \varepsilon = \frac{\sigma}{E} = \frac{28 - 2.2}{2.2} = 0.003 > 0.005 \]

\[ \phi = 0.9 \Rightarrow \text{TENSION CONTROLLED} \]

\[ \phi M_u = \phi f_{y} (b - a_{h}) = 0.9 (1274)(0.75)(20 - 1.75) \]

\[ \phi M_u = 108.9 \text{ k-ft} > M_u \]

\[ f_{\text{temp}} = \frac{0.0018 \cdot 100,000}{60,000} = 0.0018 \text{ in} \]

\[ A_{\text{temp}} = (0.0018)(12.24) = 0.5184 \text{ k-ft} \]

\[ \text{A NO. 10/12" O.C. FOR TEMP & SHRINKAGE} \]

11" x 11" x 32" is adequate as an isolated footing w/ a NO. 10 @ 12" O.C. spacing & a NO. 7 @ 12" O.C. spacing.
Reference: DESIGN CONC. FERMENTATION ROOM FOOTING

\[ A_{PFO} = \frac{P+F_L}{q_{w,11}} = 11 \times 11\text{'' FOOTPRINT} \]

\[ q_w = \frac{P}{A_{PFO}} = 3.56\text{ Ksf} \]

CHECK PUNCHING SHEAR

\[ d = 28\text{''}, \quad b_o = (14 + 28) \times 4 = 116\text{''} \]

\[ \delta = 40\text{'' (INT. COL.)} \]
\[ \phi = 1.0\text{ (SF. COL.)} \]

\[ \phi V_c = 0.9 V_c b_o d = 0.75 (4) \frac{10000 \text{ psi}}{1000} (24 + 0) d \]

\[ V_u = q_w (L^2 - (b_{col} + d)^2) = 3.56 \times 10^3 \text{ sf} (121^2 - (116 + 12)^2) \]

SOLVE FOR \( d \approx \frac{d}{12} = 34.0\text{''} \)

USE \( b = 40\text{''} \)

\[ V_u = 3.56 \times 10^3 \text{ sf} (121^2 - (116 + \frac{36}{12})^3) = 373.8 \text{ K} \]

\[ \phi V_c = 0.41 V_c b_o d \quad b_o = 2.4 + 2.6 = 60\text{''} \]

\[ \phi V_c = 0.75(4) \sqrt{1000 \text{ psi} \times 60 \times 36} = 409.8 \text{ K} \]
CHECK ONE WAY SHEAR

\[ \phi V_c = 0.75 \sqrt{f_{cd} b d} = 0.75 (2) \sqrt{4000 \times 0.12 \times 0.26} \]
\[ \phi V_c = 40.98 \text{ kips} \]

\[ V_u = f_{cu} \left( \frac{b - d_c}{2} \right) = 4.5 \text{ kips} \left( \frac{0.12 - 0.05}{2} \right) \]
\[ V_u = 7.12 \text{ kips} < 40.98 \text{ kips} = \phi V_c \]

CHECK FLEXURE

\[ M_u = \phi \left( \frac{b - d_c}{2} \right)^2 \]
\[ M_u = (3.56 \text{ kips})(0.05)^2 = 44.5 \text{ k-ft} \]

USE \[ \phi M_{min} = \frac{3.5 \text{ k-ft}}{f_y} = 1.36 \text{ #} \]

USE (1) NO. 9 @ 9" C.C. SPACING

\[ \alpha = \frac{1.3 \text{ #} (60 \text{ kips})}{0.85 (4000 \text{ kips})(12")} = 1.96 " \]

\[ \frac{d - c}{c} = \frac{d - c}{c} \geq 0.005 \]

\[ \phi M_{n} = \phi f_y A_s \left( \frac{d - c}{c} \right) \]
\[ \phi M_{n} = 0.9 (60 \text{ kips})(0.14 \text{ #}) (36" - 0.96") = \]

\[ \phi M_{n} = 210.1 \text{ k-ft} > M_u \]
Reference: TEMP. STEEL

\[ A_s = 0.003(18) = 0.054\text{in}^2 \times (12\text{in}) = 0.864\text{in}^3 \]

*USE NO. 9 @ 12" O.C. SPACING

\[ 1\times11\times40" \text{ ISOLATED FOOTING W/} \]
\[ \text{NO. 9 @ } 9" \text{ O.C. AS LONGITUD.} \]
\[ \text{BAR W/ NO. 9 @ } 12" \text{ O.C. IS ADEQUATE} \]
APPROXIMATE SLAB DEPTH

\[ e/10 = 20 \text{ in} / 12 \text{ in} = 12^{\text{in}} \]

12^{\text{in}} THICK SLAB

BOOKEND MOMENTS FOR DEMANDS

\[ A_c = 1.5(20)(20) = 600 \text{ in}^2 \]

\[ q_{v,c} = 1.2(690)(0.25 + \frac{15}{(1500)} \left( \frac{20}{20} \right)) = 86.2 \text{ kips} \]

\[ q_{v,c} = 1.2(690)(0.25 + \frac{15}{(1500)} \left( \frac{12.2}{20} \right)) = 96.6 \text{ kips} \]

\[ m_{y} = \frac{wL^2}{8} = \frac{660 \text{ kips}(12.2)(20)}{8} \]

\[ m_{x} = \frac{wL^2}{12} = 52.2 \text{ kips ft} \]

\[ V_{y} = \frac{wL}{2} = \frac{660 \text{ kips}(12.2)}{2} = 3960 \text{ kips} \]
DESIGN NEGATIVE REINFORCEMENT

\[ A_s = \frac{M_u}{f_y (\frac{d}{2})} \]
\[ a = 12'' - 1.5'' - 0.85'' \]
\[ a = 10.05'' \]
\[ A_s = 32.0K ft \]
\[ \frac{f_y}{f_y (\frac{d}{2})} = 0.848 \# \]

*TEST A NO. 7 @ 9" SPACING*

\[ \alpha = \frac{A_f A_t}{0.8 f_y (\frac{d}{2})} = \frac{\frac{1}{2} (0.674) (60.42^2)}{0.85 (4.25) (12)} = 1.17 \]

\[ C = \alpha \sqrt{\frac{D}{E}} = \frac{1110}{60.42} = 1.37 \]

\[ \varepsilon = \frac{C}{C_{cr}} = \frac{1102.5}{1.37} = 0.80 \]

\[ \varepsilon_s = 0.0192 > 0.005 \quad \text{TENSION CONTROLLED} \]

\[ \phi M_a = 0.9 \left( \frac{\phi M_u}{d - \frac{a}{2}} \right) = 0.9 \left( \frac{60.42}{0.85} \right) \left( 0.8 + \frac{1}{1.0} \right) \]
\[ 0.9 M_a = 19.12 K ft \]

DESIGN POSITIVE REINFORCEMENT

\[ \frac{M_u}{\phi f_y (\frac{d}{2})} = 1.27 \# / ft \]

*USE NO. 9 @ 9" SPACING*
Reference:

\[ a = 12^\circ - 0.75\frac{2}{2} = 10.08^\circ, \quad A_0 = \frac{3}{4}(1.0) = 1.2\pi \]

\[ a = A_0 = \frac{(1.33)(1.0)}{0.25(4)(3)(12)} = 1.96 \]

\[ C = 91.3 = 2.03 \]

\[ \varepsilon_o = \frac{a-C}{C} = \frac{10.08 - 2.03}{2.03} \approx 0.009 \]

\[ 0.009 > 0.005; \quad \text{Tension Controlled} \]

\[ \phi m_n = \phi m_s (a - 91.3) = 0.8(40)(1.33)(10.08 - 91.3) \]

\[ \phi m_n = 58.2 \text{k}\text{f}\text{t}^2 \]

\[ \text{CHECK } \varepsilon' \text{ FOR CRACKING} \]

\[ \varepsilon'_{\text{max}} = \text{LESSER} \]

\[ \varepsilon'_{\text{max}} = 3b \quad \text{or} \quad 15^\circ \]

\[ \varepsilon'_{\text{max}} = \frac{15}{30} \quad \text{or} \quad 15^\circ \]

\[ \varepsilon'_{\text{max}} = 9^\circ \]

\[ \sigma_{\text{max}} = 9^\circ \]

\[ \text{DESIGN SHRINKAGE AT TEMPERATURE REINFORCEMENT} \]

\[ A_{\text{min}} = 0.0018(A_0) = 0.0018(12')(12') \]

\[ A_{\text{min}} = 0.259' \]
Reference:

\[
\begin{align*}
N_{\text{max}} &= 5 \times 15 \times 8 \times \frac{1}{60} \times \frac{1}{2} = 6.25 \text{ kips} \\
\Rightarrow \sigma &= 1.875 \text{ kips/ft}^2 \\
\end{align*}
\]

*USE NO. 4 @ 18" O.C.*

Answer:

1/2" THICK SLAB W/ #7 @ 9" SPACING AS NEGATIVE MOMENT REINFORCEMENT & #9 @ 9" SPACING AS POSITIVE MOMENT. USE NO. 4 @ 18" SPACING AS TEMPERATURE & SHRINKAGE STEEL.
Lateral: References
SEISMIC COEFFICIENTS

FROM USGS:

\[ S_{0S} = 0.856 \]
\[ S_{0L} = 0.424 \]
\[ S_{0} = 1.283 \]
\[ S_{1} = 0.483 \]
\[ S_{mS} = 1.283 \]
\[ S_{m1} = 0.636 \]

STEEL ORDINARY BRACE FRAME

\[ R = 3\frac{1}{4}, \quad N_0 = 2, \quad C_D = 3\frac{3}{4} \]

\[ c_S = \frac{S_{0S}}{R_A} = \frac{0.856}{3\frac{1}{4}} = 0.263 \]

\[ T = c_T h x = 0.003 (22.5) = 0.3099 \]

\[ C_{s_{\text{MAX}}} = \frac{S_{01}}{T(R_A)} = \frac{0.424}{0.3099 / 3\frac{3}{4}} = 0.421 \]

\[ C_{s_{\text{MIN}}} = 0.044 S_{0S} T C = 0.044 (0.856) = 0.037 \]

\[ c_S = 0.263 \]
Reference: STEEL ORDINARY MOMENT FRAME

12.2.1

\[ R = 3'1\frac{1}{2}, \quad S_0 = 3, \quad C_D = 3 \]

\[ C_S = \frac{S_{D1}}{R} = \frac{0.356}{3'1\frac{1}{2}} = 0.245 \]

\[ T = C_D h^2 = 0.0033(22.5) = 0.338 \]

12.8.3

\[ C_{S,\text{max}} = \frac{S_{D1}}{S(T/E)} = 0.124 \]

12.8.5

\[ C_{S,\text{min}} = 0.0348 \]

\[ C_S = 0.245 \]

Answer:

Reference: CONCRETE SHEAR WALL

12.2.1

\[ R = 5, \quad S_0 = 2'1\frac{1}{2}, \quad C_D = 5 \]

12.8.2

\[ C_S = \frac{S_{D1}}{R} = \frac{0.856}{5} = 0.1712 \]

\[ T = 4 h^2 = 0.02(14.5)^{0.75} = 0.1486 \]

12.8.3

\[ C_{S,\text{max}} = \frac{S_{D1}}{T^{\frac{1}{2}} R_1} = 0.124 \]

12.8.5

\[ C_{S,\text{min}} = 0.0348 \]

\[ C_S = 0.1712 \]
<table>
<thead>
<tr>
<th>Reference</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TIMBER SHEAR WALL</strong></td>
<td></td>
</tr>
<tr>
<td>10.2.2-1</td>
<td></td>
</tr>
<tr>
<td>R = 6(1/2), (n_0 = 3), (c_0 = 4)</td>
<td></td>
</tr>
<tr>
<td>12.8.2</td>
<td>(C_s = \frac{5.56}{6(1/2)} = 0.132)</td>
</tr>
<tr>
<td></td>
<td>(T = C_s h^x = 0.02 \cdot \left(12\right)^{0.75} = 0.129)</td>
</tr>
<tr>
<td>12.8.3</td>
<td>(C_{s_{\text{MAX}}} = \frac{5.56}{0.129 \cdot 6(1/2)} = 0.344)</td>
</tr>
<tr>
<td>12.8.5</td>
<td>(C_{s_{\text{MIN}}} = 0.0348)</td>
</tr>
<tr>
<td></td>
<td>(C_s = 0.132)</td>
</tr>
<tr>
<td><strong>SPECIAL MASONRY SHEAR WALL</strong></td>
<td></td>
</tr>
<tr>
<td>10.2.2-1</td>
<td></td>
</tr>
<tr>
<td>R = 5, (n = 2(1/2), (c_0 = 3(1/2))</td>
<td></td>
</tr>
<tr>
<td>12.8.2</td>
<td>(C_s = \frac{5.56}{5(1)} = 0.172)</td>
</tr>
<tr>
<td></td>
<td>(T = C_s h^x = 0.02 \cdot (20.5)^{0.75} = 0.192)</td>
</tr>
<tr>
<td>12.8.3</td>
<td>(C_{s_{\text{MAX}}} = \frac{5.56}{0.192} = 0.4416)</td>
</tr>
<tr>
<td>12.8.5</td>
<td>(C_{s_{\text{MIN}}} = 0.0348)</td>
</tr>
<tr>
<td></td>
<td>(C_s = 0.172)</td>
</tr>
</tbody>
</table>
Reference: WIND PRESSURE FOR COMPONENTS OF ROOF

LOW RISE BUILDING DIRECTONAL APPROACH

PECE 7-10

1) RISK CATEGORY II

1BL 1.5.1

A8E 7-10

1) V = 110 MPH

FIG 26.5-19

\[ \sqrt{26.0} \]

\[ \sqrt{16.7} \]

\[ \sqrt{2.0} \]

\[ \sqrt{16.10} \]

1) EXP 3.0.4-1

\[ K_p = 1.0 \]

\[ \text{PARTIALLY ENCLOSLED} \]

\[ GCF = \pm 0.55 \]

\[ K_h = 0.17 \]

\[ q_h = 0.00256 K_c K_p V^2 \]

\[ q_h = 0.00256 (0.7)(1.0)(0.85)(110\text{ MPH})^2 \]

\[ q_h = 18.43 \text{ psf} \]

FIG 26.4.5

2) GCF

ZONE 1

ZONE 2

ZONE 3

\[ A = 265.75 \]

\[ A = 150 \text{ HD} \]

-0.9

-1.1

-1.1

+0.2

+0.2

+0.2

EQ 30.4.1

\[ \text{ZONE1} \]

\[ \text{ZONE2} \]

\[ \text{ZONE3} \]

\[ q_h = 18.43 \text{ psf} [-0.55 + 0.2] = 16.45 \text{ psf} \]

\[ q_h = 18.43 \text{ psf} [-0.55 - 0.9] = 6.45 \text{ psf} \]
STEP 7

ZONE 2

\[ P = 9.8 \left( G_{cp} - G_{cr} \right) = 19.43 \text{psf} \left[ \left( -0.55 - 1.1 \right) \right] \]

\[ P = -10.14, -30.41 \text{psf} \]

ZONE 3

SAME ⇒ \[ P = -10.14, -30.41 \text{psf} \]

OVERHANGS

\[ A = 3.10 = 304 \text{in}^2 \]

ZONE 1 ZONE 2 ZONE 3

\[ G_{cp} = -1.65 \quad G_{cp} = -1.65 \quad G_{cp} = -1.8 \]

ZONE 1 Z2

\[ P = G_{cp}(q_h) = -1.65(18.43) = -30.91 \text{psf} \]

ZONE 2

\[ P = G_{cp}(q_h) = -1.8(18.43) = -33.17 \text{psf} \]

DESIGN FORCES

- DESIGN WHOLE ROOF FOR 30.41 psf OF UPLIFT & 16 psf (MIN.) OF DOWNWARD LOAD.

- DESIGN OUTRIGGERS @ OVERHANG FOR 33.17 psf & 16 psf (MIN.) OF GRAVITY LOAD.
Reference:

- MINERS WIND
- EXPOSURE B
- SURFACE ROUGHNESS B

LOW RISE

\[ \frac{h}{D} < 0.05 \]

\[ \frac{h}{L} < 20 \] = SMALLEST HORIZONTAL DIL

\[ \chi = 28 \]

ASCE 7

1) RISK CATEGORY III

\[ V = 110 \text{ mph} \]

2) \[ K_e = 0.85 \]

3) \[ K_{ex} = 1.0 \]

4) EXPOSURE B

5) \[ q_{ref} = \frac{A_{ref}}{D^2} = 0.00250 K_e K_{ex} K_d V^2 \]

\[ = 0.00250(0.85)(0.7)(110 \text{ mph})^2 \]

\[ q_{ref} = 13.9 \text{ psf} \]

6) \[ \sum_{\Delta} \] 0.6

\[ a = \min \left[ 0.1(96), 0.4(12) \right] \]

\[ a = 4.8^\circ \]

\[ 2a = 9.6^\circ \]
Reference:

\[
(0.61 + 0.55) \times 18.4 \text{ ft} = 21.34 \text{ ft} - \text{Answer:}
\]

\[
(0.41 + 0.55) \times 18.4 \text{ ft} = 17.69 \text{ ft} - \text{Answer:}
\]

\[
(0.43 + 0.55) \times 18.4 \text{ ft} = 18.95 \text{ ft} - \text{Answer:}
\]

\[
E_{\text{roof}} = \frac{10}{16} \left[ 21.34 \text{ ft} \times 18.95 \text{ ft} + 18.95 \text{ ft} \times 17.69 \text{ ft} \right]
\]

\[
E_{\text{roof}} = 18.95 \text{ kN}
\]
SEISMIC WEIGHT (ADMIN) 

LOADING IN N/S.

DL @ B.W.: 19 psf

PERPENDICULAR WALLS:

PERIMETER: \((9\frac{1}{2}'' + 8\frac{1}{2})2 = 208\frac{4}{16}''\)

WALL D.L. TAKEN F.:

STUDS: \(208\frac{4}{16}'' \cdot \frac{1}{16}'' = 157\) STUDS

STUDS - 180 STUDS (ACCOUNT FOR CORNER)

STUD WT. - (180 STUDS) \(1.79 \text{ psf} \times (12\frac{1}{4}) \times \frac{1}{16}'' \times \frac{1}{16}''

STUD WT. - 1 psf

5/8" GYRBOARD: \(208\frac{4}{16}'' \times 2.75 \text{ psf} \times (12\frac{1}{2}) \times \frac{1}{16}'' \times \frac{1}{16}''

5/8" GYR. BOARD - 1.79 psf

7/8" STUCCO: \(208\frac{4}{16}'' \times 10 \text{ psf} \times (12\frac{1}{2}) \times \frac{1}{16}'' \times \frac{1}{16}''

7/8" STUCCO - 6.5 psf

TOTAL WEIGHT: \(19 \times (11.79 + 6.5) \text{ psf} = 283\text{ psf}

TOTAL WEIGHT = (283 psf) \times 12.96 = 5433\text{ lb}
Reference: \( \text{CH 28 Wind Codes} \)

\textbf{ACSE 7 1.5.1}

1) Risk Category 1

\textbullet{} Use Risk Cat. II (Admin/Bulding)

\textbf{Eq 26.5-1A 2)} \( v = 110 \text{ mph} \)

\textbf{Eq 26.6.10 3)} \( K_o = 0.85, K_z = 1.0, \text{ Exposure B} \)

\textbullet{} Partially Enclosed, (Forklift Entrance)

\( G_{pi} = 0.55 \)

\textbf{Eq 26.3-1 4)} \( K_z = 0.7 \)

\textbf{Eq 48.3-1 5)} \( q_{we} = 18.46 \text{sf} \quad (\text{Ref. Admin}) \)

\[ \begin{align*}
\alpha &= \min \left[ 0.1 \left( \frac{32.66}{20} \right), 0.4 (20) \right] \\
\alpha &= \min \left[ 3.26, 8 \right] \\
2\alpha &= 6.53
\end{align*} \]
Reference:

\[ P_{100} = 21.34 \text{ psf} \]
\[ P_{50} = 17.68 \text{ psf} \]
\[ P_{40} = 18.0 \text{ psf} \]
\[ P_{24} = 14.54 \text{ psf} \]

Answer:

\[ F_{\text{roof}} = \frac{20}{2} \left[ (0.53)(21.34 + 18) \text{ psf} \right] \times \frac{(50.0 - 0.53)(12,000 \times 0.94)}{12} \]

\[ F_{\text{roof}} = 5,491 \text{ k} \]
Reference: 

SEISMIC WEIGHT (CASE STORAGE)

DL TO BW: 18 psf

ASSUME 8" THICK N.W. MASONRY WALL: 74 psf

METAL SIDING: 2.5 psf

TOTAL WEIGHT:

DL: (18 psf) (20.3) (32.5) = 17,248 K

WALL: (76.5 psf) (20) (23.6 + 24") = 43,335 K

TOTAL WEIGHT: 60,583 K
Reference: MWERS (FERMENTATION ROOM)

USE CH. 28 ANALYSIS (ASCE 7)

CASE 7

1) RISK CATEGORY III

2) V = 110 mph

3) $K_0 = 0.85$, $K_2 = 1.0$, EXPOSURE B, PARTIALLY ENCLOSED, $G_{cp} = 0.55$

4) $K_2 = K_1 = 0.7$

5) $a_{20} = 0.45b = 18.4$ ft

\[ \alpha = \min \left[ \frac{0.1(200)}{0.4(23)} \right] \]
\[ = \min \left[ 20.6, 9.2 \right] \]
\[ = 9.2 \]
\[ 2\alpha = 18.4 \]
Reference:  

7) \[ P_{01} = 18.9 \text{ psf} \left( 0.61 + 0.55 \right) = 21.34 \text{ psf} \]

\[ P_{01} = 17.66 \text{ psf} \]

\[ P_{04} = 18 \text{ psf} \]

\[ P_{04} = 14.54 \text{ psf} \]

\[ E_{\text{room}} = \frac{2}{3} \left( 17.4 \cdot \left( 21.3 + 19.8 \right) \times 10^3 \right) + \left( 200 \times 12.4 \right) \times 14.54 \times 10^3 \]

\[ E_{\text{room}} = 77.8 \text{ kN} \]
SEISMIC WEIGHT OF SUBTERRAIN STORAGE

Weight at Diaphragm 1: \(2.47 \times 16\)\(^{2} \times 9.4 = 92.8\) k

Walls (N-S): \((0.16 \times 16)(1)(34.16)(1.1)^{2} = 28.2\) k

Total Seismic Weight = 121 k

SEISMIC WEIGHT (MEETING ROOM)

Weight of Diaphragm: \(90 \times 32.5 \times 16 = 468\) k

Weight of Walls: \(2 \times 1.4 \times 16 \times 1.1 = 33.8\) k

Total Weight = 85 k

SEISMIC WEIGHT (FERMENTATION RM.)

Weight of Diaphragm: \(29 \times 206 \times 39 = 352.5\) k

Weight: 352.5 k

Weight of Column: \(8 \times 24 \times 20(0.028)(22) = 11.04\) k

Weight of Column: \(8 \times 24 \times 11.04\) k

10x10 Plaster: \((0.184)(10)(10) = 18.4\) k

Weight of 10x10 Plaster: 18.4 k

Weight of 12.5 k

ceiling contribution for plaster: \(12.5 k \times \frac{6}{22} = 3.5\) k

\(\text{Total Weight} = 352.5 k + 11.04 k + 3.5 k\)

Total Weight = 367.0 k
SEISMIC WEIGHT (BARREL AGING)

* EAST-WEST

DEAD LOAD TO COLUMN: 715 psf

COLUMN: S.W.: \( \frac{6.11 \times 1.120}{26} = 0.9 \) K

\( 0.9K/20 \times 31.5 = 2.19 \) psf

WALL S.W.: ASSUME 18" TALL

EXT: \( \frac{150}{2} \times \frac{18}{12} \times \frac{18}{2} \times \frac{282}{2} = 510.3 \) K

INT: \( \frac{150}{2} \times \frac{18}{12} \times \frac{18}{2} \times \frac{5}{2} = 27 \) K

PERIMETER OF PERPENDICULAR WALLS

TOTAL SEISMIC WEIGHT (F-W):

\( 5405.4K + 0.9K + 510.3K + 27K = 5943.6K \)

\( F_{\text{seismic}} = 10179 \) kips

* NORTH-SOUTH

DIAPHRAGM = 5405.4K

COLUMN = 0.9K

EXT WALL = \( 0.15 \times \frac{21}{12} \times \frac{100}{2} \times \frac{12}{12} = 243 \) K

INT WALL = \( 0.15 \times \frac{18}{12} \times \frac{100}{2} \times \frac{8}{12} = 54 \) K

TOTAL WEIGHT: 5703.3K

\( F_{\text{seismic}} = 976.4K \)
Reference: Seismic vs Wind (Admin) N-S

\[ V = \frac{0}{2} \times W = \left(0.132\right)\left(34.33\text{OK}\right) = 7.17\text{K} \]

\[ V_{\text{Wind}} = 18.95\text{K} \]

\( \text{Wind governs} \)

Seismic vs Wind (Case Storage) E-W

\[ V_{\text{Seismic}} = 6.39 \times W = 0.1712\left(34\text{OK}\right) = 11.23\text{K} \]

\[ V_{\text{Wind}} = 5.49\text{K} \]

\( \text{Seismic governs} \)

Seismic vs Wind (Barrel Airing)

\[ V_{\text{Seismic}} = 0.1712\left(5910.6\text{K}\right) = 1013\text{K} \]

\[ V_{\text{Wind}} = 0\text{K} \]

\( \text{Seismic governs} \)

Seismic vs Wind (Barrel Vault)

\[ V_{\text{Seismic}} = 0.1712\left(2626.2\text{K}\right) = 449.6\text{K} \]

\[ V_{\text{Wind}} = 0\text{K} \]

\( \text{Seismic governs} \)
<table>
<thead>
<tr>
<th>Reference</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEISMIC VS WIND (TANK ROOM)</strong></td>
<td></td>
</tr>
<tr>
<td>$v_{seismic} = C_{sw} = (0.1 \cdot 12) \cdot (21k) = 20.7K$</td>
<td>TANK ROOM</td>
</tr>
<tr>
<td>$v_{wind} = OK$</td>
<td></td>
</tr>
<tr>
<td><strong>SEISMIC GOVERNS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SEISMIC VS WIND (FERMENTATION ROOF)</strong></td>
<td></td>
</tr>
<tr>
<td>NORTH-SOUTH</td>
<td></td>
</tr>
<tr>
<td>$v_{seismic} = C_{sw} = (0.245) \cdot (30.5k) = 88.8K$</td>
<td>FERMENTATION</td>
</tr>
<tr>
<td>$v_{wind} = 77.8K$</td>
<td>ROOF: NORTH</td>
</tr>
<tr>
<td><strong>SEISMIC GOVERNS</strong></td>
<td>SOUTH</td>
</tr>
<tr>
<td>EAST-WEST</td>
<td></td>
</tr>
<tr>
<td><strong>SEISMIC GOVERNS BY INSPECTION</strong></td>
<td></td>
</tr>
<tr>
<td>$v_{seismic} = w_{c} = \left(\frac{601.5k}{(0.243)}\right) \cdot \frac{3}{2}$</td>
<td>FERMENTATION</td>
</tr>
<tr>
<td>$v_{seismic} = 45.1K$</td>
<td>ROOF: EAST</td>
</tr>
<tr>
<td></td>
<td>WEST</td>
</tr>
</tbody>
</table>
Lateral: Administration Room
FLEXIBLE DIAPHRAGM ANALYSIS

\[ W_1 = (2.13 \text{ kips} + 13 \text{ psf}) \cdot 6 = 23.6 \text{ kips} \]
\[ W_2 = (7.66 \text{ kips} + 14.5 \text{ psf}) \cdot 6 = 193.2 \text{ kips} \]

\[ \text{WALL 1} \]

\[ M_{01} = 0 = (2.36 \text{ kips}) \cdot (9.6 \text{ ft}) \left( \frac{9.6}{2} \right) + (193.2 \text{ kips}) \cdot (48 - 9.6) \]

\[ F_2 = 51672.9 \text{ lbs} \]

\[ \sum F_y = 0 = 4677.9 \text{ kips} + 9.6(235 \text{ kips}) - (48 - 9.6)(193.2 \text{ kips}) \]

\[ F_1 = 5000 \text{ lb} \]
WALL 2

\[ \sum M_{y2} = 0 = (1932.2 \text{ k}) \left( \frac{48}{2} - 48 \right) = 32'' F_2 \]

\[ F_2 = 5.96 \text{ k} \]

\[ \sum F_y = 0 \quad F_3 = 2.31 \text{ k} \]

\[ ^* \quad \text{WALL 1: 5000.6 ft-lb} \]

\[ \text{WALL 2: 2313 ft-lb} = 6987.9 \text{ ft-lb} \]

\[ \text{WALL 3: 6965 ft-lb} \]
**Reference:**

STEVAK WALL 1

5.0K

\[ W_{D} = 111.66\text{ft} \]

\[ W_{D} = 9.0k \]

\[ W_{D} = 130.4\text{cf} \]

\[ P_{D} = (W_{D} + W_{B})/20 = 130.4\text{cf} / 20 = 6.52\# \]

**Answer:**

MAXIMUM COMPRESSION: 2.412K, 5.01X 12/6 = 12.6K

MAX COMPRESSION: 3.1K

MAX TENSION: -0.6(24.12) - 0.6(5.01) / 20

MAX TENSION LOAD: 1.02K

*FULL SHEAR WALL INDICATES NO NEED FOR A COLLECTOR.*
**Collector (Shear Wall 2)**

- **Reference:**

- **Answer:**

  \[ \text{Answer} = 2270.7 \text{ kN} \]

  \[ V_w = 1698.79 \text{ kN} \]

  \[ P_D = W_D \cdot \ell_w \]

  \[ W_D = 149.6 \text{ kip} \]

  \[ P_D = \left( 49.3 \text{ kip} \right) \left( 13.5 \right) = 2.02 \text{ k} \]

- **Max Comp.:**

  \[ 2.02 + 0.6 \left( 0.9874 \right) 12 = 13 \text{ k} \]

- **Max Ten.:**

  \[ 0.6 \left( 2.02 \right) - 0.6 \left( 0.9874 \right) 12 = -2.12 \text{ k} \]
Reference:

Collector (Shear Wall 3)

\[ \text{Answer:} \]

COLLECTOR (SHEAR WALL 3)

\[ \text{341.5 \text{ kip}} \]

\[ \text{116.5 \text{ kip}} \]

\[ \text{W_d = 1300 \text{ lb}} \]

\[ \text{V_w = 6955 \text{ lb}} \]

\[ P_d = \frac{W_d + V_w}{2} \]

\[ P_d = \frac{1300 + 6955}{2} = \frac{8255}{2} = 4127.5 \text{ kip} \]

\[ \text{MAX COMPL:} \frac{2.1871 + 0.6(6.955)}{16.75} \]

\[ \text{MAX COMPL:} 1.08 \text{ kip} \]

\[ \text{MAX TENSION:} \frac{2}{2} (2.1871 \times 0.6(6.955)) \]

\[ \text{MAX TENSION:} -2.33 \text{ kip} \]
Reference:

**SHEAR WALL 1**

\[ V_u = 2 \cdot \frac{6.955 \times 20!}{20!} = 650 \text{ pif} \]

**NDS TABLE 4.9A**

\[ T = 2.33K \text{ (T)} \]

**USE A 15/32" STRUCT. 1 WOOD PANELS W/ 10D NAILING W/ 6" EDGE SPACING & 12" FIELD NAILING FULLY BLOCKED. USE (2) HD3B AS A HOLD-DOWN FOR UPLIFT.**

\[ V_{T1} = 1.03pif \]

\[ T_{T1} = 3.12 \times 1.03 = 3.21 \text{ pif} \]

**SHEAR WALL 2**

\[ V_u = 2 \cdot \frac{1.99 \times 1.5!}{1.5!} = 3.12 \text{ pif} \]

**NDS 19L 4.9A**

**USE 15/32" STRUCT. 1 WOOD PANELS W/ 10D NAILS W/ 4" EDGE NAILING SPOCON & 12" FIELD NAILING FULLY BLOCKED. USE (2) HD3B AS A HOLD-DOWN FOR UPLIFT.**

\[ V_{T2} = 1.43pif > 1.03pif = V_u \]

\[ T_{T2} = 3.12 > 3.12 = T_u \]
Reference:

\[ W_1 = 2362 \text{ pF} \]
\[ W_2 = 193.2 \text{ pF} \]

\[ \alpha = \min \left[ 0.1(20), 0.1(2) \right] \]
\[ \alpha = \min \left[ 2, 4 \right] \]
\[ 2\alpha = 4 \]

\[ \Sigma M_{\text{wall line 1}} = 0 = (2362 \text{ pF})(14)\left(\frac{4}{2}\right) + (193.2 \text{ pF})(16)\left(\frac{4}{2}\right) \]
\[ - F_{\text{wall line 1}} (20) \]

\[ F_{\text{wall line 1}} = 1.95 \text{ K} \]

\[ \Sigma F_{\text{E-W}} = 0 = -2362 \text{ pF}(14) - 193.2 \text{ pF}(16) - 1.95 \text{ K} \]

\[ F_{\text{wall line 2}} = 2.09 \text{ K} \]
Reference:

**EAST-WEST**

**CHORD FORCE**

\[ W_1 = 230 \text{ p.f.F} \]

\[ W_2 = 192.2 \text{ p.f.F} \]

**COLLECTOR SHEAR WALL 1**

\[ 20.3 \text{ p.f.F} \]

\[ 35^\circ 0'' \]

\[ 15^\circ 0'' \]

\[ 17^\circ 0'' \]

\[ 28^\circ 0'' \]

\[ 96^\circ 0'' \]

**Answer:**

\[ 291.4 \text{ f.f.} \]

\[ 63.9 \text{ f.f.} \]
Reference: SHEAR WALL

Answer:

\[ W_{SW} = (1.0 \times 1.5 + 0.5) \times 12 \]  
\[ W_{DEW} = 11.6 \times 14 \]  
\[ W_D = 70 \times 14 \]  
\[ Q_e = \left( \frac{2.02K}{23 + 15.5} \right) (15.5) \]  
\[ Q_e = 745 \]  

FOR COMPRESSION

GOVERNING LOAD COMBO: 1.0D + 0.7W

- 1.0D = 11.6 \times 14 + 352 \times 14 = 463.6 \times 14

- 0.7W = 0.7 \times 745 = 447

\[ P_D = \frac{463.6 \times 14 + 447}{2} \]  
\[ P_D = 7.185.8K \]  

MAX: 7.185.8K, 15.5

MAX: 3.939K

MIN: 3.246K
Reference:

FOR TENSION

GOVERNING LOAD COMB. 0.60 + 0.60W

Vw

Pd = 0.6(7.126k) = 4.273k

Vw = 4.17 kbf

Max tension: 12.84 kbf = 34.6 k

* By inspection, no uplift...

SHEAR WALL 2

W0

Wpw

Wd = W0 + Wpw = 352.0 k + 111W0 k = 363.6 kbf

Vw = 2.09 k

28 = 1.36 k

28 + 15.5 = 43.5

0.6(1.36k)

Pd = 463.6 dbf. 28

Pd = 12.98 k

Max = \frac{12.98 k + 0.6(1.36k) \times 12}{2}

Max: 6.84 k
Reference: MAX SHEAR WALL IN LINE 2

Answer:

$W_D = \frac{V_{w}}{h} = \frac{443.6 \text{ kN}}{1.5} = 295.7 \text{ kN/m}$

$W_{D,sw} = \frac{V_{w}}{h} = \frac{166.25 \text{ kN}}{1.5} = 110.8 \text{ kN/m}$

$V_{w} = \frac{443.6 \text{ kN}}{1.5} = 295.7 \text{ kN}$

$V_{w} = \frac{166.25 \text{ kN}}{1.5} = 110.8 \text{ kN}$

MAX COMPRESSION:

$443.6 \text{ kN} \times 1.25 \text{ m} = 554.5 \text{ kN/m}$

$443.6 \text{ kN} \times 1.5 \text{ m} = 665.4 \text{ kN/m}$

$\text{MAX COMPRESSION: } 453 \text{ kN/m}$

ASPECT RATIO:

$\frac{40.75}{12} = 3.4 < 3.5$
Reference: DESIGN SHEAR WALL @ LINE 1

\[ W = 447 \# , \quad V_u = 28.8 \text{ p.lf} \]

INDS

USE 5/16" STRUC. I PANELS

W/ 6D NAILING @ 6" O.C. @

PANEL EDGES & 12" FIELD

NAILING, NO HOLDOWNS ARE REQ'D, HOWEVER USE HD3B

\[ V_{all} = 500 \text{ p.lf} > 28.8 \text{ p.lf} = V_u \]

DESIGN SHEAR WALL @ LINE 2

\[ V_u = \frac{368.8 \#}{40' - 8"} = 9,000 \text{ p.lf} \]

\[ T_u = 0 \text{ K(1) } \]

USE SAME S.W. AS AT LINE 1

INDS

USE 5/16" STRUC. I PANELS

W/ 6D NAILING @ 6" O.C. @

PANEL EDGES & 12" FIELD

NAILING, NO HOLDOWNS ARE REQ'D, HOWEVER USE HD3B
### Design of RC Shear Wall Footing

<table>
<thead>
<tr>
<th>Qe (k)</th>
<th>Pa (k)</th>
<th>h (ft)</th>
<th>Ma (k-ft)</th>
<th>Length (ft)</th>
<th>Sds</th>
<th>Shear Wall Thickness (in)</th>
<th>Length of a foot</th>
<th>f'c</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.96</td>
<td>2.618</td>
<td>12</td>
<td>83.52</td>
<td>20</td>
<td>0.856</td>
<td></td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3000</td>
</tr>
</tbody>
</table>

**Check Bearing**

<table>
<thead>
<tr>
<th>Allowable Bearing (ksf)</th>
<th>S (ft)</th>
<th>Use a Width of?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.34525</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Max and Minimum Bearing**

- Qumax: 0.95486
- Qu Min: -0.71554

**Tension Uplift**

- Distance where tension soil stops: 0.642547
- Tension Load: 4.597678

**One Way Shear (Solve for d already)**

- d: 8
- Vu: 
  - IF #REF! THEN Vu = Phi Vn
  - Phi Vn: 6.309764
- No shear Demand

**Check Flexure**

- Qu @ critical section: 0.39806
- Mu: 0.14345
- As Min/ft: 0.3888

**As**

<table>
<thead>
<tr>
<th>Fy</th>
<th>b</th>
<th>a</th>
<th>c</th>
<th>Es</th>
<th>Phi</th>
<th>Phi Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.44</td>
<td>60</td>
<td>12</td>
<td>0.862745098</td>
<td>1.014994</td>
<td>0.020645</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Footing is 1' - 6" x 20' x 1' R.C. with No. 6's at 12" spacing
Reference:

**DESIGN CHORD W/LOADING IN N, V, S**

\[ L_b = 20^\circ \]

\[ P_N = 0.6(P_w) = 0.6\left(\frac{500,000 \times 10}{20^\circ}\right) = 1,776 \text{ kN} \]

\[ M_w = W_w \times L_b^2 / 8 \]

\[ W_w = (1.2 \times 50 \times 10) = 600 \text{ kN} \]

\[ M_w = (0.13 \times 600 \times 20)^2 / 8 = 6,571 \text{ kN}-\text{m} \]

\[ M_N = 0.6(M_o) = 3.9 \text{ kN}-\text{m} \]

**TRY 4 x 8 D.F. NO. 1, \( A_x = 2538 \text{ mm}^2, S_x = 30.6 \text{ kN} \)**

\[ f_b = \frac{M}{A} \times \left(\begin{array}{c} 3.3 \times 10^3 \times 12 \\ 30.6 \times 10^3 \end{array}\right) = 1.52 \text{ ksi} \]

\[ F_x = \frac{P}{A} = \frac{1.776}{2538} = 0.7 \text{ ksi} \]

\[ C_p = 1.6, C_{f_b} = 1.2, C_{f_o} = 1.0 \]

\[ f_o = (1000 \times 1.6) / (1.05) = 2000 \text{ psi} \]

\[ f_x = (1500 \times 1.6) / (1.05) = 2520 \text{ psi} \]

\[ F_{CE} = 0.822 \times 5 \times \left(\frac{20}{20^\circ}ight)^2 = 290 \text{ psi} \]

\[ \theta_0 = 150^\circ \]

\[ F_{CE} = 0.822 \times \left(\frac{20\times 12}{32^2}\right)^2 = 1,747 \text{ psi} \]

Braced @ 24" C.C., \( C_p = 1.0 \)
Reference:

\[
\left(\frac{f_e}{f_c}\right)^2 - \frac{f_b}{f_c} \left(1 - \frac{f_e}{f_c}\right) = \left(\frac{6760}{2920\text{ psi}}\right)^2 - \frac{1520\text{ psi}}{2920\text{ psi}} \left(1 - \frac{6760}{2920\text{ psi}}\right)
\]

\[= 0.85 < 1.0\]

**4 x 8 NO. 1 D.F. IS ADEQUATE FOR COMBINED STRESSES**

**COLLECTORS DESIGN**

- \( P_w = 2.27k \)
- \( M_u = \text{NEGIGIBLE} \)

**USE 4 X 8 D.F. ARCH NO. 1 FOR COMBINED STRESSES**

* LOADS IN OTHER DIRECTION ARE MINIMAL SO USE 4 X 8 AS CHORD & COLLECTOR MATERIAL
Lateral: Case Storage
**Diagram Analysis East-West**

Reference:

\[ W_2 = 0.1712 \left( \frac{18 \text{psf} \cdot 24.2^2 + 2 \cdot 76.5 \text{psf} \cdot 20 \cdot 20}{2} \right) = 352.3 \text{psf} \]

\[ W_4 = 0.1712 \left( 18 \text{psf} \cdot 29.3^2 + 76.5 \text{psf} \cdot 20 \cdot 20 \right) = 221.3 \text{psf} \]

\[ F_{OA} = F_{OB} = \frac{24^2 \cdot (252.3 \text{psf}) + 8.6 \cdot (221.3 \text{psf})}{2} \]

\[ F_{OA} = F_{OB} = 51872 \text{ K} \]
Reference:

**DIAPHRAGM ANALYSIS (EASTWEST)**

**CHOSEN FORCES**

**W**

Ri = 112.6 kF

W1 = 271.36 kF

W2 = 352.33 kF

176.8 kF

R1 = 56.18 kF

32.7 kF

22 kF

-176.8 kF

169 kF

W = 1.0 kF

36.9 kF

36.9 kF

2.0 kF

TYPICAL EASTWEST SHEAR WALL

\[ P_{\text{Tot}} = P_{\text{E}} + P_{\text{D}} = 7(\text{reg}) + 20(29.3\text{') + 18(\text{reg'.12')}) \]

\[ P_{\text{DTot}} = 43.94 k \]

\[ V_E = 5.087 k \]
<table>
<thead>
<tr>
<th>Reference:</th>
<th>Answer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECL:</td>
<td>5) ((1.2 + 0.25Q)D + 3Q)</td>
</tr>
<tr>
<td></td>
<td>(1.2 + 0.2SD = 1.2 + 0.2(0.856) = 1.3712)</td>
</tr>
<tr>
<td></td>
<td>NO REDUNDANCY: (p = 1.3)</td>
</tr>
<tr>
<td></td>
<td>MAX COMPR: (1.3712 \left(43,944\right) + \frac{1.3 \left(5,872\right) \times 10}{28.3} = 28.8)</td>
</tr>
<tr>
<td></td>
<td>MAX COMPR: (34,912)</td>
</tr>
<tr>
<td></td>
<td>MAX TENS: (\left(1.6 - 0.1H(0.256)\right)1394 + 0.7(1.33100) = 27,028)</td>
</tr>
<tr>
<td></td>
<td>MAX TENS: (7,217) (CONF.)</td>
</tr>
<tr>
<td></td>
<td>UPLIFT IS NOT AN ISSUE</td>
</tr>
</tbody>
</table>
Design of Special Monoply S.W.

\[
P_N = 2(34.9K) = 69.8K
\]

\[
M_{u} = 1.3(5,187.2K) \cdot 20 = 134.9K \cdot ft
\]

Pure Axial

Load is small; try 3" block

\[
A_n = \frac{7.625 \times 3.52}{2} = 2684 \Phi
\]

\[
A_s = (0.2 \Phi) \cdot 10 = 2 \Phi
\]

\[
\frac{E}{A_n} = \frac{7.625}{\sqrt{12}} = 2.920
\]

\[
\frac{H}{L} = \frac{20.12}{L} = 109 > 99
\]

\[
P_u = 0.8(0.8) \cdot \frac{A_n - A_s}{f_y A_s} \left( \frac{70}{1} \right)^2
\]

\[
P_N = 0.8(0.8)(15.95)(2014 - 1.3) + 605 \cdot 1.48 \left( \frac{70}{1} \right)^2
\]

\[
P_N = 1100K \quad N \quad (P_{N} = 860)
\]

Pure Bending

\[
M_{N} = 20,629.3K \cdot ft = 1710K \cdot ft
\]

\[
\phi M_{N} = 1539.3K \cdot ft
\]

Balance Point

\[
\phi P_{N} = 0.9(1539.3K \cdot ft) = 1427.6K \cdot ft
\]

\[
\phi P_{N} = 0.8(851K) = 68K
\]
Reference:

\[ \phi_{P_0} = 1280 \text{k} \]

\[ C.E \phi_{P_n} = 704 \text{k} \]

Demand:

\[ \phi_{M_{1n}} = 1539 \text{k} \]

Interaction Diagram:

Boundary Elements:

1) \( P_u \leq 0.1 \text{Agf}_m \hfill \checkmark \)

2) \( M_{1n} \leq 0.9 \leq 1.0 \hfill \checkmark \)

3) \( V_u \leq 3 \cdot A_0 \cdot f_m \hfill \checkmark \)
### TYP. EW SHEAR WALL DESIGN

#### Parameters

<table>
<thead>
<tr>
<th>b</th>
<th>d</th>
<th>Fy</th>
<th>Neutral Axis ~ Goal Seek (in)</th>
<th>Em</th>
<th>Es</th>
<th>es</th>
<th>fm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.625</td>
<td>60</td>
<td>10.642</td>
<td>0.0025</td>
<td>29000</td>
<td>0.00206897</td>
<td>1500</td>
<td></td>
</tr>
</tbody>
</table>

#### Pure Bending

<table>
<thead>
<tr>
<th>Distance (in)</th>
<th>Area of steel (in^2)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry 4.2568</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bar 1 4</td>
<td>0.4</td>
<td>0.001560327</td>
<td>45.2494832</td>
<td>18.0997933</td>
<td>120.218827</td>
</tr>
<tr>
<td>Bar 2 88</td>
<td>0.4</td>
<td>-0.018172806</td>
<td>-60</td>
<td>-24</td>
<td>1856.592</td>
</tr>
<tr>
<td>Bar 3 172</td>
<td>0.4</td>
<td>-0.037905939</td>
<td>-60</td>
<td>-24</td>
<td>3872.592</td>
</tr>
<tr>
<td>Bar 5 264</td>
<td>0.4</td>
<td>-0.059518418</td>
<td>-60</td>
<td>-24</td>
<td>6080.592</td>
</tr>
<tr>
<td>Bar 6 348</td>
<td>0.4</td>
<td>-0.079251555</td>
<td>-60</td>
<td>-24</td>
<td>8096.592</td>
</tr>
</tbody>
</table>

#### Balance Point

- Actual Neutral Axis: 190.4150943

<table>
<thead>
<tr>
<th>Distance (in)</th>
<th>Area of steel (in^2)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry 76.1660377</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bar 1 4</td>
<td>0.4</td>
<td>0.002447483</td>
<td>60</td>
<td>24</td>
<td>4473.96226</td>
</tr>
<tr>
<td>Bar 2 88</td>
<td>0.4</td>
<td>0.001344629</td>
<td>38.9942529</td>
<td>15.5977011</td>
<td>1597.44003</td>
</tr>
<tr>
<td>Bar 3 172</td>
<td>0.4</td>
<td>0.000241776</td>
<td>7.01149425</td>
<td>2.8045977</td>
<td>51.6469313</td>
</tr>
<tr>
<td>Bar 5 264</td>
<td>0.4</td>
<td>-0.000366112</td>
<td>-28.017241</td>
<td>-11.206897</td>
<td>824.658426</td>
</tr>
<tr>
<td>Bar 6 348</td>
<td>0.4</td>
<td>-0.002068966</td>
<td>-60</td>
<td>-24</td>
<td>3782.03774</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>85.0548423</td>
</tr>
</tbody>
</table>
Reference: SHEAR CHECK

\[ V_u = 1.25(5.872K) = 6.5K \]
\[ \phi V_{n} = \left[ 4 + 1.75 \left( \frac{V_u}{V_{n \text{MAX}}} \right) \right] \frac{A_{n}}{F_{n}} + 0.25 P_{w} \]
\[ \phi V_{n} = 4 \left[ 4 + 1.75 \left( \frac{6.5}{39.07} \right) \right] \frac{2624}{2} \frac{1500}{4} + (8.9) \]
\[ \phi V_{n} = 214.4K \]

* NO TRANSVERSE NEEDED
DAPHNAGM ANALYSIS (NORTH- SOUTH)

SEISMIC WEIGHT

DL: 17.248 K

WALL: \( 76.5 \text{ psf} \times \left( \frac{2}{3} \times 29.3 \right) \times 2 = 44.9 \text{ K} \)

TOTAL ROOF SEISMIC WEIGHT

TOTAL WEIGHT AT ROOF: 62.28 K

\( F_{x_{\text{Roof}}} = 0.1712 \times 62.28 \text{ K} = 10.63 \text{ K} \)

\( F_{x_{\text{Wall 1}}} = F_{x_{\text{Wall 2}}} = \frac{10.63}{2} = 5.32 \text{ K} \)
Reference:

SHEAR WALL 1 (COMBINED LOADS)

\[
\text{MAX COMP: } (1.2+0.256) \times 354K + \frac{1.25 \times 24}{20} = 31.4K
\]

\[
\text{MAX TENS: } (0.6+0.256) \times 47.35K = 0.7(10.532 K) = 82.0K
\]

\[
\text{MAX TENS: } 7.4K (\text{comb.}) = 0 < (1)
\]

Collector on Shearwall 7-4-3

Answer:

- 12'-0'
- 8'-8'
- 12'-0'
Reference:

SHEAR WALL 2 

Answer:

\[ P_D = 7 \text{kip} + 20.12 \]
\[ P_D = 17.76 \text{kN} \]
\[ C_D = \frac{5.32}{2} = 2.66 \text{kN} \]

MAX COMP.: (1.210, 0.2081) 17.76 kN + 2.66 kN = 20.42 kN

MAX COMP.: 17.94 kN

MAX TENSION: \( \frac{0.0 - 0.14}{(0.059)}(17.76) = 2.66 \text{kN} \)

MAX TENSION: -17.45 kN
DESIGN OF SPECIAL EMBOSSED S.W. 3

\[ P_u = 1.2 \cdot 0.75 \cdot 0.5 \cdot (1.6) = (1.2 \cdot 0.3085) \cdot 0.35K \]

\[ P_u = 0.3 K \]

\[ M_{uw} = N_u \cdot h = (1.3)(5.32 K)(20) = 133.2 K \cdot ft \]

*USE 8" BLOCK

PURE AXIAL

\[ A_n = 7.625 \times 392 = 2989 \text{ in}^2 \]

\[ A_s = 5(0.414) = 2.05 \text{ in}^2 \]

\[ r = 2.201 \text{ in} \]

\[ \frac{r}{h} > 0.9 \]

\[ \phi P_n = 0.8 \left[ (A_n - A_s) + f_y A_s \left( \frac{r}{h} \right)^2 \right] \]

\[ \phi P_n = 0.8 \left[ (2989 - 2.05) + 60(2.201)^2 \left( \frac{2.201}{20} \right) \right] \]

\[ \phi P_n = 917K \]

PURE FLEXURE

\[ \phi M_{uw} = \frac{1726.5 K \cdot ft}{2} \]

BALANCE POINT

\[ \phi P_n = 67.7 \text{ K} \]

\[ \phi M_{uw} = 1322.2 \text{ K} \cdot \text{ft} \]

*SHEAR IS ADEQUATE BASED ON INSPECTION
### Parameters

<table>
<thead>
<tr>
<th>b</th>
<th>d</th>
<th>Fy</th>
<th>Neutral Axis = Goal Seek [in]</th>
<th>Em</th>
<th>Es</th>
<th>es</th>
<th>f'm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.625</td>
<td>60</td>
<td>10.642</td>
<td>0.0025</td>
<td>29000</td>
<td>0.002068966</td>
<td>1500</td>
<td></td>
</tr>
</tbody>
</table>

### Pure Bending

<table>
<thead>
<tr>
<th>Distance (in)</th>
<th>Area of steel (in²)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry</td>
<td>4.2568</td>
<td>0.4</td>
<td>0.001560327</td>
<td>45.2494832</td>
<td>77.89944</td>
</tr>
<tr>
<td>Bar 1</td>
<td>4</td>
<td>0.4</td>
<td>-0.020991825</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Bar 2</td>
<td>100</td>
<td>0.4</td>
<td>-0.043543977</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Bar 3</td>
<td>196</td>
<td>0.4</td>
<td>-0.066096129</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Bar 4</td>
<td>292</td>
<td>0.4</td>
<td>-0.088648283</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Bar 5</td>
<td>388</td>
<td>0.4</td>
<td>-0.000766728</td>
<td>-60</td>
<td>-24</td>
</tr>
</tbody>
</table>

### Balance Point

**Actual Neutral Axis**

212.3018868

<table>
<thead>
<tr>
<th>Distance (in)</th>
<th>Area of steel (in²)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry</td>
<td>84.9207547</td>
<td>0.4</td>
<td>0.002452897</td>
<td>60</td>
<td>77.89944</td>
</tr>
<tr>
<td>Bar 1</td>
<td>4</td>
<td>0.4</td>
<td>0.001322432</td>
<td>38.3505155</td>
<td>15.34020619</td>
</tr>
<tr>
<td>Bar 2</td>
<td>100</td>
<td>0.4</td>
<td>0.000191966</td>
<td>5.56701031</td>
<td>2.326804124</td>
</tr>
<tr>
<td>Bar 3</td>
<td>196</td>
<td>0.4</td>
<td>-0.0009385</td>
<td>-27.216495</td>
<td>-10.88659794</td>
</tr>
<tr>
<td>Bar 5</td>
<td>292</td>
<td>0.4</td>
<td>-0.002068966</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Bar 6</td>
<td>388</td>
<td>0.4</td>
<td>-0.000766728</td>
<td>-60</td>
<td>-24</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td></td>
<td></td>
<td>84.57985237</td>
<td>17628.94992</td>
</tr>
</tbody>
</table>

**Design Force**

67.6538619

**Design Moment**

1322.171244
<table>
<thead>
<tr>
<th>Reference:</th>
<th>DESIGN OF MASONRY</th>
<th>Answer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_r = (1.2 + 0.25D) \psi_m (1.2 + 0.2(0.25D))(1.7K)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_m = 24.35K$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M_u = \frac{5.32K \times 1.3 \times 20}{2} = 69.16K \cdot \text{ft}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* USE 8&quot; BLOCK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PURE AXIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_u = 11.4&quot; \times 7.626&quot; = 109.8 \text{ in}^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A_s = 1 in \times (0.2 in) = 2.0 \text{ in}^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$r = 2.201&quot;$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$# \geq 99$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\phi P_r = (0.8) \left[0.8 + \psi_m (A_o - A_s) + f_y A_s \left(\frac{r_o}{r}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table><p>ight)^2 \right]$ |
| $\phi P_r = 0.8 \left[0.8 (1.5K) \times 109.8 \text{ in}^2 + 60K \cdot 20 \text{ in} \left(\frac{70.22}{12.00}\right) \right]$ |
| $\phi P_r = 378.6K$ |
| PURE FLEXURE |
| $\phi M_n = 307.8K \cdot \text{ft}$ |
| BALANCE POINT |
| $\phi P_n = 30.3K$ |
| $\phi M_n = 345.9K \cdot \text{ft}$ |</p>
INTERACTION DIAGRAM

BOUNDARY ELEMENTS

1) $P_u \leq 0.1 \text{ kPa}^4 \text{m}^\text{4} \checkmark$
2) $\frac{m_u}{V_{u,av}} = 0.857 \leq 1.0 \checkmark$
3) $V_u \leq 3 \text{ AN} \sqrt{\text{m}} \checkmark$
### Parameters

<table>
<thead>
<tr>
<th>b</th>
<th>d</th>
<th>Fy</th>
<th>Neutral Axis ~ Goal Seek (in)</th>
<th>Em</th>
<th>Es</th>
<th>es</th>
<th>f'm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.625</td>
<td>60</td>
<td>5.48</td>
<td>0.0025</td>
<td>29000</td>
<td>0.002068966</td>
<td>1500</td>
<td></td>
</tr>
</tbody>
</table>

### Pure Bending

<table>
<thead>
<tr>
<th>Masonry</th>
<th>Distance (in)</th>
<th>Area of steel (in²)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar 1</td>
<td>4</td>
<td>0.4</td>
<td>0</td>
<td>0.005675182</td>
<td>19.580292</td>
<td>7.832116788</td>
</tr>
<tr>
<td>Bar 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bar 3</td>
<td>36</td>
<td>0.4</td>
<td>-0.013923358</td>
<td>-60</td>
<td>-24</td>
<td>732.48</td>
</tr>
<tr>
<td>Bar 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bar 5</td>
<td>140</td>
<td>0.4</td>
<td>-0.061368613</td>
<td>-60</td>
<td>-24</td>
<td>3228.48</td>
</tr>
</tbody>
</table>

**Design Moment**

307.8333727

### Balance Point

| Actual Neutral Axis
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>76.60377358</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Masonry</th>
<th>Distance (in)</th>
<th>Area of steel (in²)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar 1</td>
<td>4</td>
<td>0.4</td>
<td>0</td>
<td>0.002369458</td>
<td>60</td>
<td>40.1136</td>
</tr>
<tr>
<td>Bar 2</td>
<td>36</td>
<td>0.4</td>
<td>0</td>
<td>0.001325123</td>
<td>38.4285714</td>
<td>15.37142857</td>
</tr>
<tr>
<td>Bar 3</td>
<td>72</td>
<td>0.4</td>
<td>0</td>
<td>0.000150246</td>
<td>4.35714286</td>
<td>1.742857143</td>
</tr>
<tr>
<td>Bar 5</td>
<td>108</td>
<td>0.4</td>
<td>0.001024631</td>
<td>-29.714286</td>
<td>-11.8857129</td>
<td>373.1665768</td>
</tr>
<tr>
<td>Bar 6</td>
<td>140</td>
<td>0.4</td>
<td>-0.002068966</td>
<td>-60</td>
<td>-24</td>
<td>1521.509434</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>-0.054283212</td>
<td>-24</td>
<td>4104.445056</td>
</tr>
</tbody>
</table>

**Design Force**

36.27373714

**Design Moment**

395.898527
DESIGN TYP. MASONRY S.W. FOOTING

\[ Q_e = 5.32 k \]
\[ P_a = 4.24 k \]
\[ M_{w0} = (5.32 k) x 20 = 106.4 k-ft \]

CHECK BEARING

\[ q_{all} = \frac{44 k}{(5)(29.3)} + \frac{6(106.4 k-ft)}{(5)(29.3)^2} = 4 kSF \]
\[ q_{fc} = (1.33) 3000 psf = 4000 psf \]
\[ S = 0.56 \]

USE \( S = 1 \)

\[ q_{w,\text{MAX}} = \frac{(44 k)(1.37)}{(29.3)(1)} + \frac{6(106.4 k-ft)}{(29.3)(1)} = 7.8 kSF \]
\[ q_{w,\text{MIN}} = 1.31 kSF \]

[Diagram of footing with dimensions]
CHECK OVERTURNING

NO TENSION UPLIFT DUE TO SOIL!

PICK DEPTH

\[ V_u = 9V_{umax} \left( \frac{9}{12} \cdot \text{fig} \right) = 2.8 \times 1300 \times \text{psi} \times (12\,\text{in}) \times 0.7887 \times d \]

\[ \phi V_n = 0.6 \left( \frac{9}{12} \right) \times 1300 \times \text{psi} \times (12\,\text{in}) \times d = 0.7887 \times d \]

\[ \phi V_n = 5.6 - 2.8 \times d = 0.7887 \times d \]

\[ d = 1.56 \,\text{in} \quad \text{USE} \quad h = 12\,\text{in} \quad d = 8\,\text{in} \]

\[ \phi V_n > V_u \quad \text{ONE WAY SHEAR} \]

CHECK FLEXURE

CRITICAL SECTION IS 2\,\text{in} FROM EDGE OF SHEAR WALL

\[ M_u = 2.5 \times \text{ksf} \left( 1 - \left( \frac{1}{12} \right)^{1/2} \right) + \left( 2.8 \times 2.5 \right) \left( 1 - \left( \frac{1}{12} \right)^{1/2} \right)^{1/2} \]

\[ M_u = \text{NEGIGIBLE} = 0.59 \times \text{ksf} \]

\[ 2.5 \times \text{ksf} \]

\[ 2.8 \times \text{ksf} \]

\[ A_{sw} = (0.0018) \times A_y = (0.0018) \times (12\,\text{in}) \times (12\,\text{in}) = 0.20 \times \text{in} \]

USE NO. 4's @ 18\,\text{in} C.C.
Design of RC Shear Wall Footing

<table>
<thead>
<tr>
<th>Qe (k)</th>
<th>Pa (k)</th>
<th>h (ft)</th>
<th>Ma (k-ft)</th>
<th>Length (ft)</th>
<th>Sds</th>
<th>Shear Wall Thickness (in)</th>
<th>Length of a foot</th>
<th>fc</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.32</td>
<td>43.94</td>
<td>20</td>
<td>106.4</td>
<td>29.3333</td>
<td>0.856</td>
<td>8</td>
<td>1</td>
<td>3000</td>
</tr>
</tbody>
</table>

Check Bearing

Allowable Bearing (ksf) = 4
5 (ft) = 0.559574
Use a Width of 1

Max and Minimum Bearing

<table>
<thead>
<tr>
<th>Qumax</th>
<th>Qum Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.795937824</td>
<td>1.312053</td>
</tr>
</tbody>
</table>

Tension Uplift

Tension Load due to Soil
N/A

One Way Shear (Solve for d already)

d | Vu | if #REF! Vu Equals | Phi | Vn |
---|---|----------------|----|----|
8  | 0 | 6.309764 |

Check Flexure

<table>
<thead>
<tr>
<th>Qu @ critical section</th>
<th>Mu</th>
<th>As Min/ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.548623718</td>
<td>0.590787</td>
<td>0.2592</td>
</tr>
</tbody>
</table>

As | f_y | b | a | c | Es | Phi | Phi Mn |
---|----|---|---|---|----|-----|--------|
0.31 | 60 | 12 | 1823.529 | 2145.32872 | -0.003 | 0.9 | -1271.911765 |

Footing is 1' x 29' - 4" x 1' R.C. with No. 5's at 12" spacing
Reference:

**DESIGN LATERAL CONNECTION**

\[ D = (16,000 \text{ kips}) \times (21.25 \text{ ft}) = 470 \text{ kips} \]

\[ L_c = (20,000 \text{ kips}) \times (2.25 \text{ ft}) \times (2.25 \text{ ft}) = 587 \text{ kips} \]

**TOTAL LOAD:** 1057 kips

**USE TEL 2014 CAPACITY: 1070 kips**

---

**DESIGN WALL ANCHOR**

ASCE 1

12.11-1

\[ F_p = 0.45 \times 0.5 \times 3 \times 1.2 = 1.383 \text{ kips} \]

\[ \sigma = 0.93 \times 1.0 \times 4.1 \times 0.5 = 20 \text{ kips} \]

**SIMPSON CATALOG**

- (1) HD3B IS ADEQUATE: 1.895 kips
- 1.895 kips > 1.383 kips
Lateral: Fermentation Room
FERMENTATION DIAGRAM ANALYSIS (EAST-WEST)

\[ W = \frac{95,100 \text{ K}}{\sqrt{a b^2}} = 1.60 \text{ KLF} \]

\[ E_{\text{IN}} = 92.0 \text{ K} \left(10.16^{\circ}\right) - 42^\circ \left(F_{A2}\right) \]

\[ F_{A2} = 45.60 \text{ K} \]

\[ F_{A1} = 49.44 \text{ K} \]

GOVERNS
Reference:  

ORDINARY STIL BRACE FRAME

Answer:

* IGNORE DEADLOAD

$P = 1.3$

$20'-0''$

$24'-0''$

$A = 17$

$F = 9/11$

$F = 9(12.36k)(1.3) = 32.136k$

Maximum Compression = $32.136k \div 4 = 8.8k$

Maximum Tension = $38.56k$

Maximum Tension? = $38.56k$
Reference: DESIGN OF ORDINARY BRACE FRAME

BRACE DESIGN:

AXIAL DEMAND: \(38.56\text{K} \times \sin(\tan^{-1}(\frac{8}{20})) = 9.7\text{K}\)

* USING TRI-PYRAMID ROD:

TRI-PYRAMID ~ A35-12E MID-STRENGTH Stainless Steel CATALOG W/ A YIELD STRENGTH OF 101.7K

NOTE: SINCE Fig. 2 IN Ai5/3.11 WANTS "MINIMAL INELASTIC DEFORMATION, DUCTILITY IS NOT A CONCERN, SO USE HIGH STRENGTH CABLE"

~ A03-1000: HIGH STRENGTH STAINLESS STEEL IS ADEQUATE W/ A YIELD STRENGTH OF 120K

COLUMN DESIGN:

\[P_{O-E} = \frac{38.56\text{K}}{\cos(\tan^{-1}(\frac{8}{20}))} = 42\text{K}\]

\[P_{u} = (1.2)(0.25D)D + 0.55P_{O-E}\]

\[P_{u} = 0.5 + 2(42\text{K}) = 84\text{K}\]
CHECK COMPRESSION OF COLUMN:

\[ P_u = 8.4k \]
\[ P_{\text{N}} = 10k > 8.4k \]
\[ \rightarrow \text{FOR W8X31} \]

W8X31 IS ADEQUATE AS THE WORST CASE SCENARIO OCBF COLUMN W/ AN EFFECTIVE LENGTH OF 21'-0" W/ A992 STEEL.

CHECK COMPRESSION OF BEAM:

\[ P_u = \text{NEGLIGIBLE} = 0.153k \]
\[ M_u = \text{NEGLIGIBLE} = 17.3k\text{-ft} \]

* W8X31 IS ADEQUATE @ AN UNBRACED LENGTH OF 20'-0" & USING A992 STEEL IS ADEQUATE FOR MINIMAL LOADING.
Beam/Column: W8×31

A = 9.13 in², d = 8", b_f = 8", f = 0.435

t_w = 0.285 in, t = 5 3/8", f_{adv} = 0.899

I_x = 110 in⁴, S_x = 27.5 in³, f_s = 3.417

r = 30.4 in³, f_{u} = 202 in²

Detailing Information:

A03-0875 High Strength Rod w/
B210-0375 Clevis w/ a Pin Diameter
of 1.5". 0 Bolt w/ a Jaw Gap
of 1.56, Throat Depth of 2.91", Edge
distance of 2.13".

Throat Depth: X 2.4" X X
 X 2.13" X X
Edge Dist: 2.13"

DAWGAP: 1.5"

PIN OD: 1.5"
CHECK BLOCK SHEAR

\[ \theta = 20^\circ \]

\[ 20 / 110 (9.7k) = 91.55K \]

\[ F_{nv} = 30k\text{si} \]
\[ F_{u} = 58k\text{si} \]

\[ \phi R_n = 0.75 \left[ 0.6 \left( F_{nv} + F_{u} \right) \right] \]

\[ \phi R_n = 113.2k \]

\[ \phi R_{n,max} = (10, 0.6 F_{u} A_{g} + F_{u} A_{nt}) \]

\[ A_{g} = (4.0 \times \frac{1}{2}) = 2.0 \text{#} \]
Reference:

\[
\phi R_n = \phi (0.65 f_y f_{u y} + \frac{V_{u y}}{f_{u y}}) \text{factored}_{\text{frame design}} \]
\[
\phi R_{n,\text{max}} = 0.75 \left[ 0.65 (36ksi)^2 + 10.58^3 \right] (1.625) \]
\[
R_{n,\text{max}} = 103 \text{k} \]
\[
\phi R_n = 103 \text{k} > 92 \text{k} \]

So, \( \frac{1}{2} \) thick plate is adequate w/ \( \frac{1}{4} \) of failure plane on each side.

CHECK WELD

AS1.400 UNIFORM FORCE METHOD

\( a_b = \frac{6}{12} = 4'' \)
\( e_b = 0'' \)
\( \alpha = 12'' \)
\( \beta = 4'' \)
\( \Theta = \tan^{-1} (\frac{\beta}{\alpha}) = 19.3^\circ \)

\( \alpha + \delta \tan \Theta = 10.0'' \)
\( e_b \tan \Theta = 1.4 \)

**MUST CHECK MOMENT**
Reference:

\[ R = \sqrt{(x+a)^2 + (y+b)^2} \]
\[ R = \sqrt{(2+0)^2 + (3+4)^2} = 5.07'' \]

\[ \theta_{e} = \frac{E}{\sigma} \cdot \frac{P}{L} = \frac{21,609}{5.07} = 42.69 \text{k} \]

\[ H_{e} = \frac{E}{\sigma} \cdot \frac{P}{L} = 0 \text{k} \]

\[ H_{o} = \frac{E}{\sigma} \cdot \frac{P}{L} = \frac{21,609}{5.07} = 42.69 \text{k} \]

Answer:

\[ \text{DESIGN FOR SHEAR (WELD)} \]
\[ (Q_{RN}) = (0.6)(F_{SW})\left(\frac{12}{10}\right) \]
\[ (Q_{RN}) = 0.75(0.6)(10)(3)\left(\frac{12}{10}\right) \]

\[ 3/16'' \text{ FILLET WELD FOR SHEAR} \]

\[ \text{DESIGN FOR TENSION} \]

\[ \text{FOR TENSION} \]
\[ 3/16'' + 1/16'' \text{ AT 1/4'' FILLET WELD ON BOTH SIDES}. \]
DESIGN WELD FOR MOMENT

\[ kL = \frac{1}{4}, n = 0.25, A = 0 \]

\[ a = \frac{b}{2} = 4'' = 0.0666 \]

\[ c = 1.49 \]

\[ d_{min} = \frac{P_n}{f_{ccd}} = \frac{60}{500} = 9.7 \]

\[ 5/8'' \text{ FILLET WELD} \]
FERMENTATION ROOF DIAPHRAGM ANALYSIS

NORTH-SOUTH

W = \frac{48.56}{268.0} = 0.180 K

W = 425.0 P/l

KEY GOVERNING MOM; FRAME FORCE

F_A = \left(\frac{45}{2}\right) \left(425.0 \text{ P/l}\right) = 12.77K

CHORD FORCE

M_{\text{maximum}}
Reference: Governing Collector

Answer:

Moment Frame Loading

\[ Q_e = \frac{1}{12} P_d \]

\[ Q_e = 12.77k \]

\[ 3 + 1.0 \]

\[ P_d = 21.2k \] (c)

\[ P_{d,\text{max}} = 10.9k \] (c)

Diaphragm

[Max Comp: 21.2k + 12.77k * 24] / 20

[Max Comp: 30.10k] (c)

[Max Tens: 10.9k - 12.77k * 24] / 20 = 4.5k (T)
Reference:

ORDINARY MOMENT FRAME DESIGN

ALLOWABLE DRIFT: \( \Delta = 1.0\) 

\[ \frac{\Delta}{\delta} = \frac{(0.025)(2.35\text{ in})}{1.0} = 7.05\text{ in} \]

\( C_D = 3, I_e = 1.0, \theta = 29000\text{k-ft} \)

\[ K = 2 \left( \frac{12\text{EI}}{h^2} \right) = \frac{24(29000\text{k-ft})(1.0)}{(23.5 \text{ in}^4)(12\text{ in})^2} \]

\[ K = \frac{(0.031k)}{I_e} \]

\[ P_x = \frac{V}{K} = \frac{1}{10}(88.50k)(0.031k) \]

\[ P_x = 2.854\text{ in} \]

\[ P_x = \frac{C_D P_x}{I_e} = \frac{3 \cdot (2.854\text{ in})}{1.0} \]

\[ \Delta = 121.4\text{ in}^4 \]

TRY W 12X19 \( \Rightarrow \) \( P_x = 130\text{ in}^4 \)

\[ \frac{P_x}{I_e} = \frac{2(10\text{EI})}{h^3} \]

\[ V = 0.6\text{ in} \]
Reference:

**STORY DRIFT:**

\[ f_x = 6.6'' < 7.05'' = \Delta_y \]

**FRAME STABILITY**

\[ K_x = 21.2 \text{ kips} \]
\[ L = 6.4 \]
\[ I_x = 1.6 \]
\[ V_k = 38.56 \text{ kips} \]
\[ h_x = 12.5 \times 12 = 282'' \]
\[ C_o = 3.0 \]

\[ \Theta = \frac{P_x A_1 C_o}{V_k h_x C_o} = \frac{(21.2 \times 6.6)(1.0)}{(38.56)(282)(3.0)} \]
\[ \Theta = 0.00187 \text{ radians} \]

\[ \Theta_{max} = \frac{0.5}{3 \times 0.5} = 0.5 \times 0.167 = 0.167 < 0.25 \]

\[ \Theta_{max} > \Theta \]
\[ 0.167 > 0.00187 \]
CHECK COLUMN

\[ M_{y1,top} = 48.7k-ft \]
\[ f = 4.32k/c\text{e} \]
\[ P_L = 1.5k/c\text{e} \]
\[ V_L = 0.7k/c\text{e} \]

\[ C_B = \frac{12.5L_{max}}{2.5L_{max} + M_{min}^{\text{eq}} (2/3 + 3/4)} = 1.67 \]

USE TABLE 6-1

BY INSPECTION (FL/FR),
W12x22 Fails

TRY W12x40 \( K_L = 2.4 \)

\[ b_{x} = 4.94\times10^{-2} \]
\[ P = 3.05\times10^5 \]

\[ P + P_e = (0.00305)(43.2k) = 0.132 \]

\[ \sigma_{t,100k} = \frac{b_{x}b_{y}k_{y}}{400} = 2.16\times10^{-3} \]

\[ b_{x,\text{min}} = 4.16\times10^{-5} > 2.96\times10^{-5} \]

\[ b_{x} = b_{x,\text{min}} = 4.16\times10^{-5} \]

\[ \frac{P_L}{2P_L} + \left( \frac{\sigma_{t,100k}}{M_{c}} \right)^2 = \frac{P_L}{2} + \frac{0.00305(43.2k)^2(0.00416)(187)}{8} \]

\[ \frac{P_L}{P_L} + \frac{0.00305(43.2k)^2}{8} = 2.35 > 1.0 \]

FAILS...
TRY W 12\times 9\frac{1}{2} : \theta = 23.5^\circ, x = 24\frac{1}{2}

P = 0.0044 \text{ kips}, b_x = 10.0087

* BY INSPECTION ... USE $b_x = 0.0016$

$P_P = (0.0044)(42.22) = 0.164 < 0.2$

USE \[ P_P = \frac{8}{9} b_x M_t \]

\[ P_P + \frac{9}{8} b_x M_t = 0.164 + \frac{9}{8} (0.00187)(1876 - 6) \]

\[ P_P + \frac{9}{8} b_x M_t = 0.914 < 1.0 \checkmark \]

W 12\times 9\frac{1}{2} IS ADEQUATE FOR COMBINED AXIAL (COMP.) & FLEXURE AT A BRACE LENGTH OF 23.6\text{"} & A992 STEEL & ADEQUATE FOR SHEAR

* COLUMN IS ADEQUATE IN TENSION BY INSPECTION \( P_u = 1.5K < (T) \)

\[ \phi V_a = 210K > V_a \checkmark \]
Reference:

DESIGN BEAM

\( P_u = 20.7 \text{kips} \)

\( M_u = 50.7 \text{kips feet} \)

\( V_u = 39.6 \text{kips} \)

\( V_{UW} = 2 \times 9.0 = KL = 42' \)

ASV 3001

\( P = 0.00413 \quad b_x = 0.00239 \)

\( b_x = \frac{0.00145}{c_0} \)

\( P_r + P_c = (0.00413)(20.7) = 0.0861 \text{kips} \)

\( P_{fr} < 0.2 \) USE

\[ \frac{P_{fr}}{P} + \frac{9}{8} b_x m \leq 1.0 \]

\[ \frac{P_{fr}}{P} + \frac{9}{8} b_x m = 0.962 < 1.0 \]

CHECK SHEAR

\( AV_n = 210 \text{kips} > 39.6 \text{kips} \)

W12x96 A992 STEEL BEAM IS ADEQUATE FOR COMBINED LOADING OF COMPRESSION & BENDING AT AN UNBRACED LENGTH OF 41'0".

*NOTE UPsize COLUMN TO W12x100 FOR \( \frac{M_{PC}}{M_{PD}} > 1.0 \) ... DON'T TRUST E1.4 IN AISC 341
Reference:

\[ P_{uu} = 43.2 kN, P_{ll} = 1.5 \times (-1) \]

**BEAM**: W12 x 9

- \( A = 28.2 \text{ in}^2 \)
- \( t_a = 12.9 \text{ in} \)
- \( t_w = 0.55 \text{ in} \)
- \( t_c = 0.97 \text{ in} \)
- \( K_{cc} = 1.5 \)
- \( t_{sl} = 1.18 \text{ in} \)
- \( I_{ax} = 14.7 \text{ in}^3 \)
- \( M_{w} = 17.0 \)

**COLUMN**: W12 x 10

- \( A = 21.2 \text{ in}^2 \)
- \( t_a = 12.9 \text{ in} \)
- \( t_w = 0.61 \text{ in} \)
- \( t_c = 1.23 \text{ in} \)
- \( t_{sl} = 0.93 \text{ in} \)
- \( K_{cc} = 1.5 \text{ in} \)
- \( I_{ax} = 16.4 \text{ in}^3 \)
- \( M_{w} = 15.9 \)

**BEAM**:

- \( M_p = 1.1 \text{ kN-m} \)
- \( M_{pa} = (1.1)(10^4) \text{ in}^3 / 50 \text{ kN} \)
- \( M_p = 8893.5 \text{ kN-m} \)
- \( M_{pa} = 17911.25 \text{ kN-m} \)

**COLUMN**:

- \( M_p = 1.1 \text{ kN-m} \)
- \( M_{pa} = (1.1)(10^4) \text{ in}^3 / 50 \text{ kN} \)
- \( M_p = 9927 \text{ kN-m} \)
- \( M_{pa} = 18268.9 \text{ kN-m} \)

**CHECK PANEL ZONE**

\[ P_{e} / P_{y} = 43.2 kN / (150 \times (31.2 \text{ in}^2)) = 0.028 \]

0.028 < 0.75

**ASCE SPEC.**

\[ B_n = 0.6 F_y d t w (1 + 3 \beta_{etw} \gamma_{etw}) \]

- \( B_n = 0.46 F_y d t w (1 + 3 \beta_{etw} \gamma_{etw}) \)
Reference:

\[ R_n = 0.6 \left( \frac{508 \text{ psi}}{11.4 \text{ in}} \right) \left( \frac{12.4''}{0.061''} \right) \left( \frac{14'' \text{ in}}{11.4'' \text{ in}} \right) \left( \frac{11.4'' \text{ in}}{0.061''} \right) \]

\[ R_n = 386.5 \text{ K} \]

\[ M_{ue} = R_n \left( d_b - 0.3'' \right) = 386.5 \text{ K} \left( 12.4'' - 0.3'' \right) \]

\[ M_{ue} = 483.9 \text{ K in}, \ 386.5 \text{ K ft} \]

\[ V_{ue} = \frac{M_{ue}}{H} = \frac{386.5 \text{ K ft}}{23.5} = 16.4 \text{ K} \]

\[ M_{ue} = (386.5 \text{ K} + 16.4 \text{ K}) (12.4'' + 0.3'') \]

\[ M_{ue} = 483.9 \text{ K in}, \ 4103 \text{ K ft} \]

\[ E_{min} = 2 (1.1) \left( \frac{E_y}{M_y} \right) \frac{M_o}{L_c} \]

\[ V_{ue, A0} = \frac{2 M_{ue}}{E_{min}} = \frac{2 (483.9 \text{ K ft})}{(42 - 12.4''/12)} = 19.6 \text{ K} \]

\[ V_u = (19.6 \text{ K}) + 43.2 \text{ K} = 62.8 \text{ K} \]
<table>
<thead>
<tr>
<th>Reference</th>
<th>Design End Plate</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASG300</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$d_h = \frac{2 \cdot \mu_{ue}}{V_{cp} \cdot F_{rc,eq}} = \frac{2(42.25 \cdot 4.5 - n)}{1 \cdot (0.75 \cdot 0.25)(22.6 + 0.1 + 0.15 \cdot 2.5)}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$d_h = 0.81$</td>
<td>7/6.6 N bolts</td>
</tr>
<tr>
<td>ASG311</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F_{rc} = 325 \text{ ksi} \cdot (\frac{2}{d_h}) = 344.1 \text{ K}$</td>
<td></td>
</tr>
<tr>
<td>ASG311</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P_{M, no} = 0.75P_e \cdot (2 \cdot d) = 0.75(2)(15.12 \text{ K}) = 5633.9 \text{ kip} \cdot m = 4632.5 \text{ kip}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P_{\text{MIN}} = 5633.9 \text{ kip} \cdot m &gt; 4836 \text{ kip} \cdot m = \mu_{ue}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Determine thickness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$s = \frac{1}{2} \sqrt{d_p g} = \frac{1}{2} \sqrt{(22.6)(9.8)} = 2.64''$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P_0 = 3.0''$, $P_{FO} = 2.0''$, $P_{FM} = 2.0''$, $d_e = 1.25''$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$d_e &lt; s$</td>
<td></td>
</tr>
<tr>
<td>ASG41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide 41</td>
<td>$y_p = \frac{7}{2} \left[ 22.6 \left( \frac{1}{2.125} \right) + 19.6 \left( \frac{1}{2.5} \right) + 15.1 \left( \frac{1}{2.5} \right) \right] + \cdots$</td>
<td></td>
</tr>
<tr>
<td>ASG41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide 41</td>
<td>$12.1'' \cdot \frac{1}{2.125} + \frac{3}{4} \left[ 22.6 \left( 1.25 + \frac{3}{4} \right) + 19.6 \left( 2 + \frac{3}{4} \right) \right] + 15.1 \left( 2 + \frac{3}{4} \right) + 12.1'' \left( 2.65 + \frac{3(3)}{4} \right) + 3'' \left[ 1 + 4'' \right]$</td>
<td></td>
</tr>
<tr>
<td>ASG41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guide 41</td>
<td>$y_p = 2.32$ in</td>
<td></td>
</tr>
</tbody>
</table>
Reference:

\[ \tau_{pl,req} = \frac{(1.11)0.1\mu_e}{\sqrt{f_{yg} \cdot Y_p}} = \sqrt{0.9(36ksi)(232in)} \]

\[ \tau_{pl} = 0.132" \text{ in V8E 3/4" thick ASTM A240 PLATE} \]

**DESIGN END STIFFENER PLATE**

ANSCE 311

\[ t_{ex,req} = t_{ex} \left( \frac{f_{yb}}{f_{ys}} \right) = 0.55" \left( \frac{60ksi}{36ksi} \right) \]

ANSCE 311

EQ 3.15

\[ t_e = 0.7638" \text{ in 7/8" thick ASTM A240} \]

\[ h_{st} = P_{ot} \cdot 3.25 \div 2 + 3 + 1.25 = 6.25" \]

\[ L_{ex} = \frac{h_{st}}{\tan 30°} = 10.8" \div 11" \]

LOCAL BUCKLING:

\[ \lambda = 0.56 \sqrt{\frac{E}{f_y}} = 0.56 \sqrt{\frac{29000ksi}{36ksi}} \]

\[ \lambda = 16.9 \]

\[ \lambda = \frac{h_{st}}{L_{ex}} = 6.25 / 7.14 = 7.14 \]

\[ \lambda < \lambda_c, \quad 7.14 < 16.9 \]

**LOCAL BUCKLING IS FINE**
DETERMINE TYPE & SIZE OF STIFFNER WELD

\[ V_n = 0.6 \cdot t \cdot A_{weld} = 0.6 \cdot (3000 \text{ psi}) \cdot (7/8) = 18.9 \text{ kips} \]

2 SIDED WELD: \[ W_{req} = \frac{V_n}{2 \cdot (0.66 \cdot (3/4))} = \frac{18.9}{2 \cdot 0.66 \cdot (3/4)} = 0.424 \text{ in} \]

* 7/16" WELD THICKNESS

CHECK BOLT BEARING

* \[ R_N = 2.4 \cdot d \cdot f_u = 2.4 \cdot (7/8) \cdot (3/4) \cdot 38 \text{ ksi} = 51.35 \text{ kips} \]

\[ R_N = 91.35 \text{ kips/bolt} \] - ALL 8 BOLTS

* \[ R_N = 1.2 \cdot (3 - 15/10) \cdot (3/4) \cdot (58 \text{ ksi}) = 107.7 \text{ kips/bolt} \] - 6 INNER BOLTS

* \[ R_N = 1.2 \cdot (11/4 - 15/10) \cdot (3/4) \cdot (58 \text{ ksi}) = 40.7 \text{ kips/bolt} \] - 2 OUTSIDE BOLTS

\[ \phi R_{N, \text{total}} = 0.75 \left[ 6 \cdot (107.7 \text{ kips/bolt}) + 2 \cdot (40.7 \text{ kips/bolt}) \right] \]

\[ \phi 2R_N = 545.8 \text{ kips} > 62.8 \text{ kips} = V_n \]
BEAM FLANGE TO END PLATE WELD

\[ Q_{RN} = C \times (E_u \times b_r) \times f_e = \]
\[ Q_{RN} = (0.75) \times (0.6) \times (50 \times 3) \times (12.2) \times (0.9) = 247 \text{ kN} \]

\[ F_{EU} = \frac{983 \times 0.4}{12.9 - 0.9} = 380.5 \text{ kN} \]

\[ \theta = (90^\circ - (20^\circ - 0.6^\circ)) = 17.2^\circ \]

\[ a_c = 23.79'' \approx 1.50'' \text{ BECAUSE LOAD IS AT AN ANGLE} \]

\[ W_{KN} = \frac{F_{EU}}{L \times 2} = \frac{380.5 \text{ kN}}{1.5 \times 2} = \frac{380.5 \text{ kN}}{3} = 126.83 \text{ kN.m} \]

\[ W_{KN} = 0.48'' \text{ 1/2'' THICK FILLET WELD} \]

BEAM WEB TO END PLATE WELD

\[ Q_{RN} = C \times (E_u \times b_r) \times f_e = \]
\[ Q_{RN} = (0.9) \times (50 \times 3) \times (0.55) = 247.85 \text{ kN} \]

\[ W_{Kw} = \frac{Q_{RN}}{2 \times (0.10 \times 0.10)} \times (1.5) \]

\[ W_{Kw} = \frac{247.85 \text{ kN}}{2 \times (0.10 \times 0.10)} \times (1.5) \]

\[ W_{Kw} = 0.37'' \text{ 3/8'' FILLET WELD} \]
COLUMNS FLANGE STRENGTH CHECK

\[
S = \frac{1}{2} \sqrt{\frac{6F_{u}g}{f_{c}}} = \frac{1}{2} \sqrt{\frac{6 \times 22,000}{228}} = 3.99
\]

\[
P_0 = 3\text{ in}, \quad P_{so} = 2\text{ in}, \quad P_{si} = 2\text{ in}, \quad C = \frac{P_0 + P_{so} + P_{si}}{2}
\]

\[
y_c = \frac{P_0}{2} \left[ h_2 + h_3 \left( \frac{1}{5} \right) \right] + \frac{2}{3} \left[ h_1 + \frac{C}{2} + \frac{5}{6} h_1 + h_2 \left( \frac{1}{2} + \frac{a}{6} \right) \right] + h_3 \left( \frac{P_{so} + P_{si}}{2} \right) + 3/2
\]

\[
y_c = 241.3\text{ in}
\]

\[
\phi M_{cr} = \phi F_{y} y_{c} t = 0.9 \times 50,000 \times (241.3) \times (0.99)^{0.8} = 886,130 \text{ in-lb}
\]

\[
\phi M_{cr} = 10,433.44 \text{ lb-in} = 886,130 \text{ in-lb}
\]

\[
\phi M_{cr} > M_{ue} \quad \text{NO STIFFENER REQUIRED}
\]
Reference:

**EAST WEST COLLECTOR**

\[ P_{iB} = Q_e \cdot \frac{L}{L} = (23,41 K) \cdot \frac{2}{\ell} = 46.8 K \]

\[ M_u = \left( \frac{1}{2} + 0.2 \left( \frac{\text{SID}}{M_D} \right) \right) \frac{M_D}{7} \]

\[ M_D = \frac{w_l \ell}{s} = \frac{(0.153 \times 40)}{3} = 20.75 K \cdot \ell \]

\[ M_u = \left( 1.2 + 0.2 (0.83) \right) \frac{M_D}{3} = 42.16 K \cdot \ell \]

**TRY W 10x49 @ KL = 40 USING TEL 41**

\[ P = 11 \times 10^{-3} \quad \text{bx} = 8.18 \times 10^{-3} \]

\[ P_{ex} = \left( 11 \times 10^{-3} \right) (46.8) = 0.5184 \]

\[ \rho_{ex} + Mx \cdot bx \leq 1.0 \]

\[ 0.5184 + \frac{(2.16 \times 150)}{(8.18 \times 10^{-3})} = 0.86 \leq 1.0 \checkmark \]

**CHORD STRESSED FROM EQ. IN E-W**

\[ P_{Qe} = \frac{Q_e}{d} = \frac{293.23}{200} = 1.41 K \]

\[ P_x = P_{Qe} - P = (1.41 K) \cdot 2 = 2.82 K \]

\[ M = 230 K \cdot \ell \quad \text{USE WBX35 AS CHOICE} \]

[**W10X49 IS ADEQUATE FOR LOADING**]

\[ P_{u} = 46.8 K \quad M_u = 42.16 K \cdot \ell \]
Reference:

N-S LOADING CHORD DESIGN

\[
P_n = \left( \frac{78.8k - 4e}{5a - 4} \right) \frac{L - 2}{3} = 3.75 \text{ k}\]

*: USE COLLECTOR DESIGN OF EAST WEST

N-S COLLECTOR DESIGN

\[M_n = 230k \text{ ft}\]

\[P_n = P_{Q @ A_n} = (5.2k)(3) = 15.6k\]

USING TABLE (0-1 w/ A & B

TRY W/ 8X40

\[P = 2.94 \times 10^{-3}, \quad b_x = 3.59 \times 10^{-3}\]

\[P_{Fx} = (2.94 \times 10^{-3})(15.6k) \leq 0.2\]

\[\frac{P_{Fx} + 9b_x \alpha \max}{2} = \frac{2.94 \times 10^{-3}(15.6k) + 9(3.59 \times 10^{-3})}{2},\]

\[= 0.951 \leq 1.0 \checkmark\]

W/ 8X40 IS ADEQUATE FOR LOADING

\[P_n = 3.75k, \quad M_n = 230k \text{ ft}\]
Lateral: Barrel Aging Room
CENTER OF RIGIDITY

\[ x = 63', \quad y = 30' \]

\[ V_{f_2} = V_{f_1} = \frac{1}{2} \left( 1017 k \right) = 508.5 k \]

TORSIONAL SHEAR

\[ e = 63' + 62.4' = 0.6' \]

\[ e_{acc} = (120') (0.05) = 6.3' \]

\[ e = 30' - 30' = 0 \]

\[ q_{acc} = 60' (0.05) = 3' \]

WALL | R | R | \( Rir \) | \( Rir' \)
--- | --- | --- | --- | ---
1 | 30' | 30' | 900 | 
2 | 30' | 30' | 900 | 
3 | 63' | 63' | 3969 | 
4 | 63' | 63' | 3969 | 

\[ \sum \]

\[ V_{T1} = \frac{20'}{9738} \left( 1017 k \right) (63') = 21.62 k \]

\[ V_{T2} = 21.62 k \]

\[ V_{T3} = \frac{63'}{9738} \left( 1017 k \right) (63') = 45.4 k \]

\[ V_{T4} = 45.4 k \]
### Wall Forces

**E-W**

\[ V = V_{1} + V_{2} = 508.5k + 21.62k = 530.1k \]

\[ V_{2} = 530.1k \]

### North South

**Direct Shear**

\[ V_{D} = 476.4k + 1/3 = 486.2k \]

**Torsional Shear**

\[ V_{T1} = \frac{32}{9738}(476.4k)(2^2) = 9.02k \]

\[ V_{T2} = 9.02k \]

\[ V_{T3} = \frac{62}{9738}(476.4k)(3^2) = 18.95k \]

\[ V_{T4} = 18.95k \]

\[ V_{2} = V_{4} = 486.2k + 18.95k = 507.2k \]
SHEARWALL 1 & 2 DESIGN

WALL THICKNESS

\[
\frac{t_{W}}{d_{W}} = \frac{18}{127.5} < 2.0
\]

**Suggested** \( t_{W} = 25.5 \text{ in} \) 

**NUMBER OF CURTAINS**

\[
V_{w} = 1.3 \left( 520.1K \right) = 682.1K
\]

\[
2 A_{c} \sqrt{f_{c}} = 2 \left( 12.5 \times 12'' \right) \left( 18'' \right) \left( 800 \text{ psi} \right)
\]

\[
2 A_{c} \sqrt{f_{c}} = 348 \text{ in.} \text{ lb} > 689 K
\]

\[\Rightarrow \quad \frac{h_{c}}{d_{W}} < 2.0 \]

But \( t_{W} = 18'' \) 

USE 2 CURTAINS

REINFORCEMENT LIMITS

\[
S_{+min} = \frac{S_{+min}}{A_{c}} = 0.0025 = \frac{A_{s}}{A_{c}}
\]

\[
A_{s, min} = \left( 0.0025 \right) \left( 128.5 \times 12'' \right) \left( 18'' \right)
\]

\[
A_{s, min} = 68.9 \text{ in.} \text{ lb} \sim 0.54 \% f_{c}
\]

**USE (2) NO. 5's @ 12'' O.C.**
**CHECK SHEAR**

\[ V_{n} = A_{c} \gamma_{c} (x_{c} \gamma_{c} z_{c} + f_{c} f_{y}) \]

\[ h_{w}/f_{w} \leq 2.0 \quad ; \quad x_{c} = 3.0 \]

**USING NO.5 @ 12" O.C.**

\[ f_{c} = 0.625 \text{ ksi} \]
\[ 18" \times 12" = 216 \text{ ksi} \]

\[ V_{n} = A_{c} \gamma_{c} (x_{c} \gamma_{c} z_{c} + f_{c} f_{y}) \]

\[ V_{n} = 127.5 \times 12 \times 18 \times (3.0) \times 400 \text{ psi} + 0.0028 \times 0.5 \text{ ksi} \]

\[ V_{n} = 9,910.7 \text{ K} \quad \text{\( \phi \)} V_{n} = 7475 \text{ K} \]

\[ V_{u} = 689.1 \text{ K} < 7475 \text{ K} = \phi V_{n} \]

\[ \Rightarrow \text{ADEQUATE FOR SHEAR} \]

\[ V_{n,\text{max}} = 10 A_{c} \gamma_{c} f_{c} = 17,117 \text{ K} \geq V_{n} \]

**CHECK OUT OF PLANE**

\[ M_{u,\text{in-plane}} = (689.1 \text{ K}) \times 18 = 12,403.8 \text{ K} \]

\[ R_{u} = 1.3712 \left( 127.5 \times 18 \times \frac{12}{12} (0.15 \text{ ksi}) + 0.75 \times 0.5 \times 0.5 \right) \]

\[ R_{u} = 1762 \text{ K} \]

\[ M_{u} = \left( 1.2 + 0.2 S_{03} \right) \left[ \frac{216 \text{ ksi}}{18.18 + 1000} \right] \frac{1 \text{ ft}}{2} \]

\[ M_{u} = 112 \text{ k-ft} \]

\[ 1000 \text{ psi/ft} \]
Reference:

\[ M_{\text{out}}^{\text{tot}} = 12.75 \text{ k-ft} \]
\[ V_{\text{out}}^{\text{tot}} = \left(\frac{0.216}{2} \text{ k-ft} + \left(\frac{1.08 \cdot 0.216}{2}\right)\right) \text{ k-ft} = 9.088 \text{ k-ft} \]
\[ V_{N\text{out}} = 9.967.7 \text{ k-ft} \]

CHECK OUT OF PLANE FLEXURE

\[ M_u = 112 \text{ k-ft} \]
\[ d = \frac{8^2 - 0.75 \cdot 0.375 \cdot 0.625}{2} \]
\[ A_s = fy A_s = (0.3)(0.160)(0.03) = 0.455 \]
\[ C = 0.532 \text{ in} \]
\[ \frac{d - C}{\alpha_{cu}} > 0.002 \text{ in} \]
\[ \phi = 0.9 \]

\[ \phi M_N = \phi f_y A_s (d - 0.92) < M_u \]

Fails! Try No. 10's @ 9" O.C.

\[ A_s = 1.69 \text{ k-ft} \]
\[ a_f = f_y A_s = 2.14 \text{ k-ft} \]
\[ C = 2.92 \text{ k-ft} \]
\[ \frac{a - C}{\epsilon_{cu}} = \frac{10.375 - 2.92}{2.92} = 0.015 \geq 0.003 \]
\[ \phi = 0.9 \]
\[
\begin{align*}
\phi M_{\text{c}} &= \frac{\phi y A_s (a - a/2)}{L} = 0.9 \left( 60 \times \frac{1/4}{1.14} \right) \left( 0.375 - \frac{2.48}{2} \right) \\
\phi M_{\text{c}} &= 115.1 \text{k-ft} > 112 \text{k-ft} \\
\text{CHECK IN PLANE FLEXURE} \\
\text{IGNORE GRAVITY BECAUSE IT WILL HELP CAPACITY & MAKE THIS MORE COMPLICATED} \\
\phi M_{\text{c}} &= 218.6 \text{k-ft} > M_u \\
\text{BOUNDARY ELEMENTS} \\
\frac{h_w}{w} &< 2.0 \text{ NO SPECIAL B.E.} \\
\frac{400/f_y}{f_y} &> 3.0 \checkmark \\
\text{USE } A_{\text{min}} = 8'' @ B.E. \\
V_u &< A_c V_f = 1741.78 \text{k} > V_u \\
\text{TERMINATE TRANS REINFORCEMENT} \\
18'' \text{ THICK HW CONCRETE, W/ 2 CURTAINS OF REINFORCEMENT W/ TYPICALLY NO.10'S & NO.4'S @ 9'' C.C. SPACING, B.E. IS SPACED @ 8'' C.C. W/ TRANSVERSE NO.4'S @ 12'' C.C. WHICH TERMINATE @ B.E.}
\end{align*}
\]
<table>
<thead>
<tr>
<th>Reference:</th>
<th>Answer:</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONC. SHEAR WALL FOOTING</td>
<td></td>
</tr>
<tr>
<td>* 18&quot; THICK WALL, F’c=3000 psi (FOOTING)</td>
<td></td>
</tr>
<tr>
<td>* BEARING CHECK: S = 5</td>
<td></td>
</tr>
<tr>
<td>* qu,max = 4.29 ksf, qumax = -2.06 ksf</td>
<td></td>
</tr>
<tr>
<td>* TENSION FORCE (UPLIFT) = 101 K</td>
<td></td>
</tr>
<tr>
<td>ONE WAY SHEAR</td>
<td></td>
</tr>
<tr>
<td>V_u = q_u,max (α/v12 + 1) = 4.29 ksf (5/2 - 1/2 + 1/2) = 17.73 ksf</td>
<td></td>
</tr>
<tr>
<td>α = α1 = 20°, b = 24&quot;</td>
<td></td>
</tr>
<tr>
<td>α1 &gt; V_u</td>
<td></td>
</tr>
<tr>
<td>CHECK FLEXURE ( A_b = (2) \text{ No. 4&quot;} )</td>
<td></td>
</tr>
<tr>
<td>M_u = 6.3K-ft/ft</td>
<td></td>
</tr>
<tr>
<td>α MN = 230.3 K-ft/ft</td>
<td></td>
</tr>
</tbody>
</table>
**Reference:**

**DESIGN SHEAR WALL 3 & 4**

\[ \frac{h_w}{b_w} = \frac{18}{60} \leq 2.0 \]

\[ h_{\text{max}} = \frac{h_w}{60} = 10' = 120" \]

*USE 18"*

**NUMBER CURTAINS**

\[ V_u = 1.3 (507.2 k) = 659.4 K \]

\[ 2A_{cv} \sqrt{f_c} = 2(60\cdot12\cdot18)(1)(4000) \]

1) \[ 2A_{cv} \sqrt{f_c} = 1639.3 K \geq 659.4 K \]

2) \[ \frac{h_w}{b_w} \leq 2.0 \checkmark \]

*\[ h = 18" \]

*\[ 2 \text{ CURTAIN REQ'T} \]

**REINFORCEMENT LIMITS**

\[ f_{u} \geq \frac{3t}{s_{min}} = \frac{0.0025}{A_{cv}} \]

\[ A_{s_{min}} = 0.0025 \cdot 12'' \cdot 18'' = 0.54 \frac{\text{in.}^2}{\text{ft}} \]

\[ \Rightarrow \text{NO. 7 @ 12'' O.C. SPACING TOP} \]

**CHECK SHEAR**

\[ V_n = A_{cv} (\alpha c_{x} \sqrt{f_c} + 3 \cdot f_{y}) = 60 \cdot 12 \cdot 18 (2.069 + 0.000030) \]

\[ V_n = 4,1630.3 K \]

\[ \phi V_n = 3477.2 K \]
\[ V_{\text{max}} = 10 A c \sqrt{f_e} = 8,196 K > V_n \checkmark \]

\[ \phi V_n = 3477.2 K > 659.4 K \]

**OUT OF PLANE LOADING**

* SHEAR *

\[ V_{\text{out}} = 427.7 K < \text{TOTAL} \]

\[ M_{\text{out}} = 112 K - \text{ft} \]

\[ V_{\text{out}} = 18'' \times (60''/2'') \left( 3.01 \left( \frac{14,000}{1000} + 0.00287 \times 6 \right) \right) \]

\[ V_{\text{out}} = 4,070.7 K > V_{\text{out}} \]

\[ V_{\text{max}} = 10 A c \sqrt{f_e} = 8,196 K \]

* CHECK FLEXURE *

* USE NO. 10's @ 9'' C.C. (FROM CONG, 3.01)

\[ \phi M_n = 115.1 K - \text{ft} > 112 K - \text{ft} \]

**CHECK IN PLANE FLEXURE**

* NEGLECT GRAVITY LOADING BY IT WILL HELP IN PLANE CAPACITY

\[ \phi M_n = 165,773 K - \text{ft} > M_n \checkmark \]
Reference: 

**BOUNDARY ELEMENT**

\[ \frac{h_w}{h_m} \leq 2.0 \] **NO SPECIAL\]

\[ \frac{400}{E_y} < \frac{f_y}{E_y} \]

**USE 8" @ B.E. SPACING**

\[ V_u < A_{w}f_{y}t = 819.66k \]

\[ V_u = 659k < 819.66k \] ✔

**TERMINATE REINFORCE TRANSVERSE**

@ B.E.

18" THICK N.W. CONC. S.W. W/2 COILS OF REBAR (LONG) W/ NO.10'S & NO.9'S TYPICAL @ 9" SPACING, B.E. LONG BARS ARE SPACED @ 8" C.C., WHICH IS CONFINED W/ NO.3 HOOPS
<table>
<thead>
<tr>
<th>Parameters</th>
<th>b</th>
<th>d</th>
<th>Fy</th>
<th>Neutral Ax</th>
<th>Ec</th>
<th>Es</th>
<th>es</th>
<th>f’c</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>60</td>
<td>107</td>
<td>0.003</td>
<td>29000</td>
<td>0.002069</td>
<td>4000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pure Bending**

<table>
<thead>
<tr>
<th>Distance (in)</th>
<th>Area of steel (in^2)</th>
<th>Strain</th>
<th>fs (ksi)</th>
<th>Force (k)</th>
<th>Moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry</td>
<td>42.8</td>
<td></td>
<td></td>
<td>4930.56</td>
<td>316542</td>
</tr>
<tr>
<td>Bar 1</td>
<td>4</td>
<td>1.47</td>
<td>0.002888</td>
<td>60</td>
<td>88.2</td>
</tr>
<tr>
<td>Bar 2</td>
<td>13</td>
<td>1.47</td>
<td>0.002636</td>
<td>60</td>
<td>88.2</td>
</tr>
<tr>
<td>Bar 3</td>
<td>22</td>
<td>1.47</td>
<td>0.002383</td>
<td>60</td>
<td>88.2</td>
</tr>
<tr>
<td>Bar 4</td>
<td>31</td>
<td>1.47</td>
<td>0.002131</td>
<td>60</td>
<td>88.2</td>
</tr>
<tr>
<td>Bar 5</td>
<td>40</td>
<td>1.47</td>
<td>0.001879</td>
<td>54.47664</td>
<td>80.08065</td>
</tr>
<tr>
<td>Bar 6</td>
<td>49</td>
<td>1.47</td>
<td>0.001626</td>
<td>47.15888</td>
<td>69.32355</td>
</tr>
<tr>
<td>Bar 7</td>
<td>58</td>
<td>1.47</td>
<td>0.001374</td>
<td>39.84112</td>
<td>58.56645</td>
</tr>
<tr>
<td>Bar 8</td>
<td>67</td>
<td>1.47</td>
<td>0.001121</td>
<td>32.52336</td>
<td>47.80935</td>
</tr>
<tr>
<td>Bar 9</td>
<td>76</td>
<td>1.47</td>
<td>0.000869</td>
<td>25.20561</td>
<td>37.05224</td>
</tr>
<tr>
<td>Bar 10</td>
<td>85</td>
<td>1.47</td>
<td>0.000617</td>
<td>17.88785</td>
<td>26.29514</td>
</tr>
<tr>
<td>Bar 11</td>
<td>94</td>
<td>1.47</td>
<td>0.000364</td>
<td>10.57099</td>
<td>15.53804</td>
</tr>
<tr>
<td>Bar 12</td>
<td>103</td>
<td>1.47</td>
<td>0.000112</td>
<td>2.52336</td>
<td>1.476035</td>
</tr>
<tr>
<td>Bar 13</td>
<td>112</td>
<td>1.47</td>
<td>-0.00014</td>
<td>-4.06542</td>
<td>-5.97617</td>
</tr>
<tr>
<td>Bar 14</td>
<td>121</td>
<td>1.47</td>
<td>-0.00039</td>
<td>-11.3832</td>
<td>-16.7333</td>
</tr>
<tr>
<td>Bar 15</td>
<td>130</td>
<td>1.47</td>
<td>-0.00064</td>
<td>-18.7009</td>
<td>-27.4904</td>
</tr>
<tr>
<td>Bar 16</td>
<td>139</td>
<td>1.47</td>
<td>-0.0009</td>
<td>-26.0187</td>
<td>-38.2475</td>
</tr>
<tr>
<td>Bar 17</td>
<td>148</td>
<td>1.47</td>
<td>-0.00115</td>
<td>-33.3364</td>
<td>-49.0046</td>
</tr>
<tr>
<td>Bar 18</td>
<td>157</td>
<td>1.47</td>
<td>-0.0014</td>
<td>-40.6542</td>
<td>-59.7617</td>
</tr>
<tr>
<td>Bar 19</td>
<td>166</td>
<td>1.47</td>
<td>-0.00165</td>
<td>-47.972</td>
<td>-70.5188</td>
</tr>
<tr>
<td>Bar 20</td>
<td>175</td>
<td>1.47</td>
<td>-0.00191</td>
<td>-55.2897</td>
<td>-81.2759</td>
</tr>
<tr>
<td>Bar 21</td>
<td>184</td>
<td>1.47</td>
<td>-0.00216</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 22</td>
<td>193</td>
<td>1.47</td>
<td>-0.00241</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 23</td>
<td>202</td>
<td>1.47</td>
<td>-0.00266</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 24</td>
<td>211</td>
<td>1.47</td>
<td>-0.00292</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 25</td>
<td>220</td>
<td>1.47</td>
<td>-0.00317</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 26</td>
<td>229</td>
<td>1.47</td>
<td>-0.00342</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 27</td>
<td>238</td>
<td>1.47</td>
<td>-0.00367</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 28</td>
<td>247</td>
<td>1.47</td>
<td>-0.00393</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 29</td>
<td>256</td>
<td>1.47</td>
<td>-0.00418</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 30</td>
<td>265</td>
<td>1.47</td>
<td>-0.00443</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 31</td>
<td>274</td>
<td>1.47</td>
<td>-0.00468</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 32</td>
<td>283</td>
<td>1.47</td>
<td>-0.00493</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 33</td>
<td>292</td>
<td>1.47</td>
<td>-0.00519</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 34</td>
<td>301</td>
<td>1.47</td>
<td>-0.00544</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>-------</td>
<td>-----</td>
<td>------</td>
<td>-----------</td>
<td>----</td>
<td>-------</td>
</tr>
<tr>
<td>Bar 35</td>
<td>310</td>
<td>1.47</td>
<td>-0.00569</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 36</td>
<td>319</td>
<td>1.47</td>
<td>-0.00594</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 37</td>
<td>328</td>
<td>1.47</td>
<td>-0.0062</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 38</td>
<td>337</td>
<td>1.47</td>
<td>-0.00645</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 39</td>
<td>346</td>
<td>1.47</td>
<td>-0.0067</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 40</td>
<td>355</td>
<td>1.47</td>
<td>-0.00695</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 41</td>
<td>364</td>
<td>1.47</td>
<td>-0.00721</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 42</td>
<td>373</td>
<td>1.47</td>
<td>-0.00746</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 43</td>
<td>387</td>
<td>1.47</td>
<td>-0.00785</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 44</td>
<td>396</td>
<td>1.47</td>
<td>-0.0081</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 45</td>
<td>405</td>
<td>1.47</td>
<td>-0.00836</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 46</td>
<td>414</td>
<td>1.47</td>
<td>-0.00861</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 47</td>
<td>423</td>
<td>1.47</td>
<td>-0.00886</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 48</td>
<td>432</td>
<td>1.47</td>
<td>-0.00911</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 49</td>
<td>441</td>
<td>1.47</td>
<td>-0.00936</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 50</td>
<td>450</td>
<td>1.47</td>
<td>-0.00962</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 51</td>
<td>459</td>
<td>1.47</td>
<td>-0.00987</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 52</td>
<td>468</td>
<td>1.47</td>
<td>-0.01012</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 53</td>
<td>477</td>
<td>1.47</td>
<td>-0.01037</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 54</td>
<td>486</td>
<td>1.47</td>
<td>-0.01063</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 55</td>
<td>495</td>
<td>1.47</td>
<td>-0.01088</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 56</td>
<td>504</td>
<td>1.47</td>
<td>-0.01113</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 57</td>
<td>513</td>
<td>1.47</td>
<td>-0.01138</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 58</td>
<td>522</td>
<td>1.47</td>
<td>-0.01164</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 59</td>
<td>531</td>
<td>1.47</td>
<td>-0.01189</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 60</td>
<td>540</td>
<td>1.47</td>
<td>-0.01214</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 61</td>
<td>549</td>
<td>1.47</td>
<td>-0.01239</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 62</td>
<td>558</td>
<td>1.47</td>
<td>-0.01264</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 63</td>
<td>567</td>
<td>1.47</td>
<td>-0.0129</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 64</td>
<td>576</td>
<td>1.47</td>
<td>-0.01315</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 65</td>
<td>585</td>
<td>1.47</td>
<td>-0.0134</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 66</td>
<td>594</td>
<td>1.47</td>
<td>-0.01365</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 67</td>
<td>603</td>
<td>1.47</td>
<td>-0.01391</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 68</td>
<td>612</td>
<td>1.47</td>
<td>-0.01416</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 69</td>
<td>621</td>
<td>1.47</td>
<td>-0.01441</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 70</td>
<td>630</td>
<td>1.47</td>
<td>-0.01466</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 71</td>
<td>639</td>
<td>1.47</td>
<td>-0.01492</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 72</td>
<td>648</td>
<td>1.47</td>
<td>-0.01517</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 73</td>
<td>657</td>
<td>1.47</td>
<td>-0.01542</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 74</td>
<td>666</td>
<td>1.47</td>
<td>-0.01567</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 75</td>
<td>675</td>
<td>1.47</td>
<td>-0.01593</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 76</td>
<td>684</td>
<td>1.47</td>
<td>-0.01618</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 77</td>
<td>693</td>
<td>1.47</td>
<td>-0.01643</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 78</td>
<td>702</td>
<td>1.47</td>
<td>-0.01668</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 79</td>
<td>711</td>
<td>1.47</td>
<td>-0.01693</td>
<td>-60</td>
<td>-88.2</td>
</tr>
<tr>
<td>Bar 80</td>
<td>720</td>
<td>1.47</td>
<td>-0.01719</td>
<td>-60</td>
<td>-88.2</td>
</tr>
</tbody>
</table>

-18.2019  2210307
Reference: CONC. SHEAR WALL FOOTING

* 18" THICK WALL, f'_c = 3000 psi

* CHECK BEARING: 5' WIDE

* Q_u, max = 3.78 ksf  Q_u, min = 2.37 ksf

* NO TENSION UPLIFT

\[ V_u = q_u \left( \frac{d}{2} \right) \left( \frac{d}{2} \right) = 14.72 \text{ kips} \left( \frac{14}{2} \right) \left( \frac{12}{2} \right) \]

\[ V_n = b d = b \left( \frac{d}{2} \right)(12000 \text{ psi})(12) \]

\[ V_n = V_u \quad d = 17.37" \quad \text{USE} \quad d = 20" \]

\[ V_n > V_u \quad \text{ONE WAY SHEAR CHECKS OUT} \]

* CHECK FLEXURE

\[ M_u = 5.322 \text{ kips-ft/ft} \]

\[ A_s, min = 2.592 \text{ #/ft} \]
<table>
<thead>
<tr>
<th>Design of RC Shear Wall Footing</th>
<th>Max and Minimum Bearing</th>
<th>One Way Shear (Solve for d already)</th>
<th>Tension Uplift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Bearing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Footing is 4" x 127" - 4" x 1" - 6" R.C. with (3) No. 9's per 24"**

### Design of RC Shear Wall Footing

<table>
<thead>
<tr>
<th>d</th>
<th>Vu</th>
<th>#REFL</th>
<th>h (ft)</th>
<th>Qmax</th>
<th>Qmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
</tbody>
</table>

### Max and Minimum Bearing

<table>
<thead>
<tr>
<th>b</th>
<th>L</th>
<th>E</th>
<th>Vu</th>
<th>Phi</th>
<th>H (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

### One Way Shear (Solve for d already)

<table>
<thead>
<tr>
<th>d</th>
<th>Vu</th>
<th>#REFL</th>
<th>h (ft)</th>
<th>Qmax</th>
<th>Qmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
</tbody>
</table>

### Tension Uplift

<table>
<thead>
<tr>
<th>d</th>
<th>Vu</th>
<th>#REFL</th>
<th>h (ft)</th>
<th>Qmax</th>
<th>Qmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
</tbody>
</table>

### Check Flexure

<table>
<thead>
<tr>
<th>d</th>
<th>Vu</th>
<th>#REFL</th>
<th>h (ft)</th>
<th>Qmax</th>
<th>Qmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
</tbody>
</table>

### As

<table>
<thead>
<tr>
<th>d</th>
<th>Vu</th>
<th>#REFL</th>
<th>h (ft)</th>
<th>Qmax</th>
<th>Qmin</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.722275</td>
<td>2.962225</td>
</tr>
</tbody>
</table>