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The Structural Design of Laramie County Community College Student Services Center

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The Structural Design of Laramie County Community College Student Services Center

For
Undergraduate Research Day
and
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by
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Abstract

Modern society entrusts structural engineers with the task of designing the structural systems for a building that maintains the architectural identity of the design. The structural engineer must choose the most cost effective material that will support the forces that the building will experience. Concrete, steel, and wood are the most common building materials that are used in structural design, and to determine the appropriate structural system and materials the engineer must consider the building's location, site parameters, architectural elements, and budget. Once the structural system is determined, the engineer designs all structural members and connections specified code standards. The final designs are included in a set of construction drawings that allow for the construction of the building. This senior design project considers a specific building's parameters to choose an efficient structural system that maintains the architectural vision for a student services center on the campus of Laramie County Community College (LCCC) in Cheyenne, WY. The project discusses the aspects of the design process including schematic design, design development, and construction drawings. The structural engineer designs all structural aspects of the building including girders, beams, columns, decking, footings, as well as all the connections of the members. Additionally, the engineer must design a sufficient lateral system for the transfer of wind and seismic loads. The project creates a feasible structural plan for the student services center at LCCC.

Introduction

Definition, Description, and Background

Buildings are a fundamental part of modern infrastructure utilizing structural engineers to create a safe, reliable, and functional design of a building's structural system that enhances the architectural integrity of a building. Structural engineers work closely with the architects, geotechnical engineers, and mechanical systems engineers to create a seamless structure that meets the client's standards and maintain building code requirements. The structural engineer works with the geotechnical engineer to create a foundation system that supports the building and all forces transferred to the system. Additionally, the structural engineer chooses the materials best suited to the building's design, most commonly used are steel, concrete, wood, or some combination of different materials. The engineer uses the structural materials to create system that transfers both gravity loads such as dead, live, roof, and snow loads, as well as lateral loads from seismic and wind forces. These are accomplished through three design phases, schematic design, design development, and construction drawings.

All these considerations are used to analyze the structural system of the Laramie County Community College Student Services Center. The student services center is a four-story building located in Cheyenne Wyoming. The four-story structure consists of both office spaces and classroom spaces, with the classroom spaces primarily on the upper floors. The façade of the building features stone cladding with curtain wall windows on the north and south facades. Two fire egress stairwells are located on the southeast and southwest of the building. The architect has specified a flat roof, with a slight slope for drainage that will also house HVAC units for the mechanical systems.

Purpose of Report

The purpose of this report is to determine the structural design of Laramie County Community College Student Center. Additionally the report will discuss the feasibility of the structure through the schematic design, design development, and construction drawing phases of the design process.

Method of Inquiry

The information contained within, and the findings of the research are the product of academic and industrial research in the field of structural engineering as well as data collected through the design of the structural system of LCCC Student Services Center using architectural drawings of the building and geotechnical report of the site. Additionally, the project was complete as a senior design team project, but this report focuses on the individual contribution to the project.

Working Definitions

For the purpose of this report, the term structural member is any building integral part in transmitting forces either directly or indirectly within the building, and engineers use the term structural systems to describe a group of components that work together to transmit forces. These elements are commonly beams, girders, columns, connections, and foundations.

The schematic design, design development, construction documents, and construction administration refer to only the structural sections of these legal documents for the purpose of this report.

Scope of the Inquiry

This report provides insight into the practicability of the structural system design of LCCC Student center through an analysis of the schematic design, design development, and construction drawing phases of the design process and provides recommendations regarding the feasibility of the structural system.

Conclusions of the Inquiry

Buildings are imperative to modern infrastructure, and structural engineers are needed to create safe, reliable and efficient structures. The structural engineer chooses the appropriate material to design the system for the both the gravity and lateral loads. Additionally, the structural engineer must works with a geotechnical team to ensure a sufficient foundation system that will support the entire building. Standard codes are used to specify the structural system and structural members of the building using the site parameters. Through the schematic design, design development, and construction drawing phases of the construction management process it is possible to design a feasible structural system for the LCCC Student Services Center.

Collected Data

First Topic of Investigation: Schematic Design

Definition

The schematic design (SD) phase is the starting point of a contract introducing the client of the building to the preliminary design of the building and the general requirements and specifications. The SD encompasses the preliminary design aspects of a building including architectural, structural, and mechanical. The American Institute of Architects (AIA) provides seven items to be included in the structural section of the SD report (Lough). These items include:

1. Determine Structural System
2. Establish Major grid lines, columns, shearwall, and other vertical elements
3. Determine dimensional requirements and size structural components
4. Address major slab openings on typical floors, size major beams and spandrel beams.
5. Address unique foundation conditions.

6. Provide general descriptive information sufficient for Schematic pricing such as estimates of pounds of rebar per square foot, etc.
7. Review pertinent portions of the Outline Specifications

However, for the purposes for this project only points one, two, and five will be discussed.

Findings

For the LCCC Student Center Geotechnical engineers provided a site assessment and foundation recommendations. The geotechnical report recommended that due to the presence of compressible soils within the proposed building footprints, the foundation should consist of spread footing foundations bearing on an over-excavated and re-compacted subgrade, or engineered aggregate piers (Laramie County Community College (LCCC) University Student Center Cheyenne, Wy). Engineered aggregate piers, also called stone columns are shown in Figure 1. Engineered aggregate piers are columns of compacted stone installed in groups in soft soil to increase bearing pressure and mitigate settlement under structural footings (Aggregate Piers: Cost Effect Successful Method to Improve Soft Soil).The columns are formed when lifts of stone are introduced to an open hole and compacted using high-energy densification equipment (Ibid). This process increases the bearing strength of a weak soil, allowing the soil to a support a structure.

Figure 1.Engineeered Aggregate Piers.
Source:https://smediacacheak0.pinimg.com/736x/a9/30/10/a93010d5a9a9f473ac9a77ed4c585139.jpg

Determining the primary structural system involves choosing the appropriate building material for the project. For structural purposes, the most common materials are timber, concrete, and steel. Timber has higher structural efficiency as carried load per unit weight compared to reinforced concrete and steel structures (McGar). Many timbers are either naturally durable or can be easily treated to make very durable against decay and fire (ibid). Structural type, location and intended service life are all factors when determining the appropriate use of timber, but in general terms it is lightweight, easily worked, very adaptable to offsite manufacturing and generally cheaper than other materials (ibid). However, timber is primary used for low rise and residential purposes, but is gaining more popularity in multi-story commercial structures.

Similar to timber, concrete is a very durable material. Concrete is a mixture of aggregates, cement, and water and a structural engineer specifies the desired strength to be manufactured (ibid). Concrete has very high compression strength and has the highest shear strength of any other material (ibid). Steel is the most common building material for a multi-story commercial building. Steel is a relatively new building material, gaining praise for being efficient and economical, and can span longer distances than either concrete or timber (ibid). Steel has high strengths in both compression, tension, allows for quicker construction time reducing the number of workers onsite as well as noise and dust during construction (ibid).

Once the unique foundations are addressed and the structural material is determined, the column grid is established. The structural engineer must take into account both the functionality and structural purposes of the design taking in to account the architect's layout of rooms and hallways (Structural Design Process). Ideally, for ease of design and structural purposes, the column grid would be consistent from floor to floor, but to ensure functionality the grid can change, but the structural engineer must ensure the proper transition of the forces.

Interpretation of Findings

Since the geotechnical report determined the soil in the area of the building to be soft, the use of engineered aggregated piers was determine to support the buildings foundation system. This system is a feasible choice because it increases the bearing pressure of the soil more than conventional subgrade improvement. However, specialty geotechnical foundation contractors are necessary to perform the design of this foundation system. This could result in additional costs and time for the project.

The material choices for this project were steel framing members with concrete footings and shear walls. Concrete is a feasible choice for the footings, and will be used for concrete shear walls if necessary, because of the material's durability and high capacity in both compression and shear. A steel gravity system was determined to be the most efficient system. Due to the architectural specifications, mainly the ribbon windows on the north and south facades as shown in Figure 2. Steel was the optimal material choice because of its ability to span longer distances and have smaller member size than concrete, which will cause minimal obstruction of views on the north and south faces. Additionally, steel construction is quicker and creates less noise and dust than other construction methods, which is important since the site is on a functioning college campus.

Figure 2. North and South Facades of LCCC Student Services Center.

Second Topic of Investigation: Design Development

Definition

The design development phase (DD) is a logical extension of schematic design. DD tasks build on the approved schematic design to reach a level of completeness that demonstrates the project can be built. Throughout the DD phase, it is important to evaluate how systems, material selection, and detailing reflect the schematic design concept (Design Development). The main task that must be accomplished in DD is preparation of drawings and documents for the client that detail project scope, quality, and design (ibid). Ultimately, the DD documents allow a client to make an informed decision whether to continue a project into the CD phase and construction itself. For this project, the DD phase focused on determining the flexure system of the building as well as the compression requirements.

Findings

For flexural members' two types of framing were under consideration including hot rolled steel shapes and open webbed steel joists for both the floor and roof framing. Figure 3 shows a typically hot rolled steel member. Hot rolled steel members are created in a mill process which involves rolling that steel at high temperatures that are above steel's recrystallization temperature, typically great than 1700^{o} F (Difference Between Hot Rolled Steel and Cold Rolled Steel). The steel is easily shaped into and formed easily into larger sizes at such high temperatures, and this method is available at cheaper prices than other methods (ibid). However, during the cooling process, the steel will shrink slightly and there is less control on the size and shape compared to other

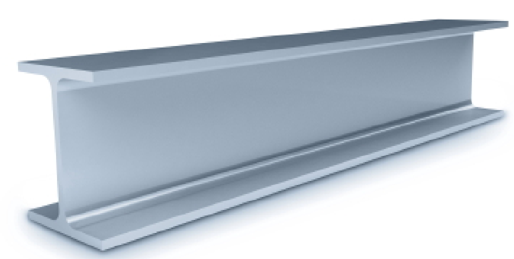

Figure 3. Typical Hot Rolled Steel Member.
Source: https://www.razorleaf.com/2010/04/tactonworks-weldment/

methods (ibid). This process is best for simple cross sections creates the most common shape for flexural design, W-shapes.

Open web steel joists (OWSJ) are a lightweight steel truss that most typically, consist of parallel chords and a triangulated web system as shown in figure 4 (Vulcraft Open Web Steel Joists and Joist Girders). OWSJ are lighter than rolled shapes for a given span, which are more economical, and allow for conduits and even duct work to pass through the chords (ibid). However, OWSJ design requires special consideration for point loads, and does not easily allow for future modifications to the structure (ibid).

Figure 4. Typical Open Webbed Steel Joists.
Source: https://www.vp.com/products/framing-systems

Once the structural engineer determines the type of flexural member for a steel building, it is possible to design the preliminary member sizes. For rolled members the American Institute of Steel Construction (AISC) dictates design, providing tables and specification necessary to determine appropriate member sizes, taking into account the load on the member as well as the allowable deflection. Once the engineer determine the member size, it is necessary to check the failure modes of the member. The failure modes that are used in determining the appropriate size of a W-shape include, plastic hinging, lateral torsional buckling, flange local buckling, and web local buckling (Steel Construction Manual). For OWSJ the sizing is much simpler, and uses manufacture data to make a selection. The design of an OWSJ involves considering the distance the joist spans, joist spacing, and the loads that are on the member (Vulcraft Open Web Steel Joists and Joist Girders). Additionally, deflection limits and maximum joist depth is taken into account (ibid). Many steel joist manufacturers supply economical load tables in order to allow designers to select the most efficient joist sizes for their projects.

Similar to flexural members, compression members are formed using rolled shapes, most commonly W shapes. Design of Compression members also utilizes the AISC manual. For compression, the limit states that engineers consider include yielding, local buckling, flexural buckling, and torsional buckling (Steel Construction Manual).

Interpretation of Findings

For this project rolled steel members, W-shapes, were determined to be the most feasible flexural member option for the floor framing. W-shapes are an economic choice, and allow for any future modifications to the building. The roof framing utilized OWSJ because they are an economical choice since the roof supports a much lower load than the floor. However, the roof of the building houses multiple HVAC units, and due their large point loads, steel rolled members will be designed to support those units.

Both the floor and roof members were sized to the appropriate specifications. For design the following loads were used:

Floor Dead Load = 80 psf
Floor Live Load = 95 psf
Roof Dead Load = 20 psf
Roof Live Load (Flat Roof Snow Load) = 21 psf
Roof HVAC units = 25 k

For the floor system, a W21 size was most common. The member sizing was controlled by deflection limits, which was l/360 for the purposes of this design. For the joist sizing, a local manufacture, Vulcraft was chosen. The design of the roof joists followed Vulcraft design requirements, and was chosen using their catalog. A K18 OWSJ was chosen for the roof system of the building. W14 hot rolled steel was designed to support the roof structural system under the HVAC units.

The columns of the building were designed using the same loads as the floor and roof systems. Due to shipping limitations, the columns were design to span two floors, which also allows for a smaller size on the upper floors, creating a more economical design, as well as ease for transportation. W shapes were also specified for the column design with W10 sizes specified on the upper floors, and W12 members are specified on the lower floors.

Third Topic of Investigation: Construction Drawings

Definition

The construction-drawing phase (CD) includes the written and graphic instructions used for construction of the project (Construction Documents, 2013). Although many elements of the building are partially defined in the phases that precede construction documentation, it is in the CDs that these take their final form (ibid). The engineer creates more focused and detailed construction documents than either the schematic design or design development phases of a project. In the CDs, every aspect of the larger building is subjected to careful scrutiny: It is tested, explored, and depicted to ensure it will be constructed correctly on the site (ibid). These documents must be accurate, consistent, complete, and understandable. For the purpose of this report, the CD phase focused on the lateral system as well as connections.

Findings

In a building design, a lateral system is necessary to resist and transfer the loads from wind and seismic forces. For the lateral force resisting system three methods were under consideration including concrete shear walls, braced frames, and moment frames. As discussed in the SD phase section, concrete has the most strength in shear than any other material; therefore, it is ideal for shear walls to resist the lateral load. However, due to architectural limitations it is not always a possible choice. Braced frames are a very common form of construction, being economic to construct and simple to analyze (Braced Frame and Moment Resisting Connection). However, similar to concrete shear walls the architecture does not always allow for the implementation of braced frames especially a design with a high window to wall ratio. Moment-resisting frames are rectilinear groups of beams and columns, with the beams rigidly connected to the columns (Bruneau, Uang, & Sabelli). The rigid connection provides the transfer of lateral forces, while not affected the architecture of the building. However, moment frames are not as efficient and are more expensive than concrete shear walls and steel bracing (ibid).

In addition to the shear walls, braced frame, or moment frame a diaphragm is necessary to transfer the lateral loads to these systems. How the lateral system works is when the wind or seismic forces pushes on the exterior walls, the exterior walls take these forces and transfer them to the floor diaphragms, which usually is the steel and concrete decking (MacRae). The diaphragm then distribute the load to the shear system proportionally, depending on the length of each of the shear system (ibid). The lateral systems are design to resist the forces that will be on each wall, and transfers them to the foundation system.

In addition to the lateral system, the CD phase focused on the connections of the building. Two types of connections were focused on during this phases, beam to girder, and girder to column. For theses connections bolts and welds were consider. Bolted connections are quicker to erect and less costly (Drucker). While welded connections can be stronger than bolted connections, welded connections can be delayed by the absence of a qualified welder, welding platforms, or cold windy weather (ibid). Additionally, the inspection process for welds are much more expensive and difficult compared to bolted connections (ibid). Once a type of connection is chosen, the design of all connections follow the guidelines in the AISC steel manual.

Interpretation of Findings

Since concrete has the most shear strength of any other material it is the most feasible option for the egress stairwells on the southeast and southwest ends of the building as well as the elevator shaft act as shear walls for the lateral forces. Steel lateral bracing on the northwest and west facades of the building were proposed if additionally lateral support was necessary. Moment frames on the north and south walls were considered because they will not obstruct any openings on the North and South facades. Rigidity calculations determined that the concrete shear walls were the only necessary lateral system needed for the building. The typical concrete and steel decking was designated for the diaphragm. Figure 5 shows a diagram demonstrates the transfers of the lateral loads, with the shear walls outlined in dark blue. As a lateral load pushes against the side of the building, it is transferred through the steel and concrete decking to the concrete shear walls, which transfers the loads to the foundation.

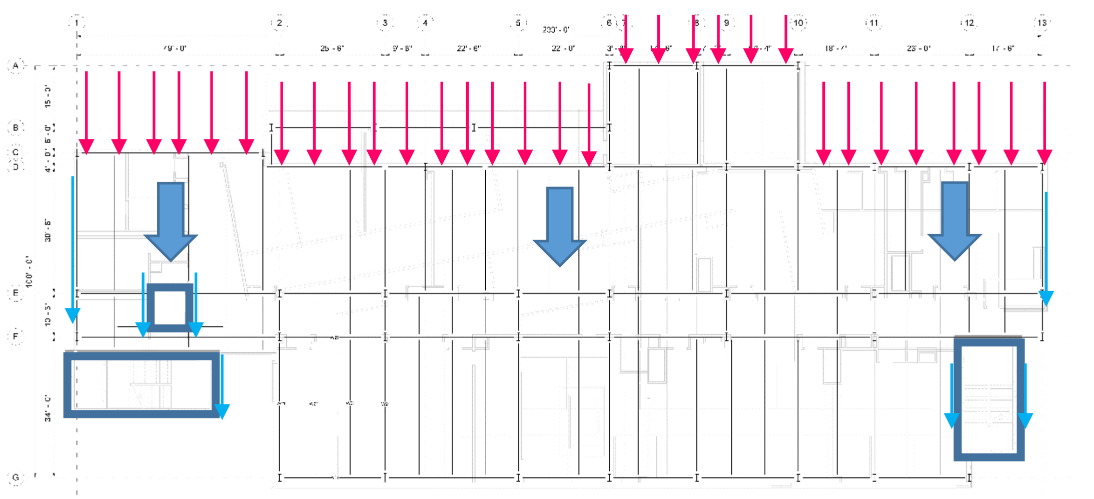

Figure 5. LCCC Student Services Center Lateral System Diagram.

For the connections bolted connects were chosen as the feasible connection due to the variability of welds and complicated inspection process. The limit states that were checked for bolted connections are bolt strength in tension and shear, preventing fracture or yield in connection plates and members, and preventing local buckling of members due to concentrated loads (Steel Construction Manual). From the AISC steel manual, the typical bolting for the beam to girder connection was 3 ¾" A490 bolts with ½" plate. For the girder to column connection, the typical size was 6 ¾" A490 boles with a L4 x 4 x .375. At the CD phase, a set of construction drawing for the LCCC student services center was created and contained in Appendix A.

Conclusion

Summary of Findings

The SD, DD, and CD phases of the construction processes were investigated using academic and professional research in the area of structural engineering as well as data collected through the design of the LCCC Student Services Center. The SD phase investigated the available materials for the project, focusing on timber, concrete, and timber. The considerations for the column grid were analyzed, requiring both structural construction and functionality. Additionally, the provided geotechnical report provided suggestions for a foundation system. Recommending spread footing foundations bearing on an over-excavated and re-compacted subgrade, or engineered aggregate piers due to the low bearing strength of the soil.

The DD phase focused on the determination and design of the flexural members as well as the compression members. For flexure, both rolled steel members such as W shapes and open webbed steel joists are available for consideration. For rolled steel shapes, the AISC manual is used for design, and OWSJ use manufacturer data for design. For columns only rolled steel shapes were used for consideration and are designed using the AISC manual.

The CD phase continues the work in the DD phase to create a set of construction drawings. Additionally, the design of the lateral systems and connections are taken into account. For the lateral system concrete shear walls, braced frames, or moment frames work with a diaphragm to transfer the lateral loads from wind and seismic forces. For the two main connections in the building, beam to girder and girder to column, both welded and bolted connects were considered and are both design the AISC manual specifications.

Overall Interpretation of Findings

A feasible structural system has been designed for the Laramie County Community College Student Services Center. In the SD phase it was determined that steel was the optimal material, and due to the low bearing pressure of the soil, strip footings resting on engineered aggregate piers were specified. Additionally, due to the floor plans of the building, it was necessary to have inconsistent column grid to maintain the functionality of the building.

The CD phase design the flexural members and compression members of the building. For the floor system, rolled steel W shapes were designed, and OWSJ were designated for the roof system. Steel W shapes were also designated for the compression members. W21 were the size designed for the floor flexural system and W12 were designed for the compression members. K18 was the OWSJ determined for the roof system using the manufacturer, Vulcraft's, catalog.

Of the three lateral systems that were analyzed the most feasible design was the concrete shear walls around the elevator shaft and egress stairwells. Locations for braced frames and moment frames were specified in necessary, but shear walls were the only necessary lateral system. Additionally, the steel and concrete decking act as a diaphragm to transfer the lateral forces. Bolted connections were the feasible design choice for the beam to girder and girder to beam connections.

Conclusions and Recommendations

Through the design process, the proper specifications were used to design a steel gravity system with concrete shear wall lateral system. This system is feasible for both design and construction, utilizing the most efficient materials and methods. The different aspects of the structural system were analyzed to determine the feasibility of the design. When designing a multistory building all material choices should be taken into account. Additionally, the geotechnical report is necessary to determine the proper foundation system to support the building. It is recommended that construction follow the specifications laid out in the documents to ensure that a safe and reliable building is constructed. Through the SD, DD, and CD phases of the construction process, a feasible structural system for the LCCC Student Services Center was designed to proper specifications.

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Appendix A

The following pages contain the complete construction drawings for the Laramie County Community College Student Services Center.

Laramie County Community College Student Services Structural Drawings

Cover Sheet
LCCC Student Services

S.0
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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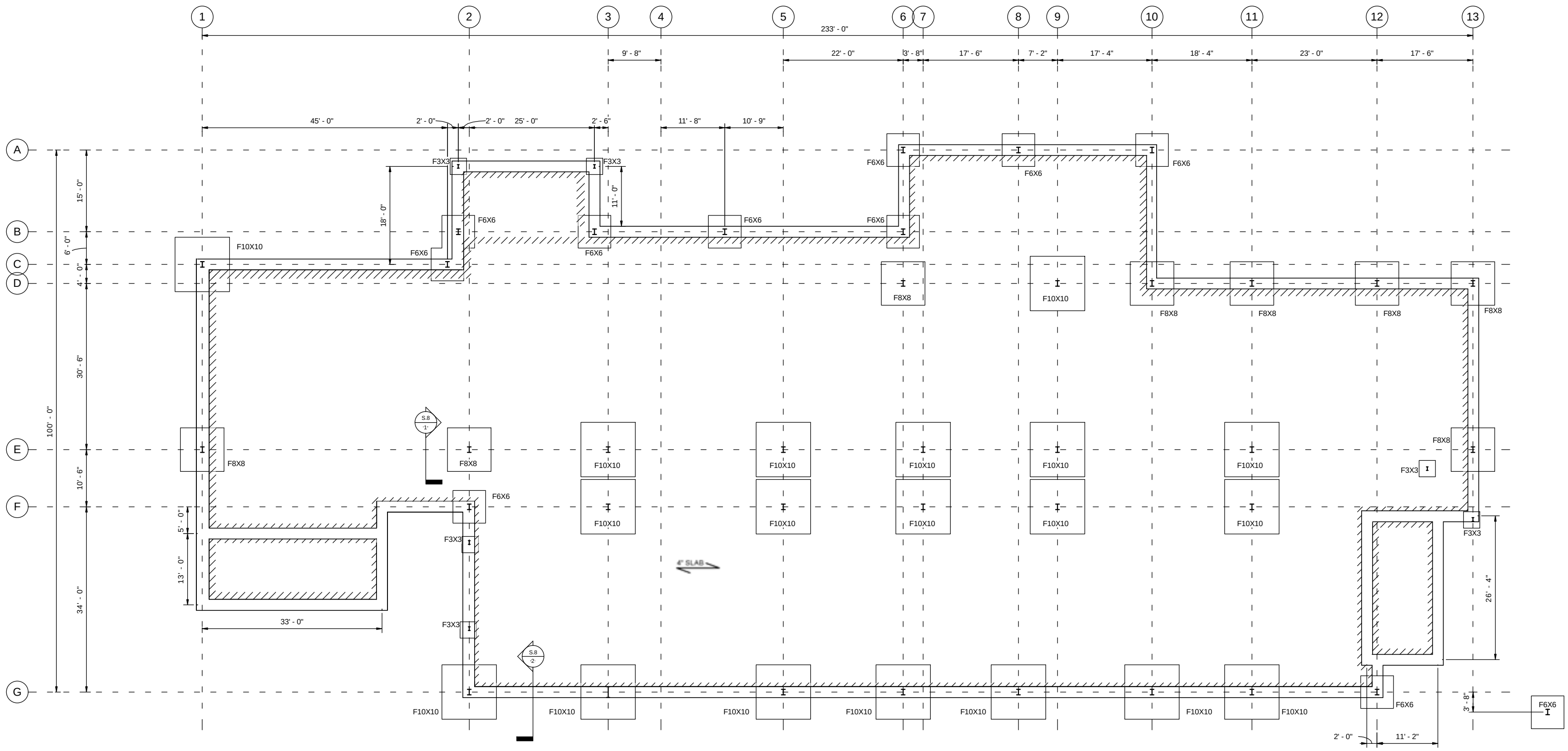

LEVEL 1 FOUNDATION & FRAMING PLAN

1 — 1/8" = 1'-0"

NOTES

1. SLAB-ON-GRADE:
    A. TOP OF SLAB-ON-GRADE ELEVATION = 100'-0"
    B. TYPICAL SLAB-ON-GRADE IS 4" THICK
2. STEM WALLS:
    A. TOP OF STEM WALL = 100'-0"
    B. BOTTOM OF STEM WALL = TOP OF EXTERIOR FOOTING
3. COLUMNS:
    A. ALL COLUMNS CENTERED ON GRIDLINES UNLESS DIMENSIONED OTHERWISE

Level 1 Foundation & Framing Plan

LCCC Student Services

S.1

CONSTRUCTION DOCUMENTS

MAY 5, 2016

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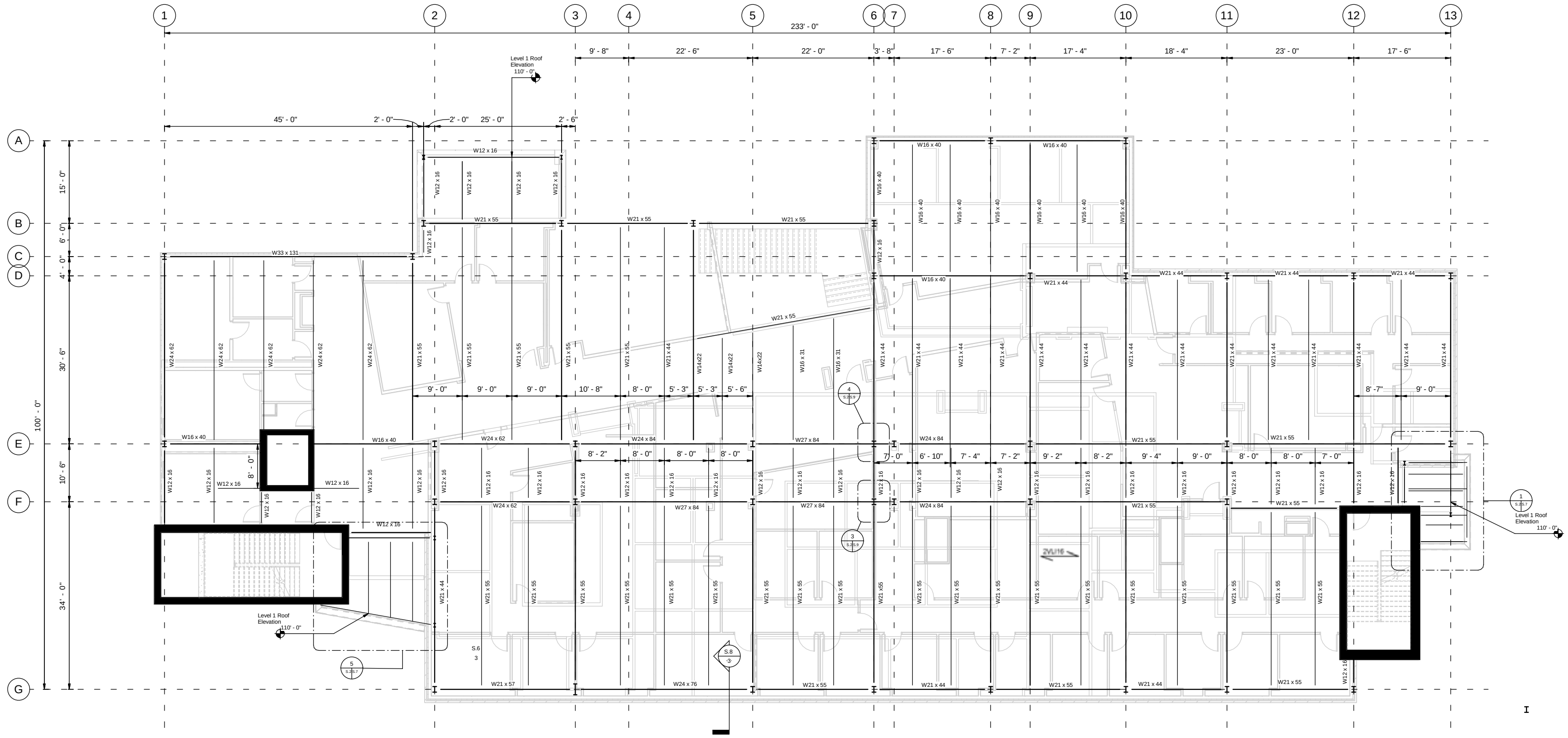

1 LEVEL 2 FRAMING
1/8" = 1'-0"

NOTES

1. SLAB-ON-DECK:
    A. TOP OF SLAB-ON-DECK ELEVATION = 116'-0"
    B. SLAB THICKNESS = 4"
2. METAL FLOOR DECK
    A. 2VLI16
3. COLUMNS:
    A. ALL COLUMNS CENTERED ON GRIDLINES UNLESS DIMENSIONED OTHERWISE
4. BEAMS AND JOISTS:
    A. ALL BEAMS AND JOISTS SPACED EQUALLY BETWEEN GRIDLINES UNLESS DIMENSIONED OTHERWISE
    B. DIMENSIONS ARE TO CENTERLINE OF ALL MEMBERS UNLESS NOTED OTHERWISE
5. COLD-FORMED STEEL FRAMING:
    A. FOR COLD-FORMED STEEL FRAMING SIZES AND SPACING, SEE S.8
6. BAY F-G 2-3 WAS DESIGNED JOIST AND GIRDER SIZES ARE RECORDED ON THE DRAWING.
7. COLUMNS FRAMING BAY F-G 2-3. ALL COLUMN HEIGHTS ARE FROM LEVEL 1 TO LEVEL 3 AND ARE SIZED WITH W12 x 72 STEEL COLUMNS WITH W8 X 10 COLUMNS FOR LEVEL 1 ROOF

Level 2 Structural Plan
LCCC Student Services

S.2
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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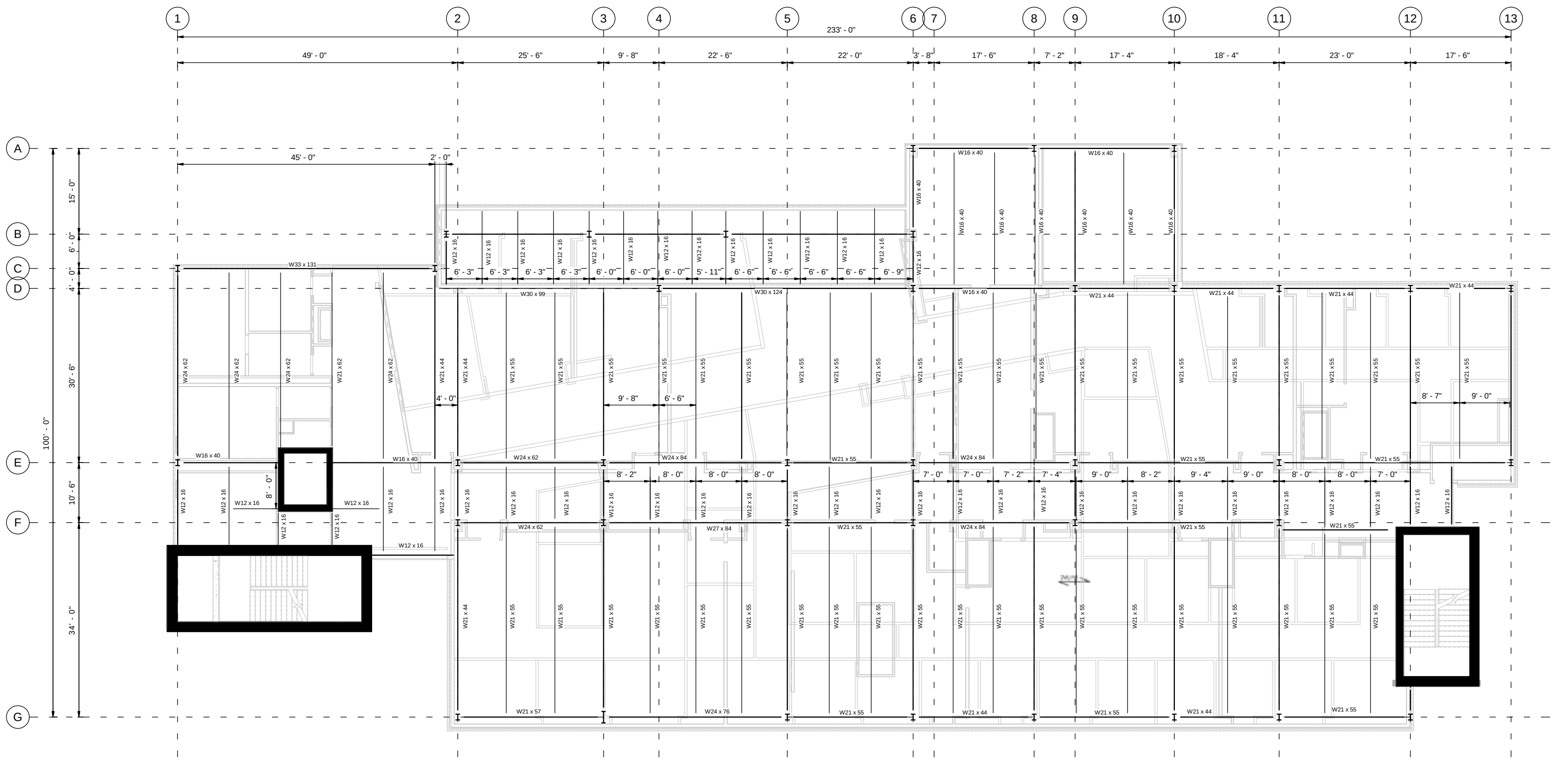

LEVEL 3 FRAMING

1/8" = 1'-0"

NOTES

1. SLAB-ON-DECK:
   A. TOP OF SLAB-ON-DECK ELEVATION = 130'-0"
   B. SLAB THICKNESS = 4"
2. METAL FLOOR DECK
   A. 2VLI16
3. COLUMNS:
   A. ALL COLUMNS CENTERED ON GRIDLINES UNLESS DIMENSIONED OTHERWISE
4. BEAMS AND JOISTS:
   A. ALL BEAMS AND JOISTS SPACED EQUALLY BETWEEN GRIDLINES UNLESS DIMENSIONED OTHERWISE
   B. DIMENSIONS ARE TO CENTERLINE OF ALL MEMBERS UNLESS NOTED OTHERWISE
5. COLD-FORMED STEEL FRAMING:
   A. FOR COLD-FORMED STEEL FRAMING SIZES AND SPACING, SEE S.8
6. BAY F-G 2-3 WAS DESIGNED JOIST AND GIRDER SIZES ARE RECORDED ON THE DRAWING.
7. COLUMNS FRAMING BAY F-G 2-3. ALL COLUMN HEIGHTS ARE FROM LEVELS 3 TO ROOF LE'AND ARE SIZED WITH W10 X 33 STEEL COLUMNS

Level 3 Structural Plan

LCCC Student Services

S.3

CONSTRUCTION DOCUMENTS

MAY 5, 2016

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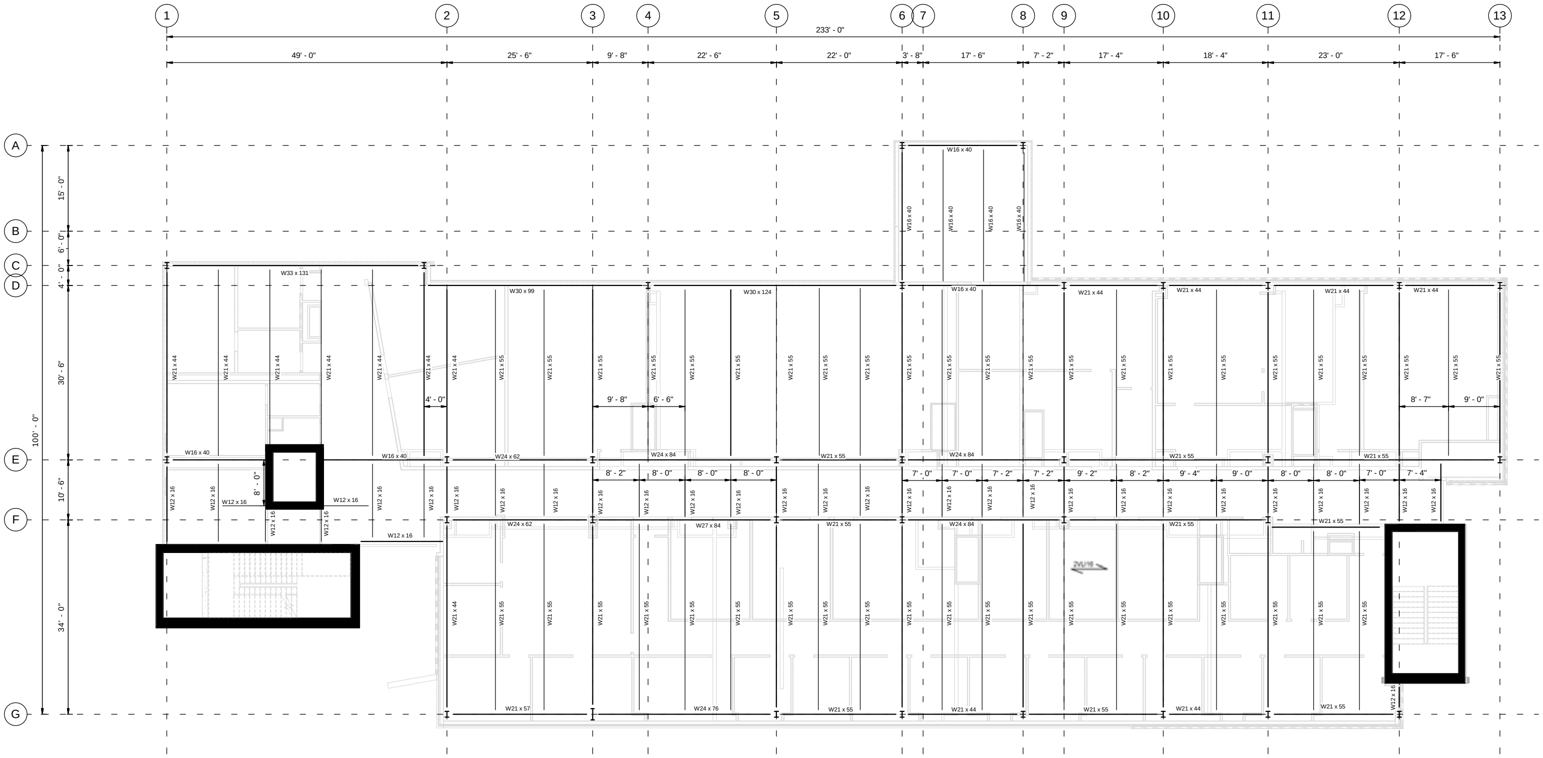

LEVEL 4 FRAMING
1/8" = 1'-0"

<u>NOTES</u>

1. SLAB-ON-DECK:
   A. TOP OF SLAB-ON-DECK ELEVATION = 144'-0"
   B. SLAB THICKNESS = 4"
2. METAL FLOOR DECK
   A. 2VLI16
3. COLUMNS:
   A. ALL COLUMNS CENTERED ON GRIDLINES UNLESS DIMENSIONED OTHERWISE
4. BEAMS AND JOISTS:
   A. ALL BEAMS AND JOISTS SPACED EQUALLY BETWEEN GRIDLINES UNLESS DIMENSIONED OTHERWISE
   B. DIMENSIONS ARE TO CENTERLINE OF ALL MEMBERS UNLESS NOTED OTHERWISE
5. COLD-FORMED STEEL FRAMING:
   A. FOR COLD-FORMED STEEL FRAMING SIZES AND SPACING, SEE S.8
6. BAY F-G 2-3 WAS DESIGNED JOIST AND GIRDER SIZES ARE RECORDED ON THE DRAWING
7. COLUMNS FRAMING BAY F-G 2-3. ALL COLUMN HEIGHTS ARE FROM LEVELS 3 TO ROOF
   LEVEL AND ARE SIZED WITH W10 STEEL COLUMNS

Level 4 Structural Plan
LCCC Student Services

S.4
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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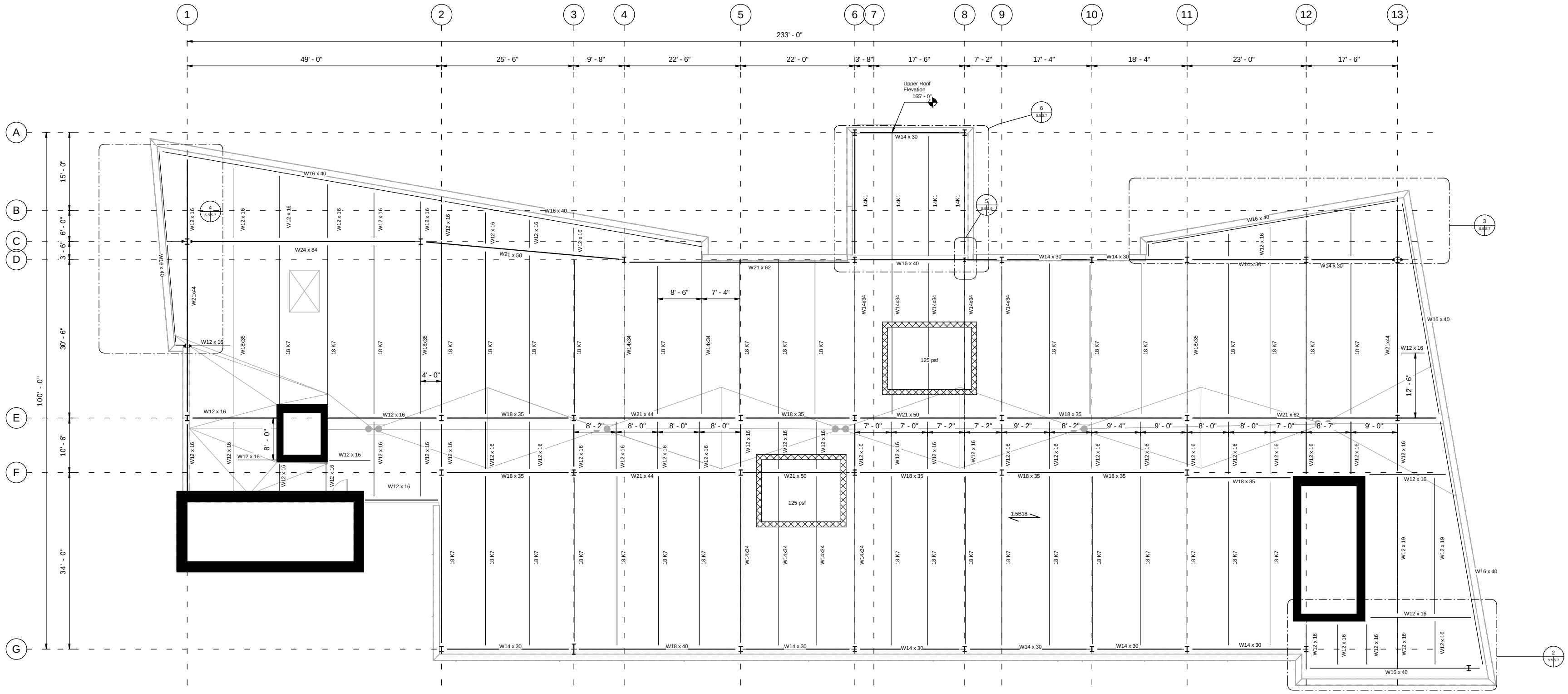

ROOF FRAMING
1/8" = 1'-0"

<u>NOTES</u>

1. ROOF:
   A. TOP OF DECK ELEVATION = 158'-0"
2. METAL ROOF DECK
   A. 1.5B18
3. COLUMNS:
   A. ALL COLUMNS CENTERED ON GRIDLINES UNLESS DIMENSIONED OTHERWISE
4. BEAMS AND JOISTS:
   A. ALL BEAMS AND JOISTS SPACED EQUALLY BETWEEN GRIDLINES UNLESS DIMENSIONED OTHERWISE
   B. DIMENSIONS ARE TO CENTERLINE OF ALL MEMBERS UNLESS NOTED OTHERWISE
   C. ALL ROOF JOISTS ARE VULCRAFT K SERIES SPACED 7 FT CENTER TO CENTER
5. COLD-FORMED STEEL FRAMING:
   A. FOR COLD-FORMED STEEL FRAMING SIZES AND SPACING, SEE S.8
6. BAY F-G 2-3 WAS DESIGNED JOIST AND GIRDER SIZES ARE RECORDED ON THE DRAWING
7. COLUMNS FRAMING BAY F-G 2-3. ALL COLUMN HEIGHTS ARE FROM LEVELS 3 TO ROOF LEVEL AND ARE SIZED WITH W10 STEEL COLUMNS

Roof Structural Plan
LCCC Student Services

S.5
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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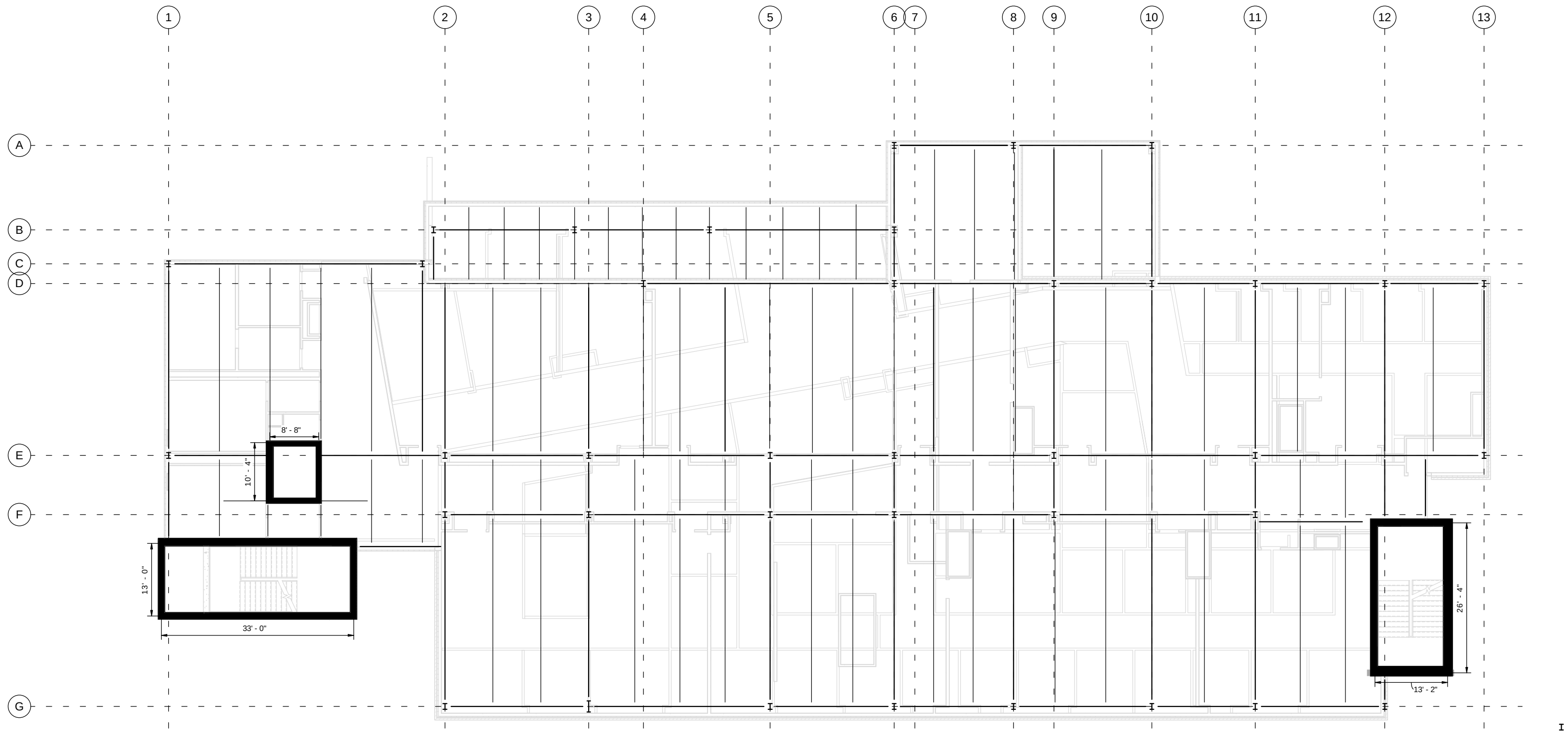

2 LATERAL SYSTEMS
1/8" = 1'-0"

NOTES

1. SHEAR WALLS:
   A. BOTH STAIRCASES AND THE ELEVATOR SHAFT WILL BE ENCASED BY CONCRETE SHEAR WALLS
   B. SHEAR WALL THICKNESS = 12"
2. RIGID DIAPHRAM OF CONCRETE AND STEEL DECKING

Lateral Systems
LCCC Student Services

S.6
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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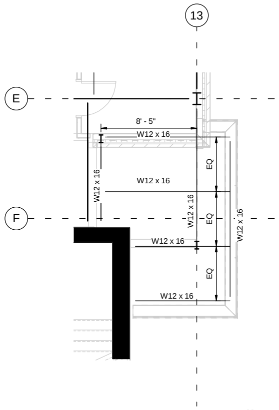
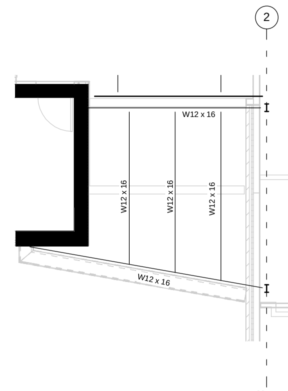
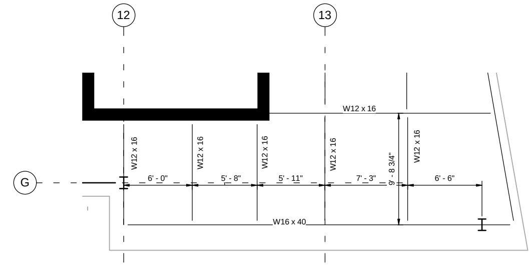


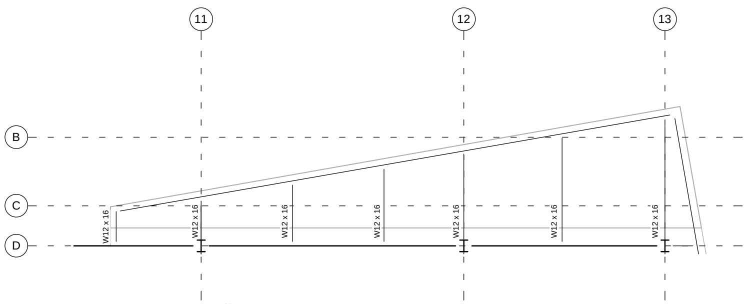
1 LEVEL 2 FRAMING - Callout 1
1/4" = 1'-0"



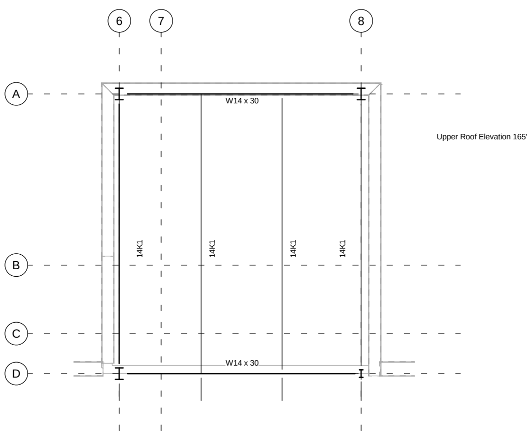
5 LEVEL 2 FRAMING - Callout 2
1/4" = 1'-0"



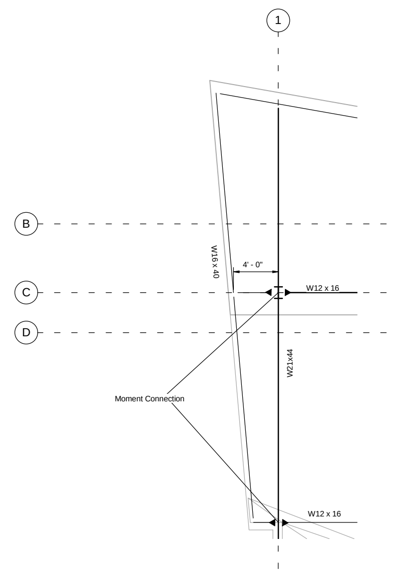
2 ROOF FRAMING - Callout 1
1/4" = 1'-0"



3 ROOF FRAMING - Callout 2
1/4" = 1'-0"



6 ROOF FRAMING - Callout 5
1/4" = 1'-0"



4 ROOF FRAMING - Callout 3
1/4" = 1'-0"

Enlarge Plans
LCCC Student Services

S.7
CONSTRUCTION DOCUMENTS
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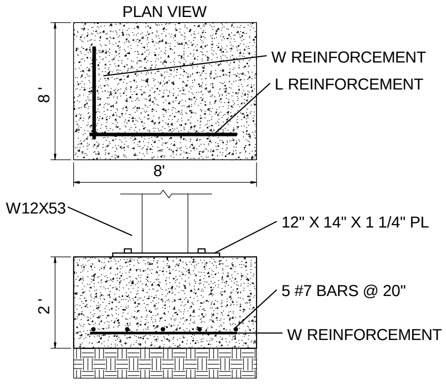
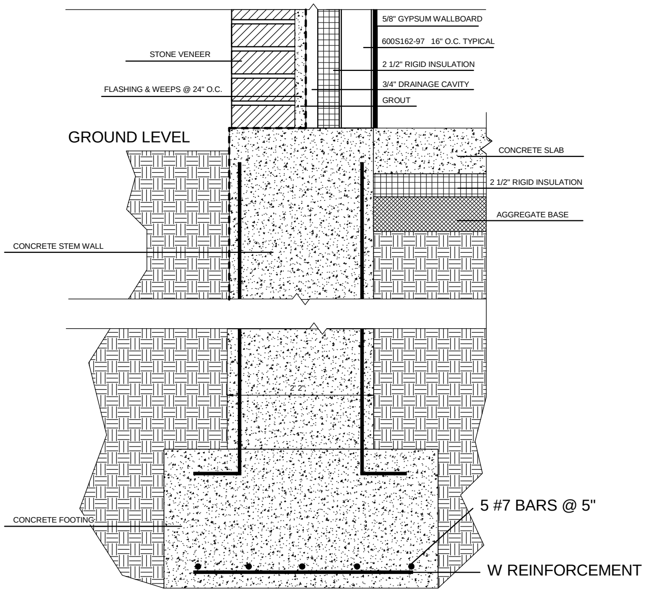
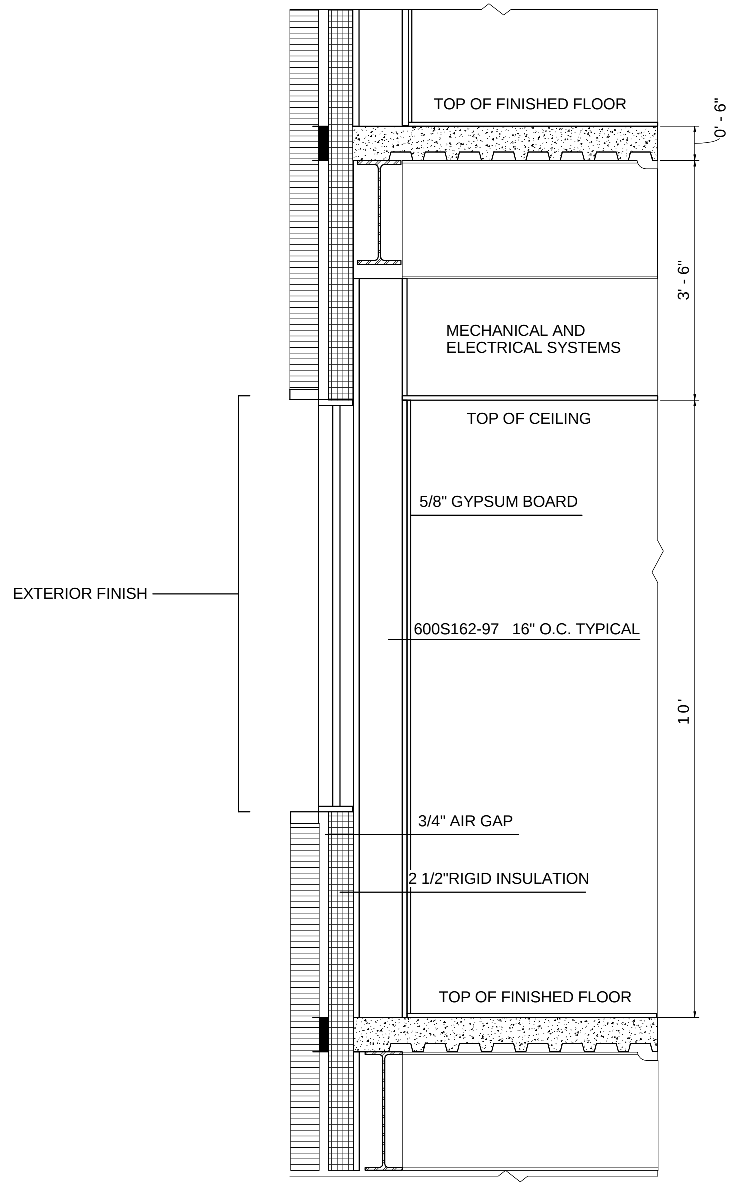


1 TYPICAL INTERIOR SPREAD FOOTING
NOT TO SCALE



2 TYPICAL STEM WALL @ STONE
NOT TO SCALE

NOTES
1. SLAB-ON-GRADE:
  A. TYPICAL SLAB-ON-GRADE IS 4" THICK
2. STEM WALLS:
  A. TOP OF STEM WALL = 100'-0"
  B. BOTTOM OF STEM WALL = TOP OF EXTERIOR FOOTING
3. FOOTINGS:
  A. TOP OF INTERIOR FOOTINGS = 99'-0"
  B. TOP OF EXTERIOR FOOTINGS = 97'-0"
  C. ALL COLUMNS CENTERED ON SPREAD FOOTINGS UNLESS DIMENSIONED OTHERWISE
  D. ALL STEM WALLS CENTERED ON STRIP FOOTINGS UNLESS DIMENSIONED OTHERWISE
  E. CLEAR COVER = 3" UNLESS DIMENSIONED OTHERWISE



3 TYPICAL ELEVATED FLOOR SECTION
NOT TO SCALE

Typical Section Details
LCCC Student Services

S.8
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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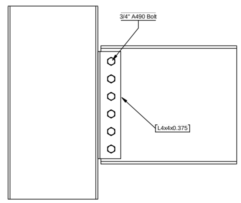
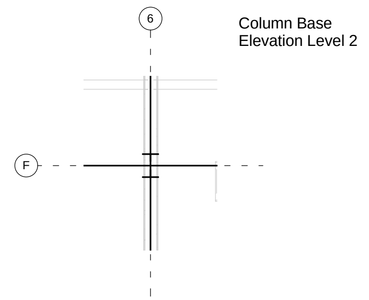
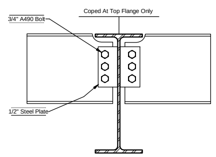


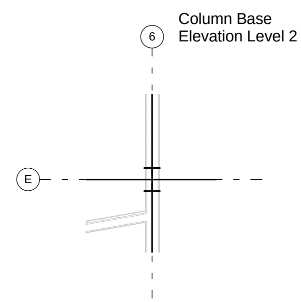
1 Beam Column Connection
1 1/2" = 1'-0"



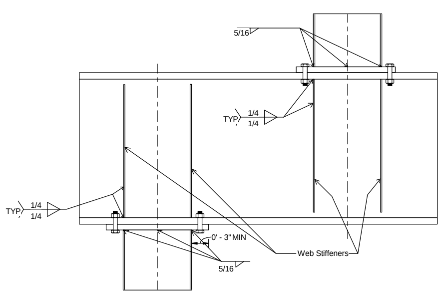
3 LEVEL 2 FRAMING - Callout 3
1/2" = 1'-0"



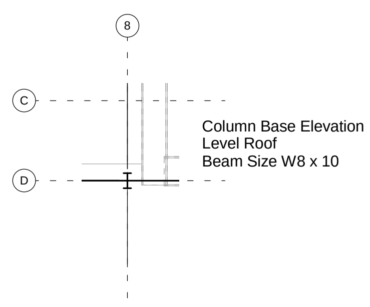
2 Beam Girder Connection
1 1/2" = 1'-0"



4 LEVEL 2 FRAMING - Callout 4
1/2" = 1'-0"



6 Transfer Beam Column Connection
1 1/2" = 1'-0"



5 ROOF FRAMING - Callout 4
1/2" = 1'-0"

Typical Connection and Column Details
LCCC Student Services

S.9
CONSTRUCTION DOCUMENTS
MAY 5, 2016

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