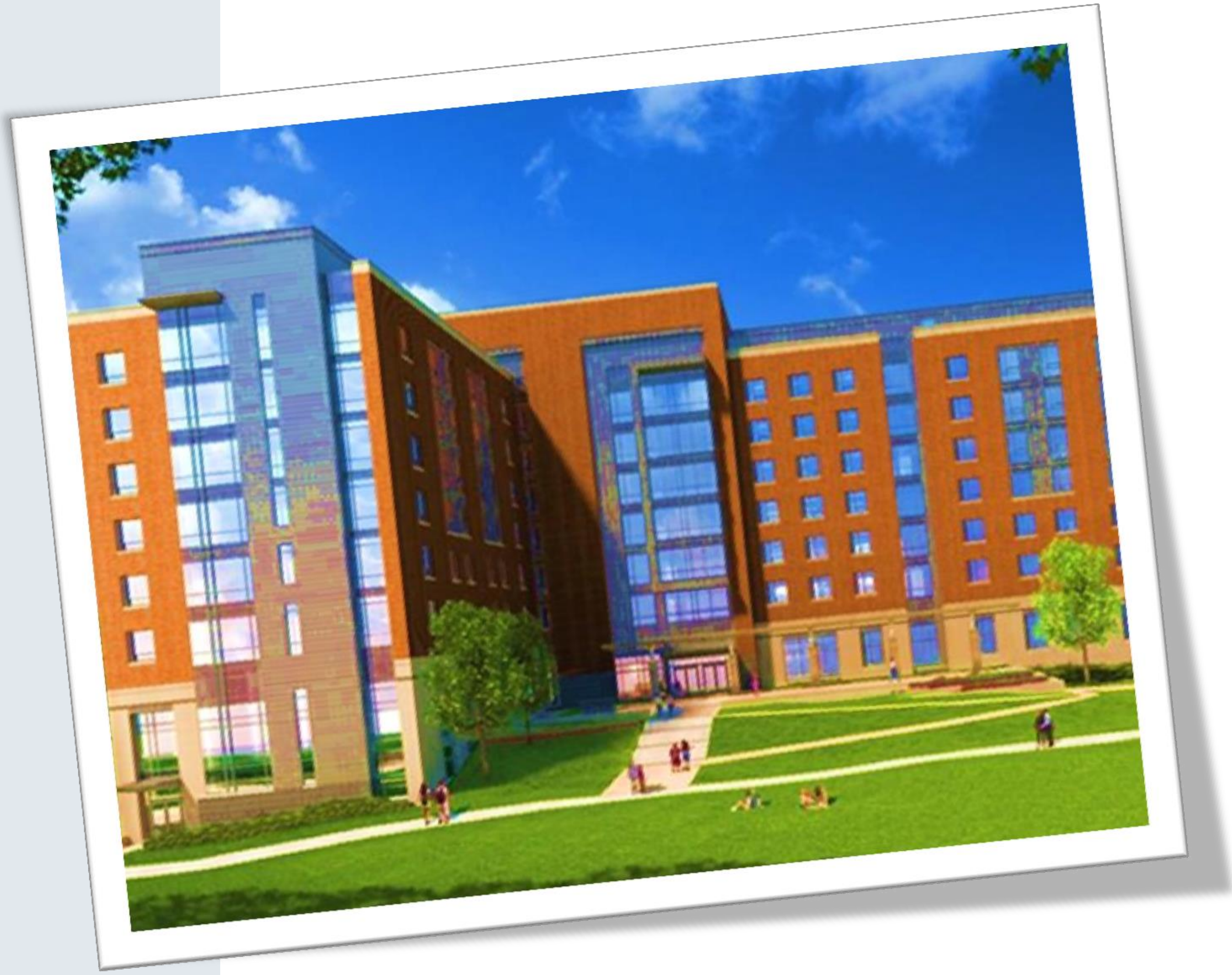
Existing Conditions Report



Prince Frederick Hall

The University of Maryland

College Park, MD

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AE Senior Thesis- Structural

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September 13, 2013

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Executive Summary

The purpose of this technical report is to establish an understanding of Prince Frederick Hall's structural and existing features. Prince Frederick Hall is nestled at the heart of The University of Maryland's campus and is a multi-use dormitory building consisting of living and office spaces. This document provides an overview of all the structural components designed by Cagley & Associates Inc. including general floor framing, structural slabs, shear wall, and the foundation system. Integration of all structural components is explained and elaborated upon. The pictures and images (unless otherwise noted) are the property of The University of Maryland and WDG Architecture PLLC and are being used solely for educational purposes.

Purpose and Scope

The focus of this technical report is to investigate the existing conditions and design features of Prince Frederick Hall (PFH). This includes detailed descriptions of the overall structural system relative to shear walls, material strengths, spans, and column layouts. Throughout the document there are diagrams of typical framing plans, framing elevations, and building/structural elevations to help define the existing conditions. Furthermore, there is a comprehensive discussion pertaining to lateral force resistance, load path, and how the applied forces travel through the concrete structure to the base.

Introduction

Prince Frederic Hall is a brand new multi-purpose dormitory under construction at The University of Maryland (UMD). The building is expected to open in September of 2014 to undergraduate students. This 185,000 square foot building is sustainable and expected to receive LEED Gold rating upon completion. Clark Construction was hired by UMD to complete this project as a design-build project with a guaranteed maximum price. The total approximate cost for the building is about 65 million dollars. The University of

Maryland is committed to providing high tech quality living while maintaining tradition. The brick façade on PFH is similar to the surrounding buildings which allow it to fit in seamlessly with the older architecture of the campus. Diagram one show the surrounding buildings; Caroline Hall, Van Munching Hall, and the University Commons with a picture of their facades. It is apparent that PFH has very similar architectural features.

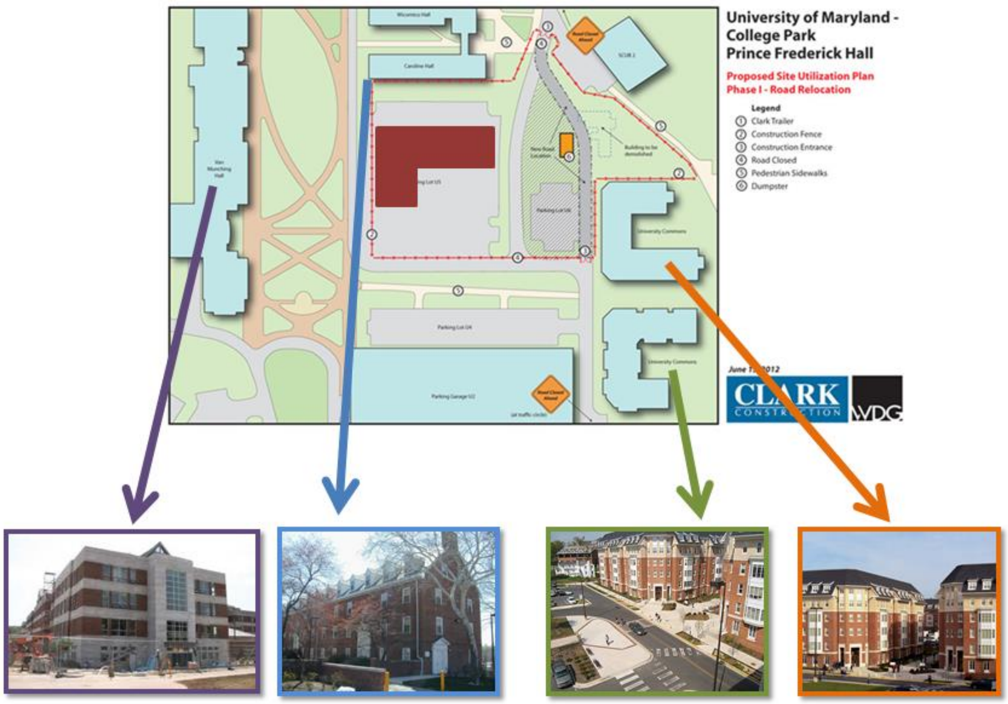


Figure 1

Prior to construction, there was a small building on the site which needed to be demolished before any work could be done. The demolition included removal of all existing buildings, footing pads, landscaping, and utility lines. Prior to removal, UMD received approval from the Maryland Historical Society. Figure 2 shown below highlights the area of construction and shows the general demolition notes.

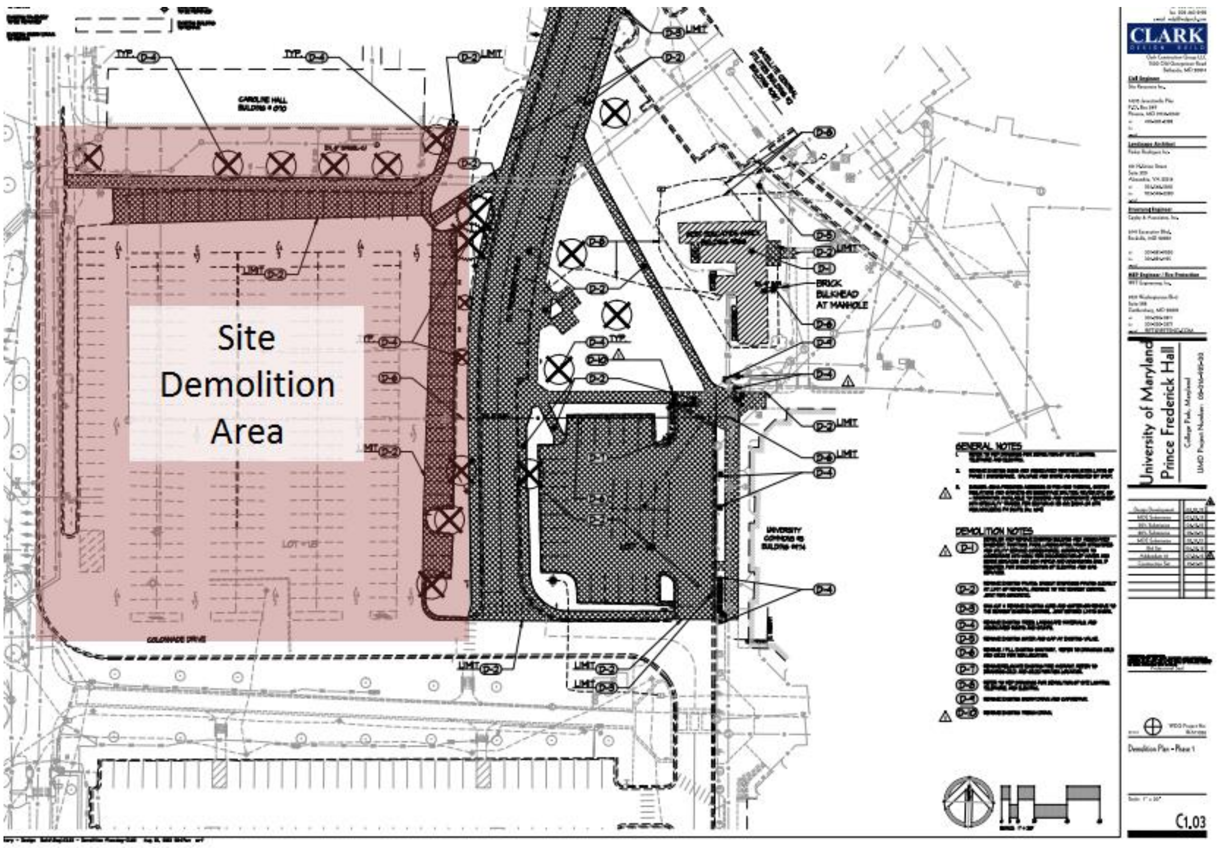


Figure 2

The layout of the intior is designed to have university space on the first and private dormatory space on the upper floors, The roof and scub floors house the mechanical and electrical rooms. The following figures are the floors plans of PFH from the basement level to the roof. These documents are labeled Figure 3-9 and note the different occupancies of the building. These different occupancies will be dicussed later for live loads accoring to IBC 2009. Also provided is a color coded key to help show the diversity of the building.

KEY 1 FOR ARCHITECTURAL DRAWINGS

Wash Rooms or Laundry Room	Office
Lobby	Roof Decking
Living Space	Roof Top Screen
Elevators	Seminar Rooms/ Multi-purpose Rooms
Hallways/ Egress	Stairs
Mechanical	Storage Rooms

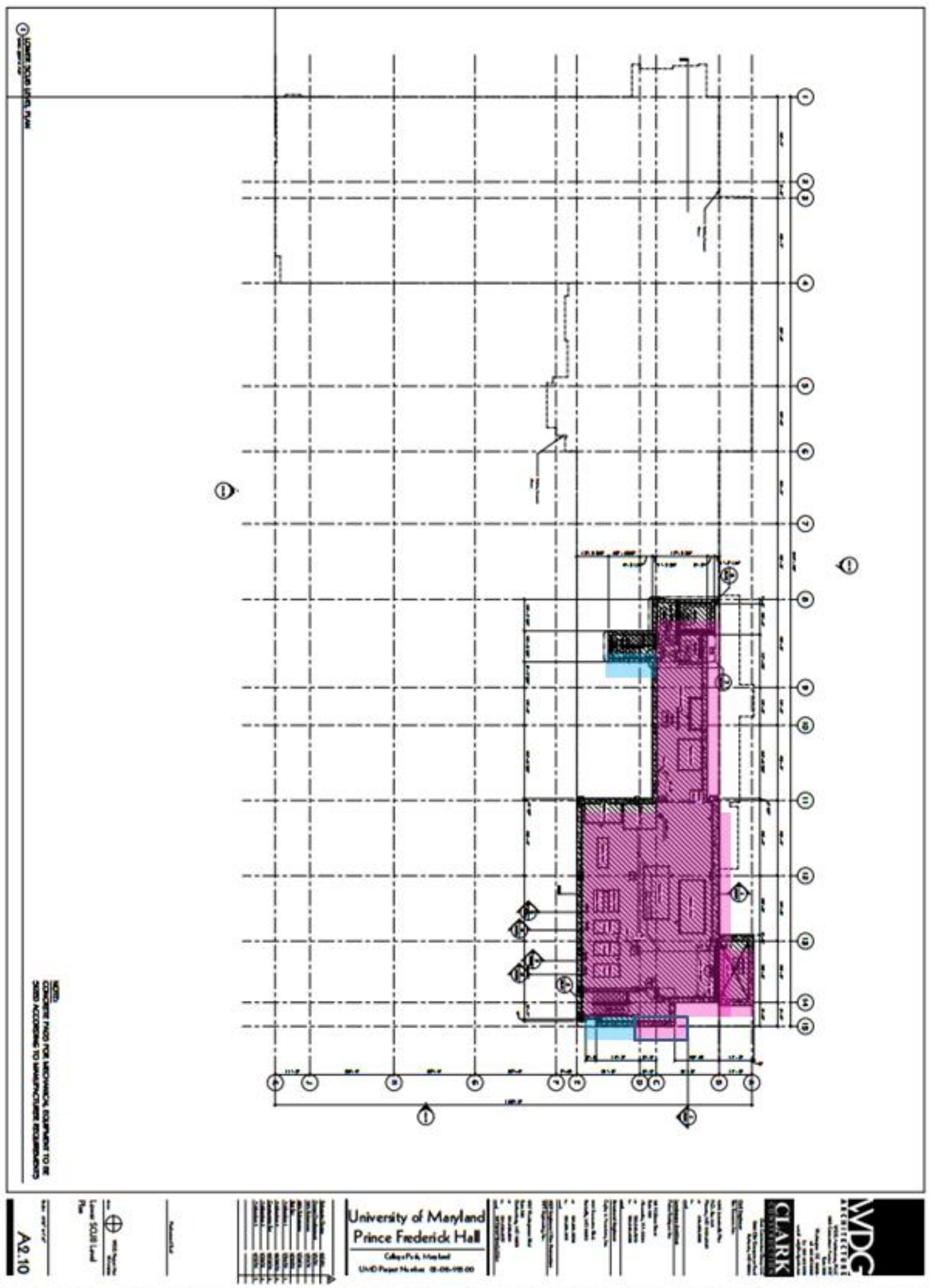


Figure 3

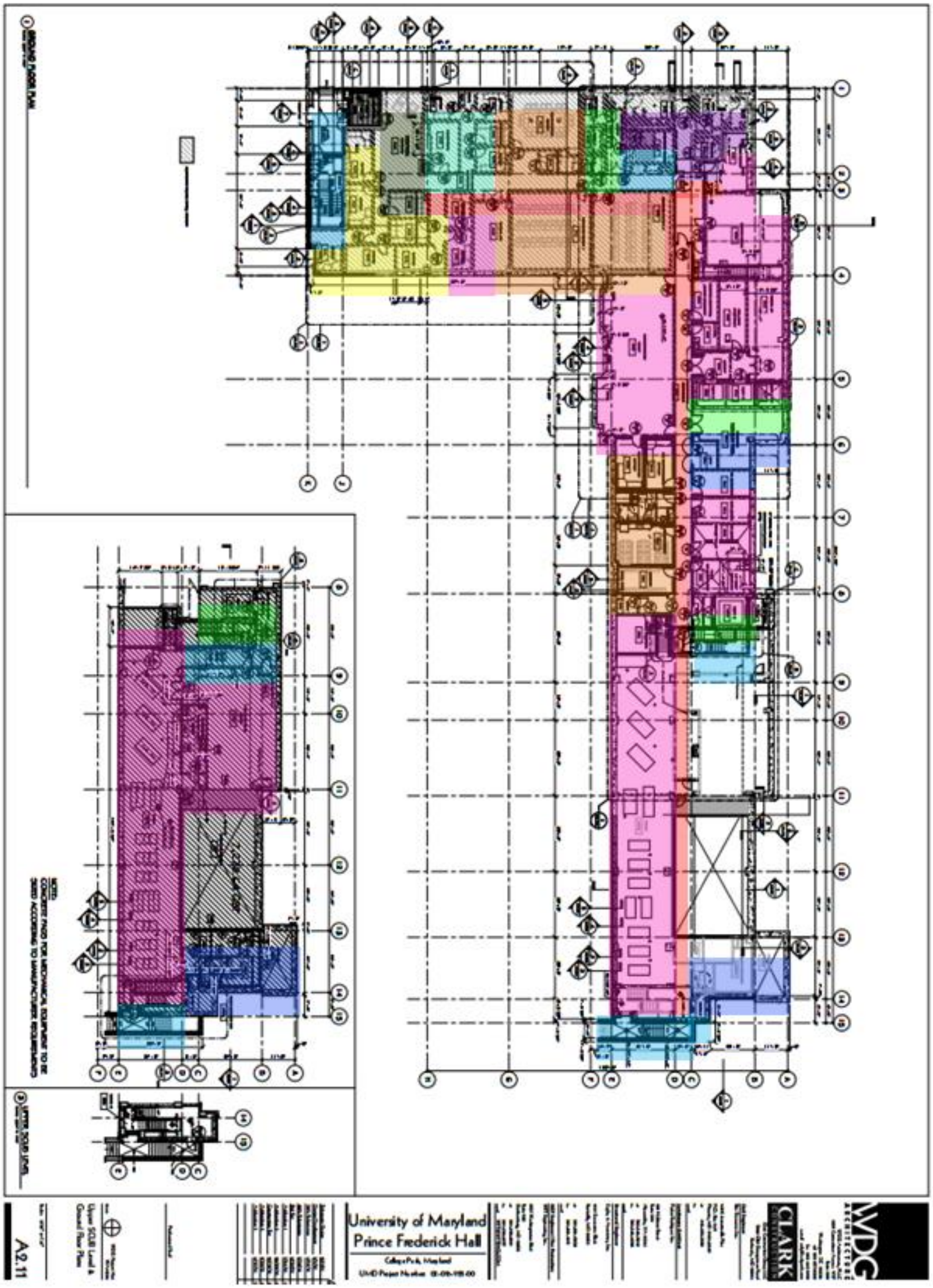


Figure 4

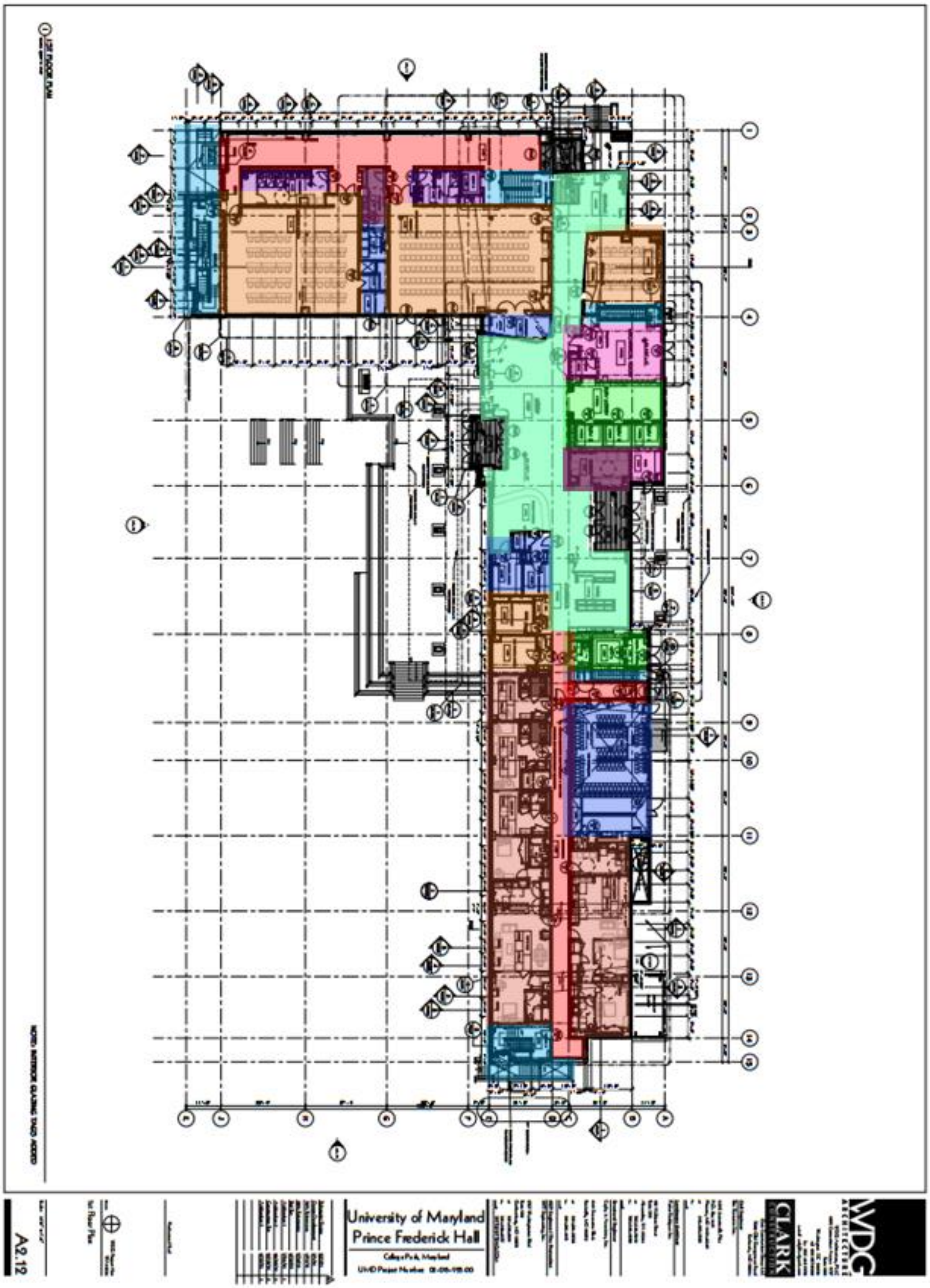


Figure 5

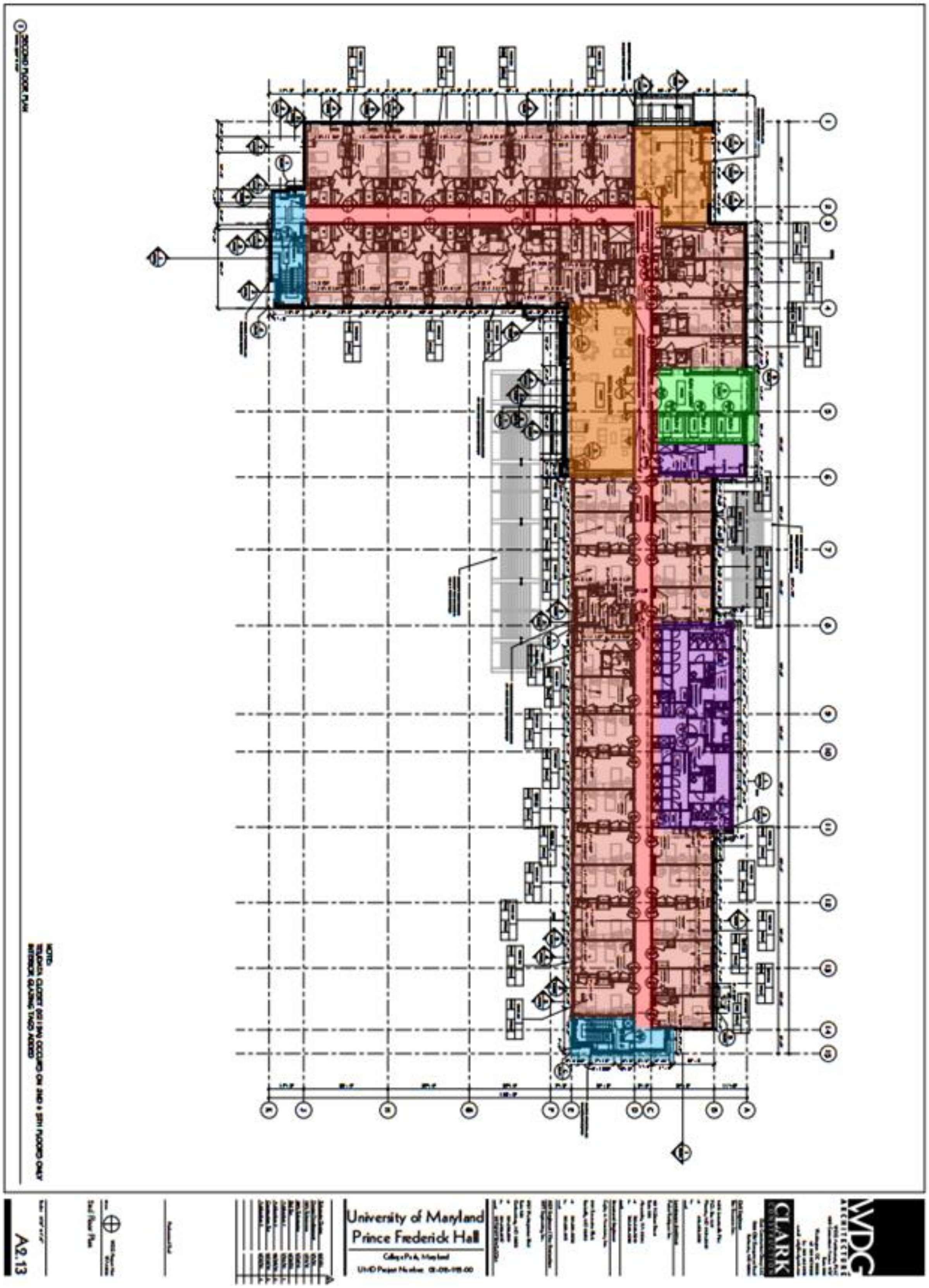


Figure 6

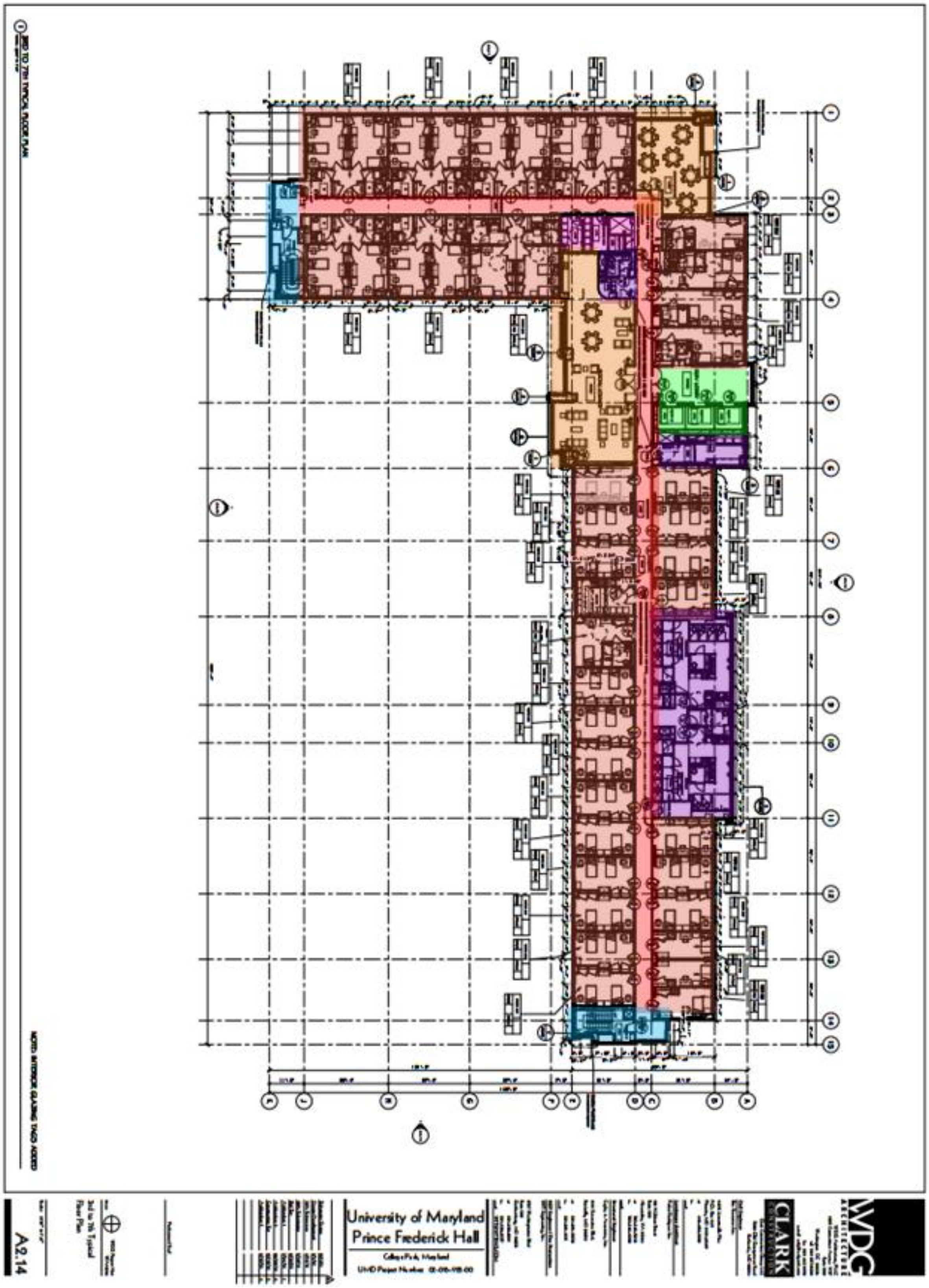


Figure 7

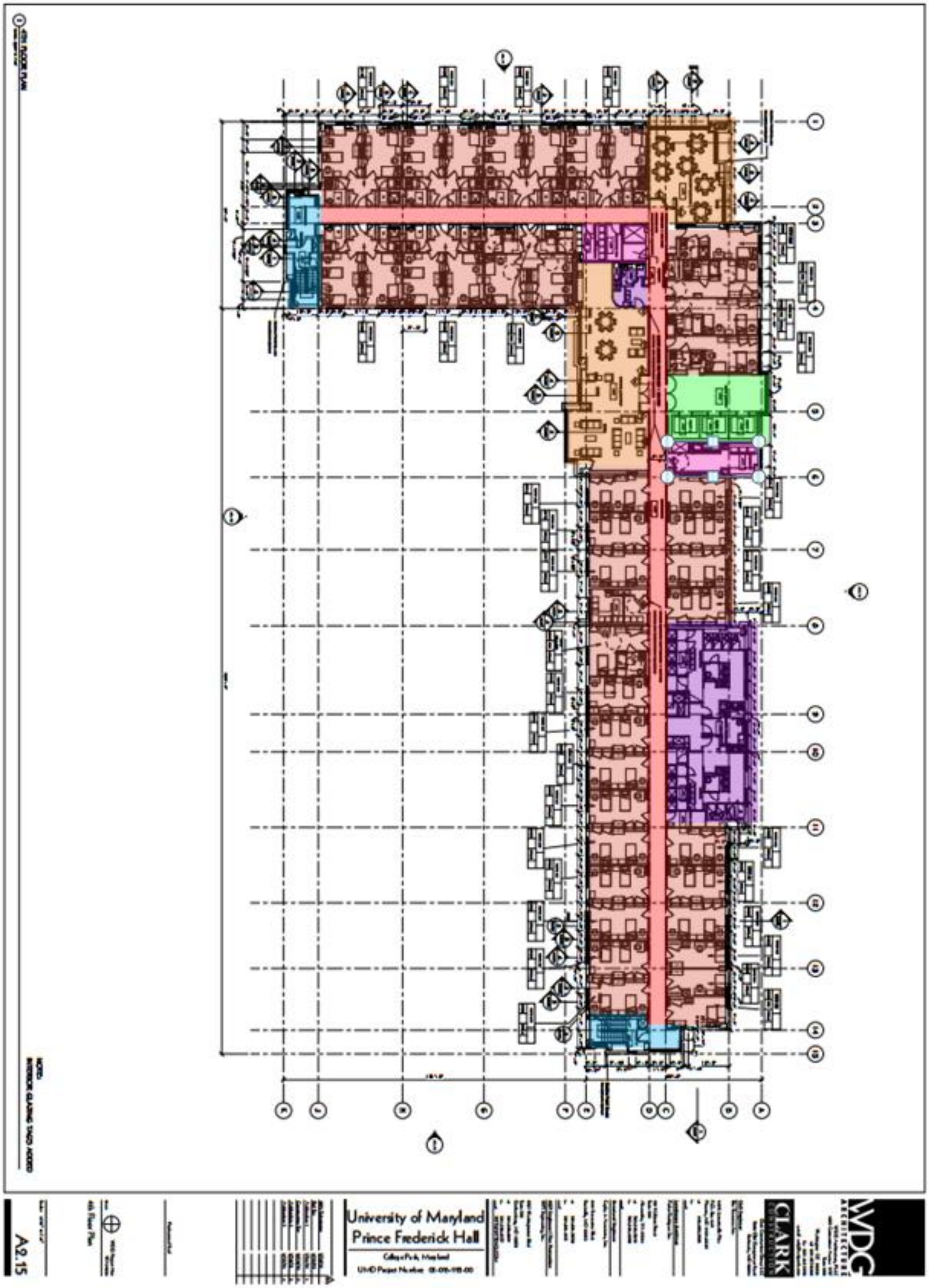


Figure 8

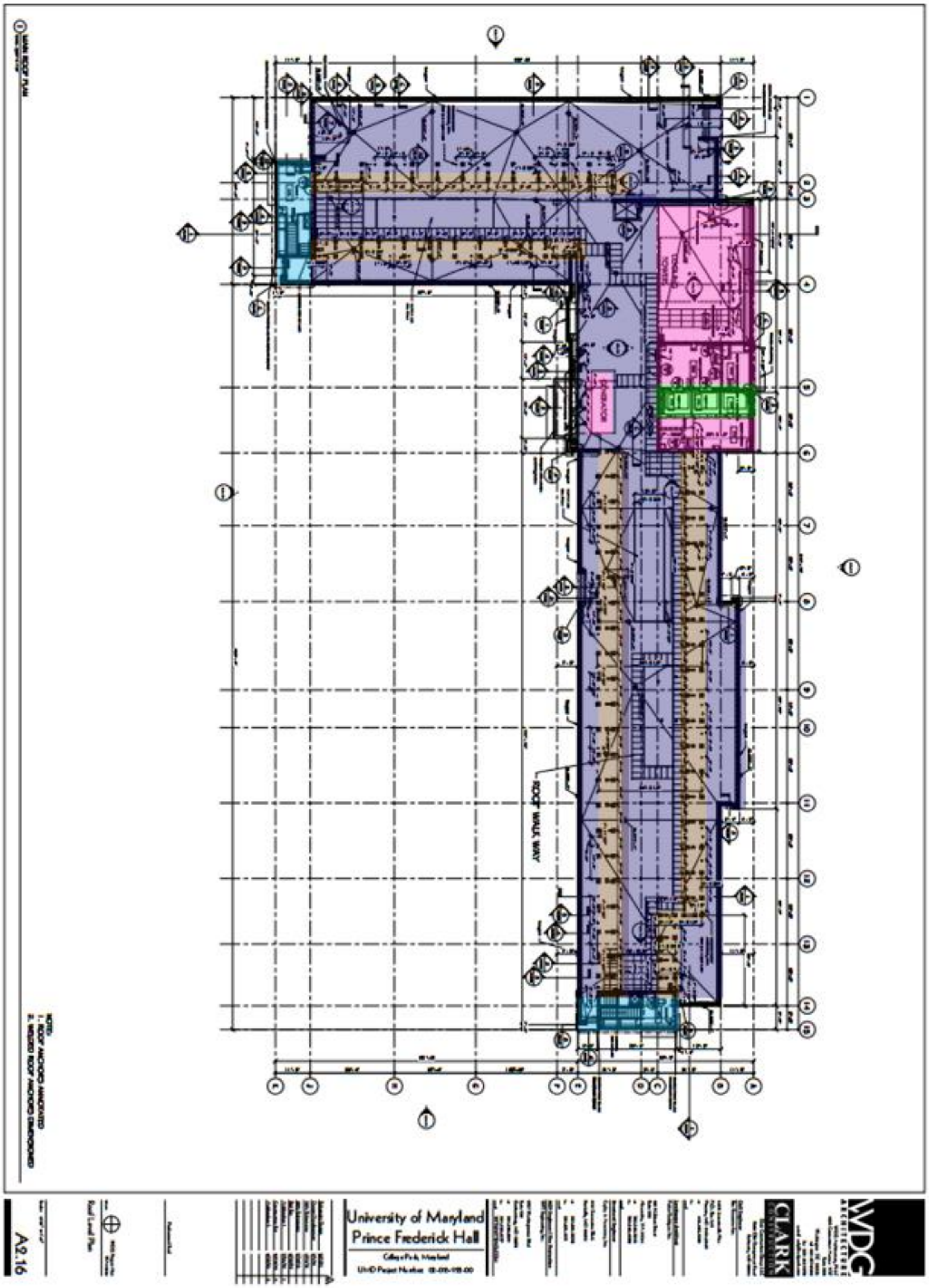


Figure 9

PFH is designed using mostly cast-in-place concrete and some applications of post-tension concrete. The concrete design is suitable for its location and occupancy; fire safety plays a major role in the design. The buildings occupancy is mixed and includes the following:

Occupancy:

Residential (310) Primary	→ Group R-2
Assembly (303)	→ Group A-3
Business (304)	→ Group B
Storage, Low Hazard (311.3)	→ Group S-2

TABLE 705.4
FIRE WALL FIRE-RESISTANCE RATINGS

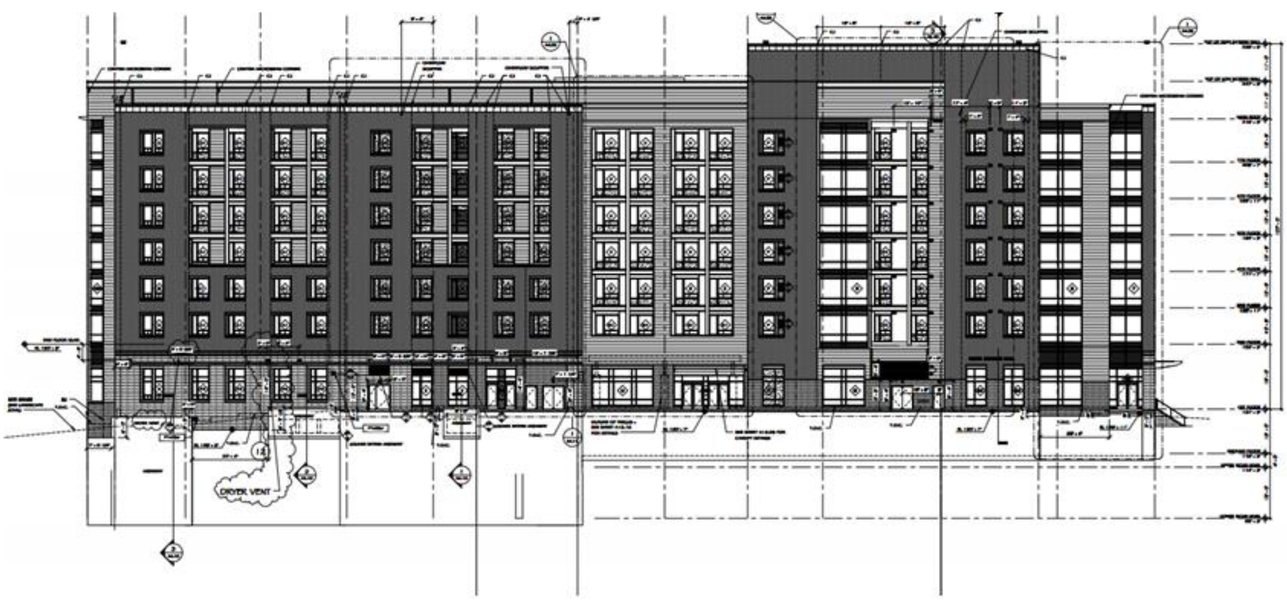
GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2	3[a]
F-1, H-3[b], H-5, M, S-1	3
H-1, H-2	4[b]
F-2, S-2, R-3, R-4	2

a. Walls shall be not less than 2-hour fire-resistance rated where separating buildings of Type II or V construction.
b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.4 and 415.5.

Figure 10 IBC 2009

PFH's main structural system is concrete slabs, concrete columns and building tall shear walls. The exterior is primarily cast stone CMU and has glass curtain walls. The following documents labeled Figure 11-14 are the elevations showing facade materials and overall height.

North Elevation



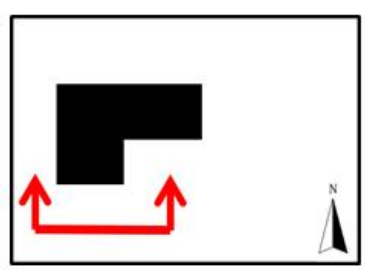
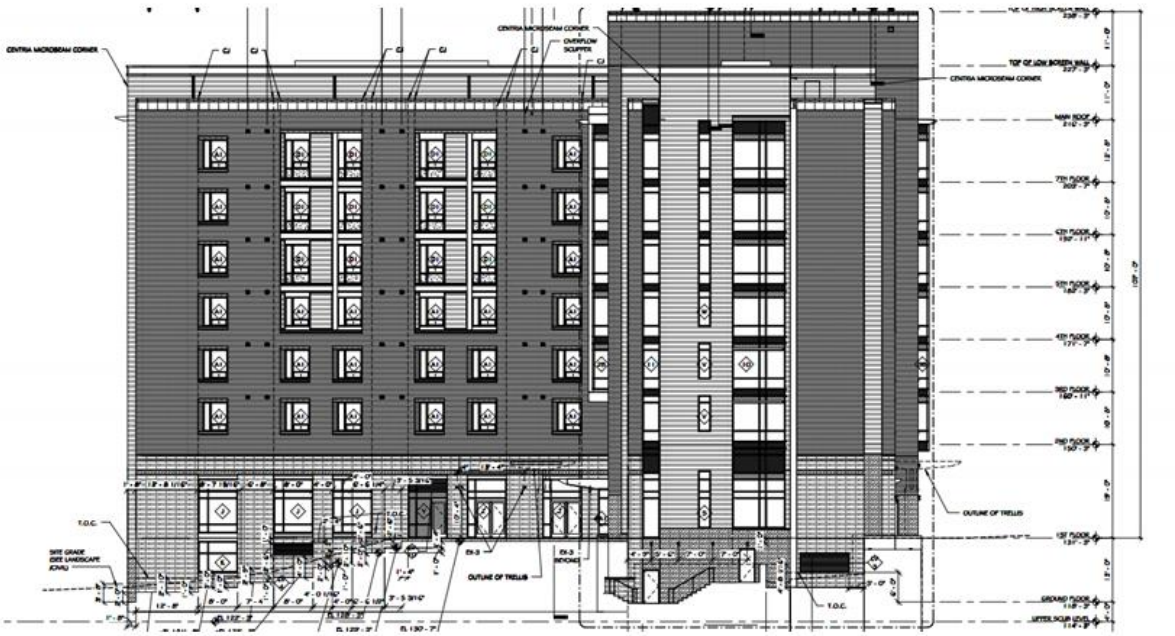


Figure 11

East Elevation



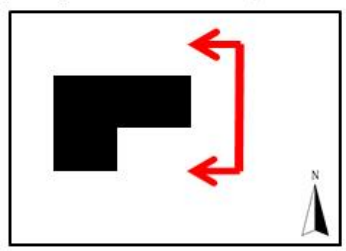
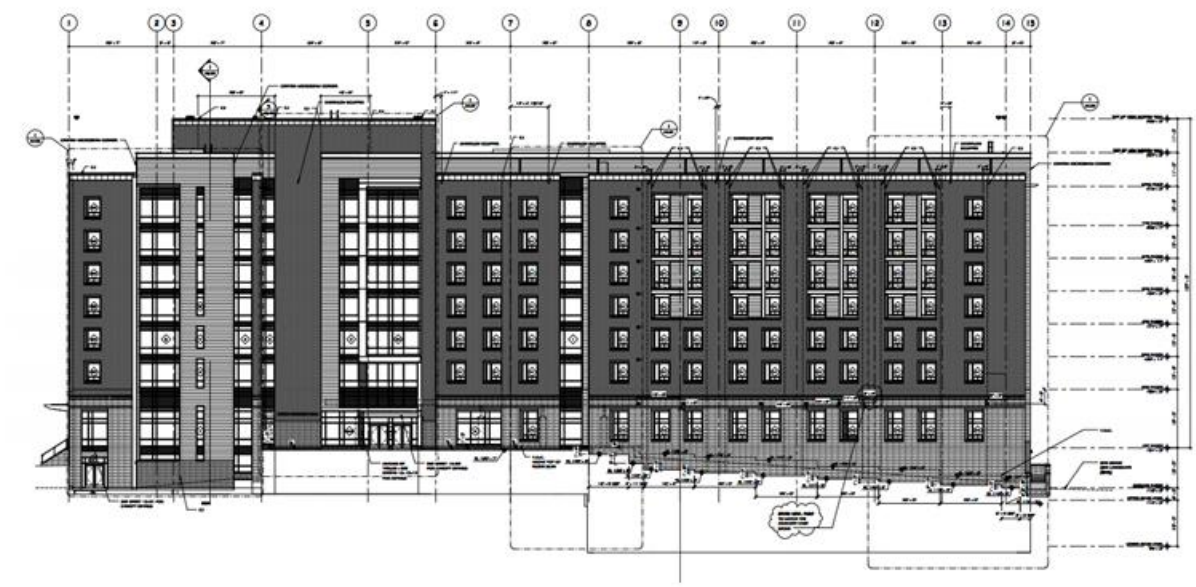


Figure 12

South Elevation



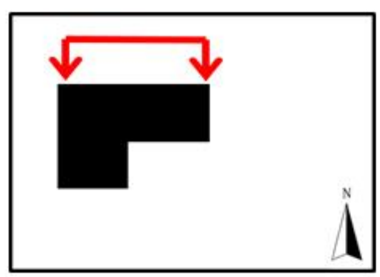
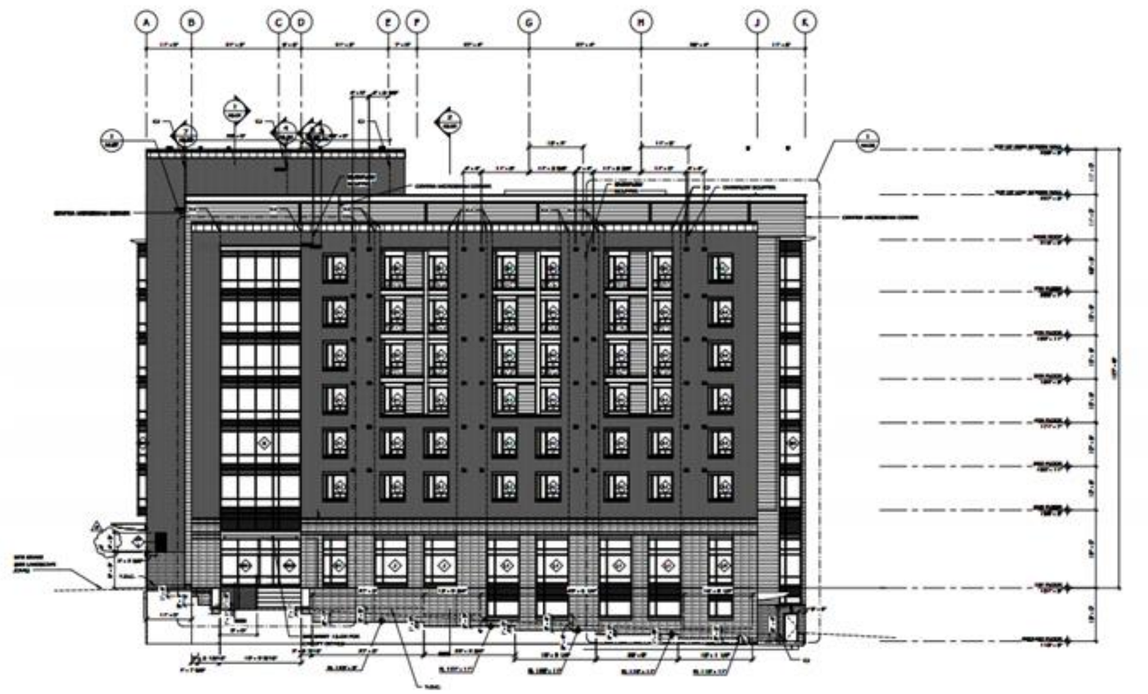


Figure 13

West Elevation



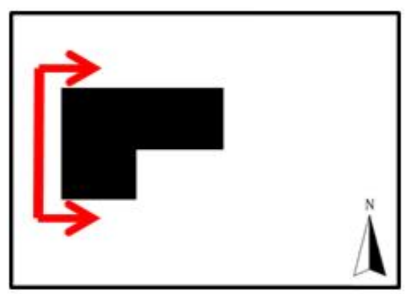


Figure 14

Structural System Overview

This section provides an overview for the structural system of Prince Frederick Hall. It describes the structural framing system including columns, slabs, materials and load paths of the building. It also describes the loads acting the building, their load paths, and how the building reacts. Also, it describes the national codes used to design the structure of the building and where is applicable.

Building Codes

This sub-section lists the applicable building codes and design standards associated with PFH.

- The International Building Code – 2009, International Code Council
- Minimum Design Loads for Buildings and Other Structures (ASCE 7) American Society of Civil Engineers
- Building Code Requirements for Structural Concrete, ACI 318, American Concrete Institute
- ACI Manual of Concrete Practice, Concrete Reinforcing Steel Institute
- Post Tensioning Manual, Post Tensioning Institute
- Steel Construction Manual, 13th edition, 2005, American Institute of Steel Construction Including ANSI/AISC 360-05 Specifications for Structural Steel Buildings, Specification for Structural Joints Using ASTM A325 or A490 Bolts and AISC 303-05 Code of Standard Practice for Steel Buildings and Bridges
- Manual of Steel Construction, Volume 2 Connections, ASD Ninth edition/LRFD First Edition, American Institute of Steel Construction
- Detailing For Structural Construction, American Institute of Steel Construction
- Structural Welding Code ANSI/AWS D1.1 American Welding Society
- Standard Specifications for Long span Steel Joists, LH Series and Deep Long span Steel Joists, DHL-Series, Steel Joint Institute
- Design Manual for Floor Decks and Roof Decks, Steel Deck Institute

Materials

Cement

- ASTM C150; Type 1 or 3

Blended Hydraulic Cement

- ASTM C595, Type is (limit to 35% max of cementitious content by weight)

Aggregates

- ASTM C33 (normal weight)

Admixtures

- Air entraining admixtures ASTM C260
- Chemical Admixtures ASTM C494

Concrete

Compressive strengths after 28 day

• Footings	3000psi
• Foundation Walls	4000psi
• Shearwalls	4000psi
• Columns	Shown in schedule
• Slab-On-Grade	3500 psi
• Reinforcing Slabs	5000 psi
• Reinforcing Beams	5000psi
• P.T. Concrete	5000psi
• Topping	3500psi

Reinforcement

- Deformed Reinforcing Bars : ASTM A615, Grade 60
- Welded Wire Reinforcement: ASTM A185
- Seven Wired Stress Relieved Pre-stressing Strands: ASTM A416, Grade 270

Steel

- Wide Flange Shapes and Tees: ASTM A992
- Square or Rectangular Hollow Structural Shapes: ASTM A500, Grade B, FY=46ksi
- Base Plates and Rigid Frame Continuity Plates: ASTM A527, Grade 50
- Other Structural Shapes and Plates: ASTM A36
- High Strength Bolts: ASTM A325-N or ASTM F1852
- Anchor Rods: ASTM F1554, Grade 36
- Galvanized Steel Roof Deck: ASTM A653 SS. Grade 33, G-90

Foundation

The location of the building is essential for the foundation design. (At this time, a geotechnical report was not made available- websoilsurvey.nrcs.gov was used to help determine soils information until further notice)

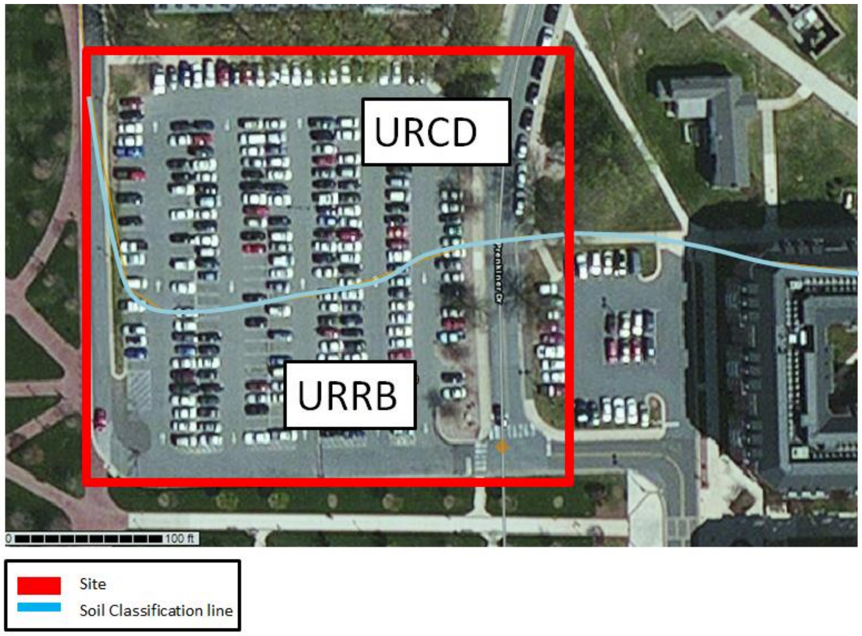


Figure 15

On the PFH site, there are two different land classifications, Urban Land Russett-Christiana Complex and Urban Land Christiana Downer Complex. The typical profile of the soils is shown in the tables below for the two different land types. More in depth analysis was done prior to construction and was competed by KCI Technologies Inc. This data is only to help describe the choice of foundation system. The actual foundation system was designed on a net allowable bearing pressure of 2000 psf.

URRB

TYPICAL DEPTH (INCHES)	PROFILE
0-4	Fine sandy loam
4-7	Loam
7-13	Loam
13-46	Clay loam
46-57	Sandy clay loam
57-77	Silty clay loam

URCD

TYPICAL DEPTH (INCHES)	PROFILE
0-12	Loamy sand
12-31	Sandy loam
31-38	Loamy sand
38-72	Sand

Building on soil types such as loam and sand poses complications and stability loss. The level of grade changes less than fifteen percent which requires the building to be designed accordingly. The diagram below shows the contour lines on the existing site before excavation. The darker red lines represent higher elevation and the lighter red lines reduce in elevation.

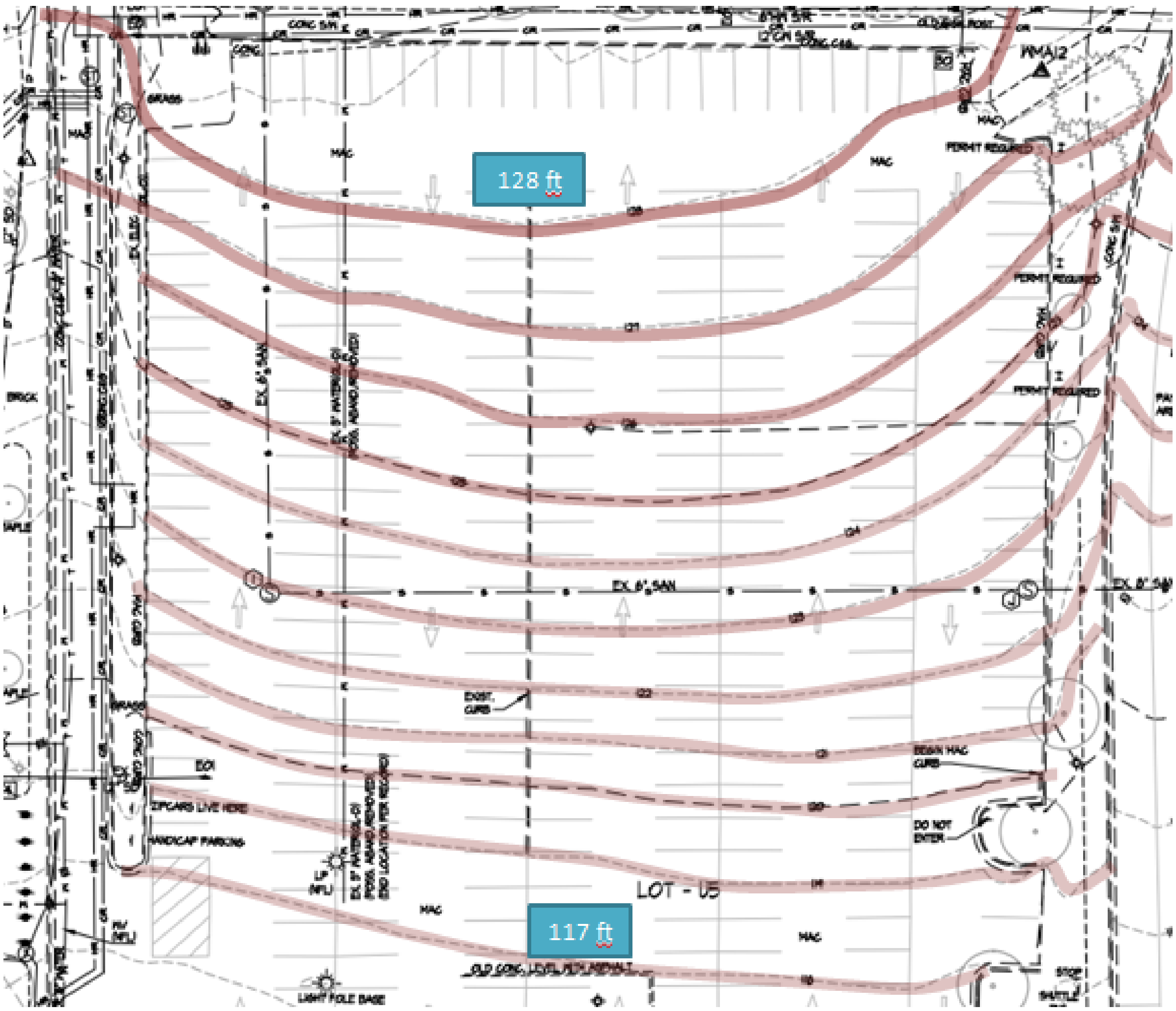


Figure 16

The foundation system of PFH is consistent of spread footers, strip or wall footers, and grade beams. The pad footers are located under the columns and are used to spread the buildings load in a square formation. The columns sit in the center of the pad footer which then distributes the loads of the building to the ground. The diagram figure 134 from (http://www.decodingeurocode7.com/downloads/10.%20Design%20of%20footings%20%28sample%29.pdf) shows the design limits at which the spread footers need to withstand.

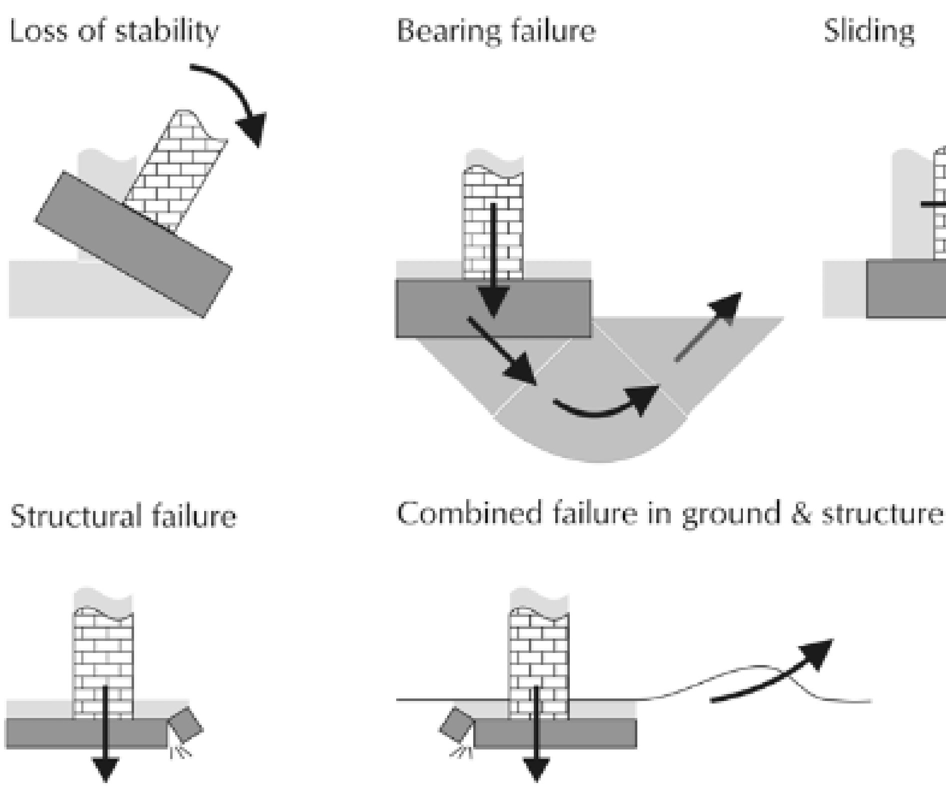


Figure 134. Examples of ultimate limit states for footings

Figure 17

Labeled in the following drawings are the locations of the spread footers, strip footers and grade beams.

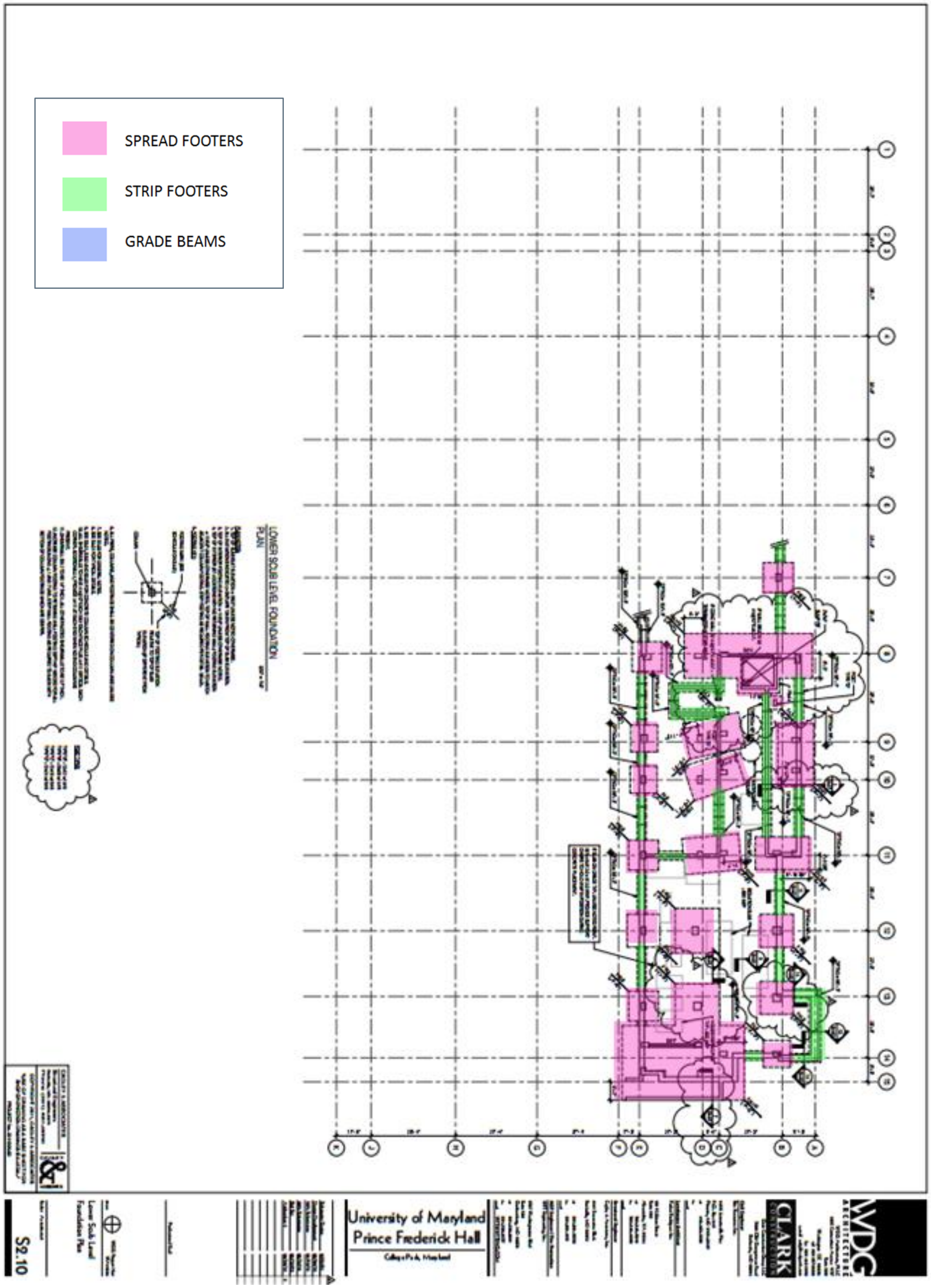

SPREAD FOOTERS
STRIP FOOTERS
GRADE BEAMS
University of Maryland
Prince Frederick Hall
CLARK
S2.10

Figure 18

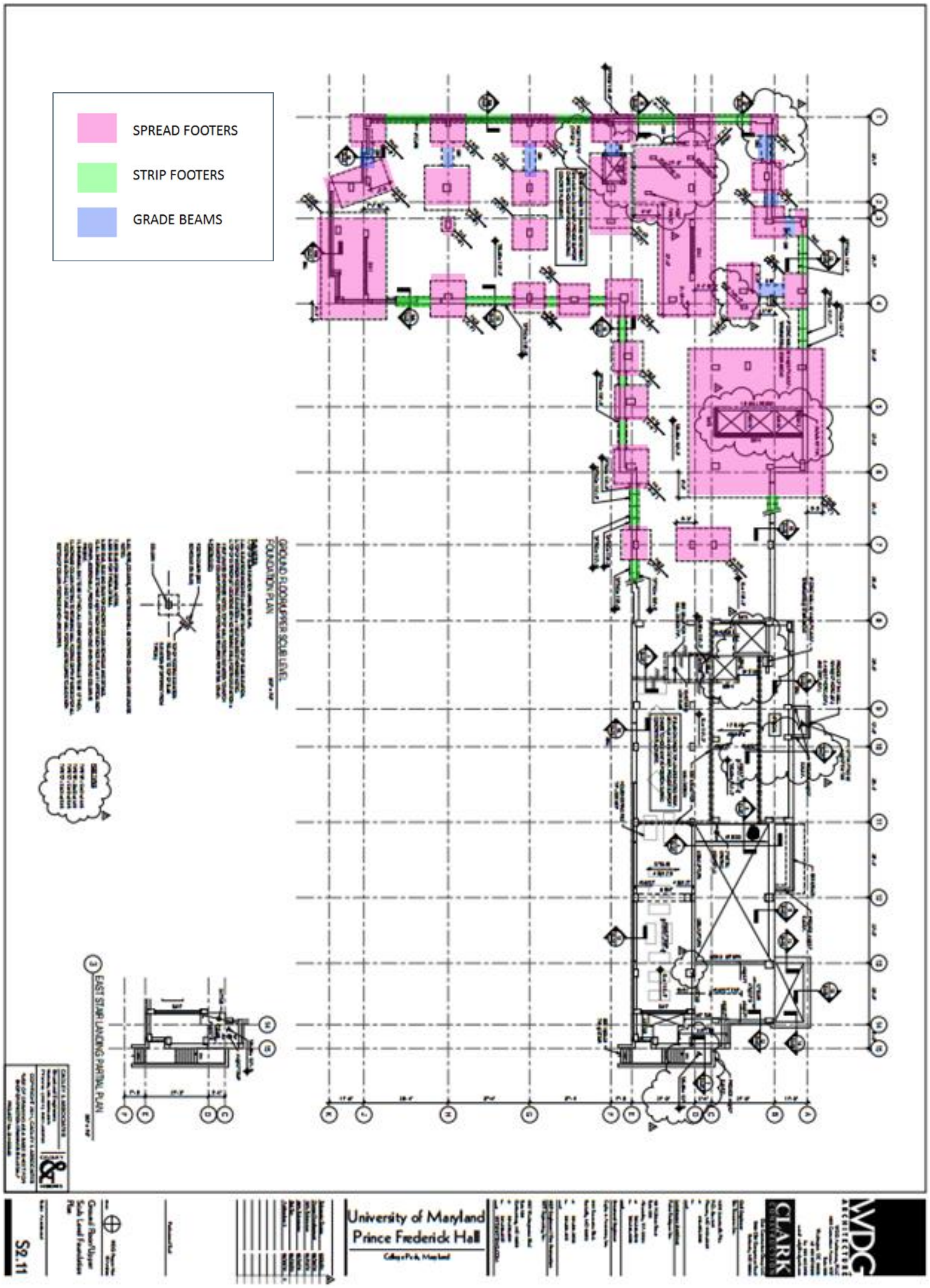
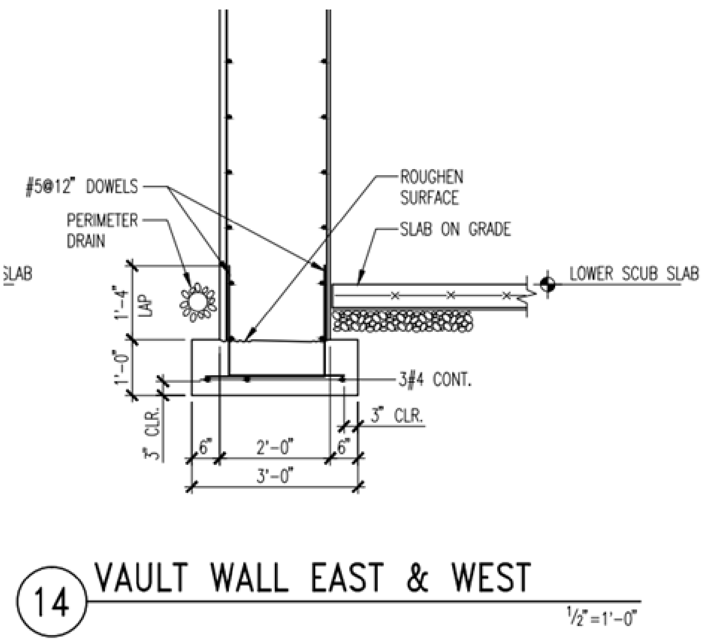
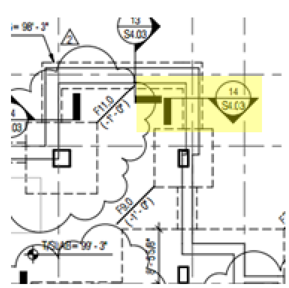

SPREAD FOOTERS
STRIP FOOTERS
GRADE BEAMS
University of Maryland
Prince Frederick Hall
CLARK
S2.11

Figure 19

The spread footers are located under every concrete column and are denoted on the plans by a dashed line. These spread footers were chosen to distribute the loads coming from the columns directly above them. Most of the spread footers in the building are unique to each column while some are shared with the column next to it. Spread footers or small foundation pads are located under the seven shear walls of the building to help retain their rigidity. Each footer meets the minimum compressive strength of 300 psi. Later in the document, shear walls will be described in full depth from the ground to the roof. The smaller spread footers are connected to an adjacent footer by a strip footer or grade beam.

The strip footings are located mostly at the edge of the building and are connected to the spread footers. They allow the foundation to maintain level while the contours of the land change. The following detail (labeled Figure 20) shows a typical strip footer with a slab on grade and the placement of rebar.





Found on page S4.03 of docs.

Figure 20

The rebar in the 12 inch deep strip footer is set with a minimum 3 inch clear from the bottom of the concrete as per ACI 318. Three number 4 bars are laid parallel the bottom of the footer and extend out further. Number 5 dowels are place two feet apart to help transfer tension from the column to the base footer.

The following column footing schedule shows that there are 22 different footers used on the building. The footing sizes varies from 4'x4'x18" to 45'x50'x60". This schedule can be found on page S2.10 of the structural documents.

COLUMN FOOTING SCHEDULE					
MARK	DIMENSIONS			REINFORCEMENT	REMARKS
	WIDTH	LENGTH	DEPTH		
F4.0	4'-0"	4'-0"	18"	5#5 EWB	
F4.5	4'-6"	4'-6"	20"	8#5 EWB	
F9.0	9'-0"	9'-0"	32"	8#9 EWB	
F10.0	10'-0"	10'-0"	34"	9#9 EWB	
F11.0	11'-0"	11'-0"	38"	10#9 EWB	
F11.5	11'-6"	11'-6"	40"	11#9 EWB	
F12.0	12'-0"	12'-0"	42"	10#10 EWB	
F15.0	15'-0"	15'-0"	46"	11#11 EWB	
F5x14	5'-0"	14'-0"	48"	6#9 LWB, 6#9 LWT 15#9 SWB, 15#9 SWT	EXTEND SHORT DIRECTION BARS INTO F15x43
F6x9	6'-0"	9'-0"	34"	9#8 EWB	2
F7x9	7'-0"	9'-0"	34"	9#9 EWB	
F8x12	8'-0"	12'-0"	36"	10#9 EWB	
F9x12	9'-0"	12'-0"	36"	10#9 EWB	
F11x18	11'-0"	18'-0"	38"	12#11 LWB, 10#9 LWT 20#9 SWB	
F12x19	12'-0"	19'-0"	40"	13#10 LWB, 11#9 LWT 20#9 SWB	
F12x21	12'-0"	21'-0"	40"	12#10 LWB, 11#9 LWT 20#10 SWB	
F14x25	14'-0"	25'-0"	42"	25#10 LWB, 15#9 LWT 31#10 SWB, 26#9 SWT	
F15x43	15'-0"	43'-0"	48"	14#10 LWB, 14#10 LWT 38#10 SWB, 38#10 SWT	
F25x41	25'-0"	41'-0"	46"	31#10 LWB, 26#9 LWT 42#9 SWB, 42#9 SWT	
F22x36	22'-0"	36'-0"	44"	23#9 LWB, 23#9 LWT 37#9 SWB, 37#9 SWT	
F27x57	27'-0"	57'-0"	50"	47#10 LWB, 37#10 LWT 70#10 SWB, 50#10 SWT	VARY BAR LENGTHS TO MAINTAIN UNIFORM SPACING
F45x50	45'-0"	50'-0"	60"	50#10 LWB, 50#10 LWT 61#10 SWB, 55#10 SWT	

Figure 21

The slab on grade is a typical 5" depth unless noted in the documents (at isolation pads) reinforced with 6x6-W 2.0 x W 2.0 wire welded frame. The mesh wire is located 1.5" from the top of the slab to insure proper bonding between the rebar and concrete as per ACI 318. All slabs-on-grade meet the minimum compressive strength of 3500psi. Directly under the slab is a vapor retarder to keep moisture from the ground to come into the slab and cracking it at freezing temperatures. There is also a ¼" isolation strip where the wall and slab meet.

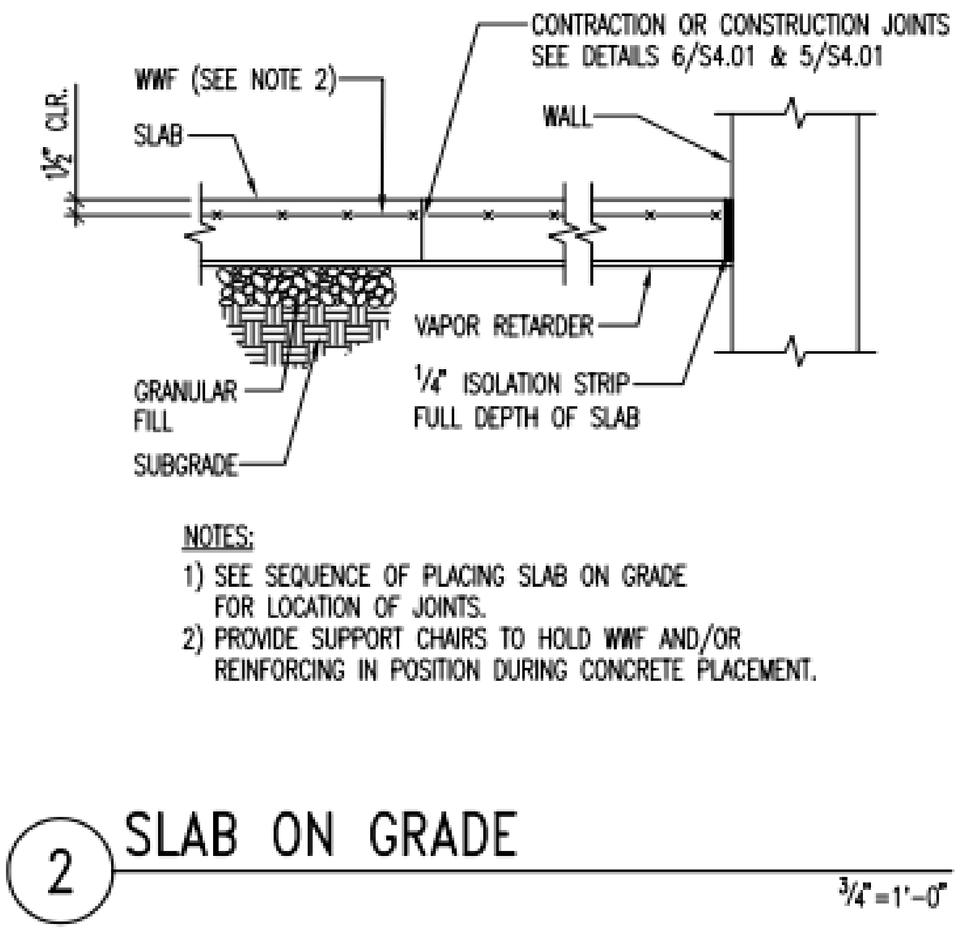
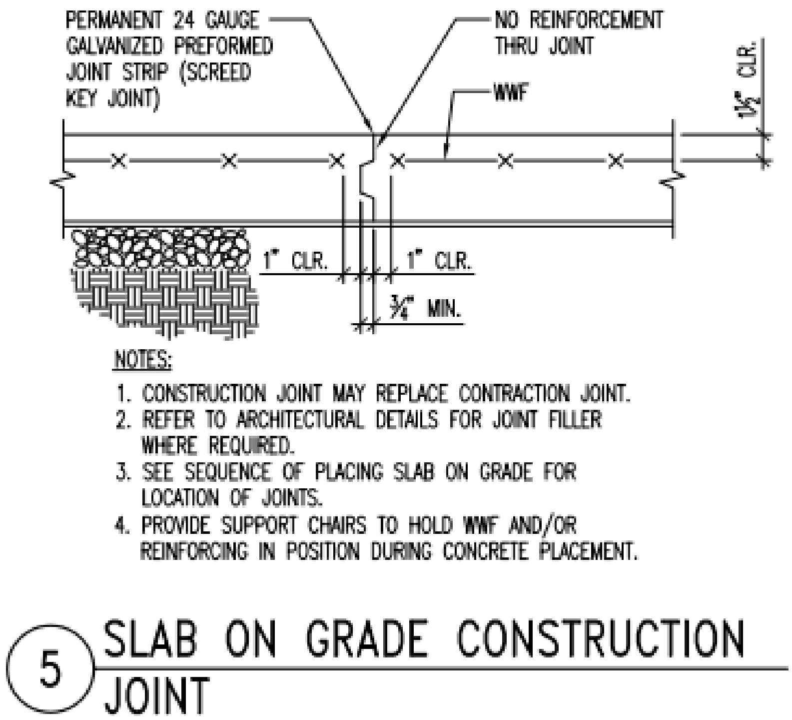


Figure 22

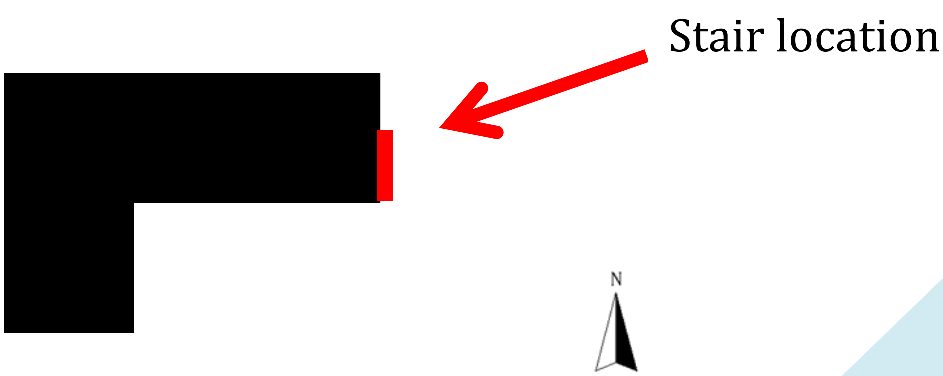
The slab reinforcement stops at construction joints as shown in the details below.



Found on page S4.01 of docs.

Figure 23

Located at the east end of the building there is an exterior stairwell that allows egress from the lower scub area. The following two details explain the layout of the stairs, the connection with the slab on grade and retaining for the stairs.



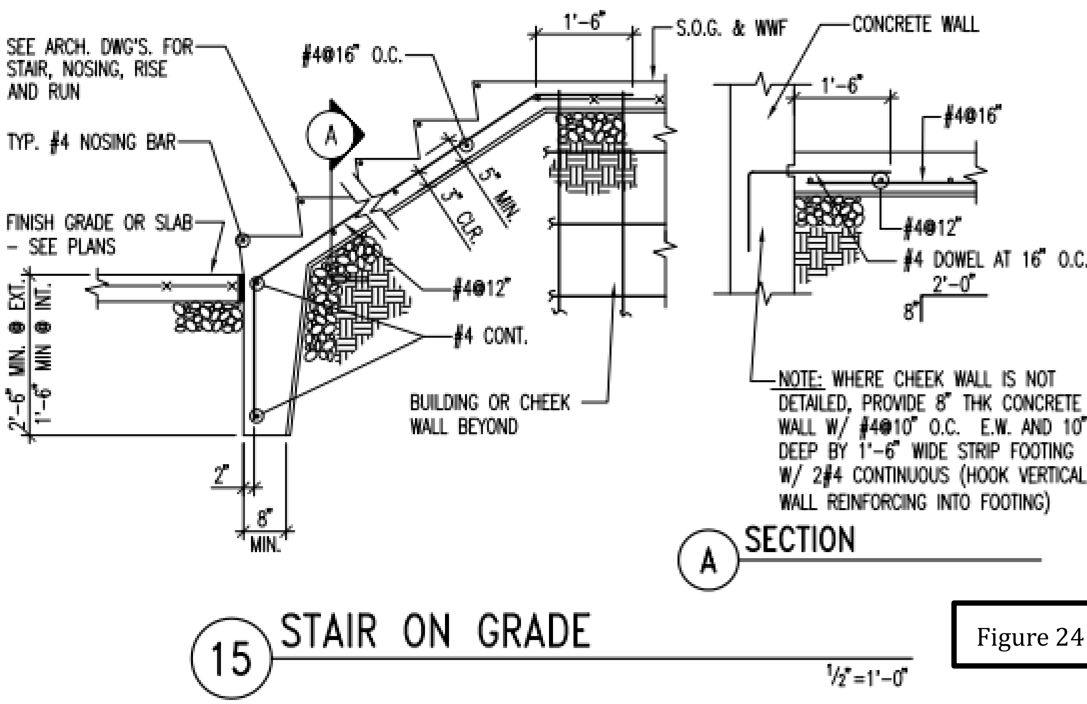
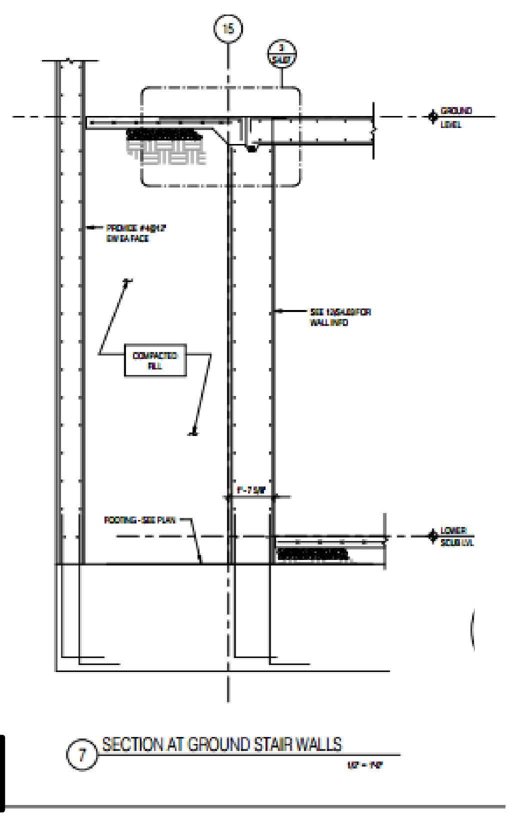


Figure 24

Detail can be found on page S4.01



Detail can be found on Page S4.07

Figure 25

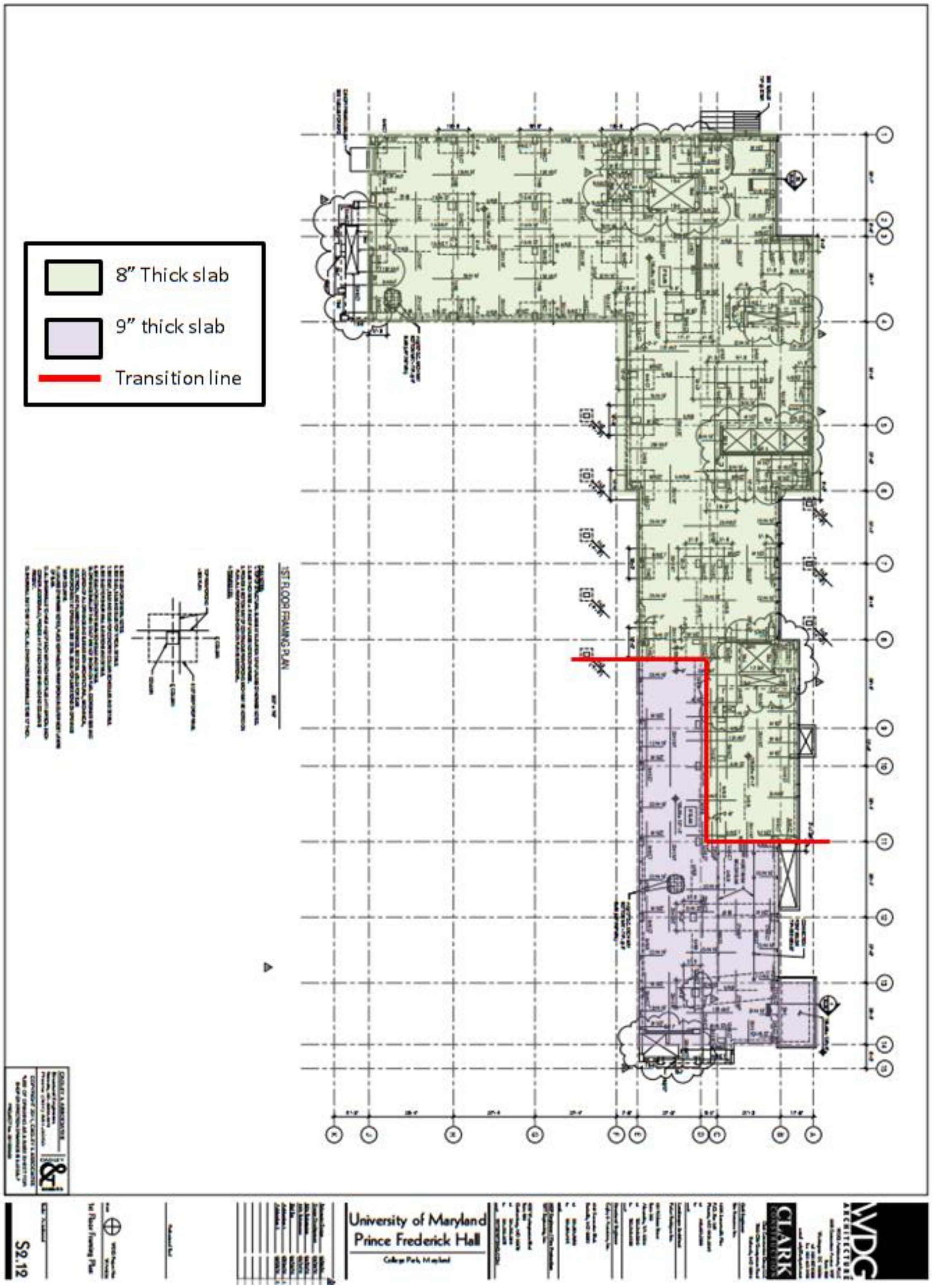
Isolation pads are added into the slab on grade for different occupational purposes such as housekeeping and different mechanical systems. These pads help deal with the vibration of the systems above them.

Gravity System

The main gravity system of PFH is a two way slab flat plate with drop panels. In this section, the structural gravity system is described from the first floor to the roof. The gravity system from the third to seventh floor is identical and will be noted in this section.

The structural engineers decided to go with a two way slab system because it is efficient, economical, and is a widely used structural system. A flat slab is essentially a flat plate which is then thickened around columns. These drop panels are used to control the negative moments transferred to the columns.

The first floor slab is designed to withhold the loads from a couple of different occupancies which include; washrooms/laundry rooms, lobbies, living space, hallways/egress, mechanical and storage. On this floor, there are two different slab thicknesses, one is 8 inches thick and the other is 9 inches. Shown in the diagram below, the 9 inch slab is the majority of the floor and sits to the west side of the building. The 8 inch slab sits to the east side of the building and has a smaller area.



8" Thick slab
9" thick slab
Transition line
University of Maryland
Prince Frederick Hall

Figure 27

The engineer decided to do two different slab thicknesses on this floor because of the difference in spans. It is more economical to design the smaller spans of the two way slab with 8" and the larger spans being 9". The 9" allows for a larger depth (d) in design which will save you on the amount of rebar needed, ultimately reducing the cost.

Along with the two way slabs, there are beams which frame out the voids.

Figure 28

Figure 29

CONCRETE BEAM SCHEDULE											
MARK	SIZE		REINFORCING				STIRRUPS				REMARKS
	W	D	BOTTOM BARS	TOP BARS			SIZE	TYPE	SPACING (INCH)	END	
				LE	FL	RE					
GB-1	48	34	4#11	-	8#11	-	#4	S2	1@3, R@12	EE	HOOK T&B BARS AND EXTEND PAST
GB-2	36	24	4#11		4#11		#4	S2	1@3, R@10	EE	COLUMN @ EA END TYP ALL GB
USB-1	12	36	2#9	-	2#9	-	#4	S2	1@3, R@12	EE	UPTURN
USB-2	12	36	2#9	-	3#9	-	#4	S2	1@3, R@12 1@3, 8@6, R@12	LE RE	UPTURN
USB-3	12	36	3#10	-	3#10	-	#4	S2	1@3, R@12	EE	UPTURN
USB-4	12	24	2#9	-	2#9	-	#3	S2	1@3, R@10	CANT.	
USB-5	8	20	2#7	-	2#7	-	#3	S2	1@3, R@8	EE	
USB-6	12	16	2#7	-	2#7	-	#3	S2	1@3, R@6	EE	
USB-7	30	24	3#9	-	3#9	-	#4	S2	1@3, R@10 1@3, R@6	EE CANT.	
1B-1	30	50	3#9	-	3#9	-	#4	D2	1@3, R@12	EE	
1B-2	12	20	2#9	-	2#9	-	#4	S2	1@3, R@8	EE	
1B-3	22	20	3#8	-	3#8	-	#4	S2	1@3, R@8	EE	
1B-4	8	20	2#7	-	2#7	-	#3	S2	1@3, R@8	EE	
1B-5	12	24	3#9	-	3#9	-	#4	S2	1@3, R@10	EE	
1B-6	8	20	2#8	-	2#8	-	#3	S2	1@3, R@8	EE&CANT	
1B-7	18	20	2#7	-	2#9	-	#4	S2	1@3, R@8	EE	
1B-8	8	16	2#7	-	2#7	-	#3	S2	1@3, R@6	EE	
1B-9	24	24	5#9	3#9	3#8	3#9	#4	D2	1@3, R@10	EE	
2G-1	24	36	4#11	-	4#11	-	#4	D2	1@3, R@12	EE	
TB-1	24	22	5#9	3#9	3#8	3#9	#4	D2	1@3, R@8	EE	
TB-2	12	20	2#6	-	2#7	-	#3	S2	1@3, R@8	EE	
TB-3	10	42	2#10	-	2#10	-	#3	S2	1@3, R@8	EE	
TB-4	8	20	2#5	-	2#5	-	#3	S2	1@3, R@8	EE	
TB-5	20	20	3#9	-	3#7	-	#3	D2	1@3, R@8		
TB-6	30	18	3#9	-	3#7	-	#3	D2	1@3, R@8	EE&CANT	
TB-7	24	20	3#7	-	3#7	-	#4	D2	1@3, R@8	EE	
TB-8	8	20	2#5	-	2#5	-	#3	S2	1@3, R@8	EE	

Beams at voids in schedule

The second floor slab is different from the first floor; it varies from 8" to sections of 3" deep. The sections of 3" slab occur at the washroom areas, allowing enough space for a flush floor finish. The second floor also has beams at the voids, similar to floor one. The flooring from the third floor to the seventh has the same slab set up as floor two; a diagram will not be shown for these.

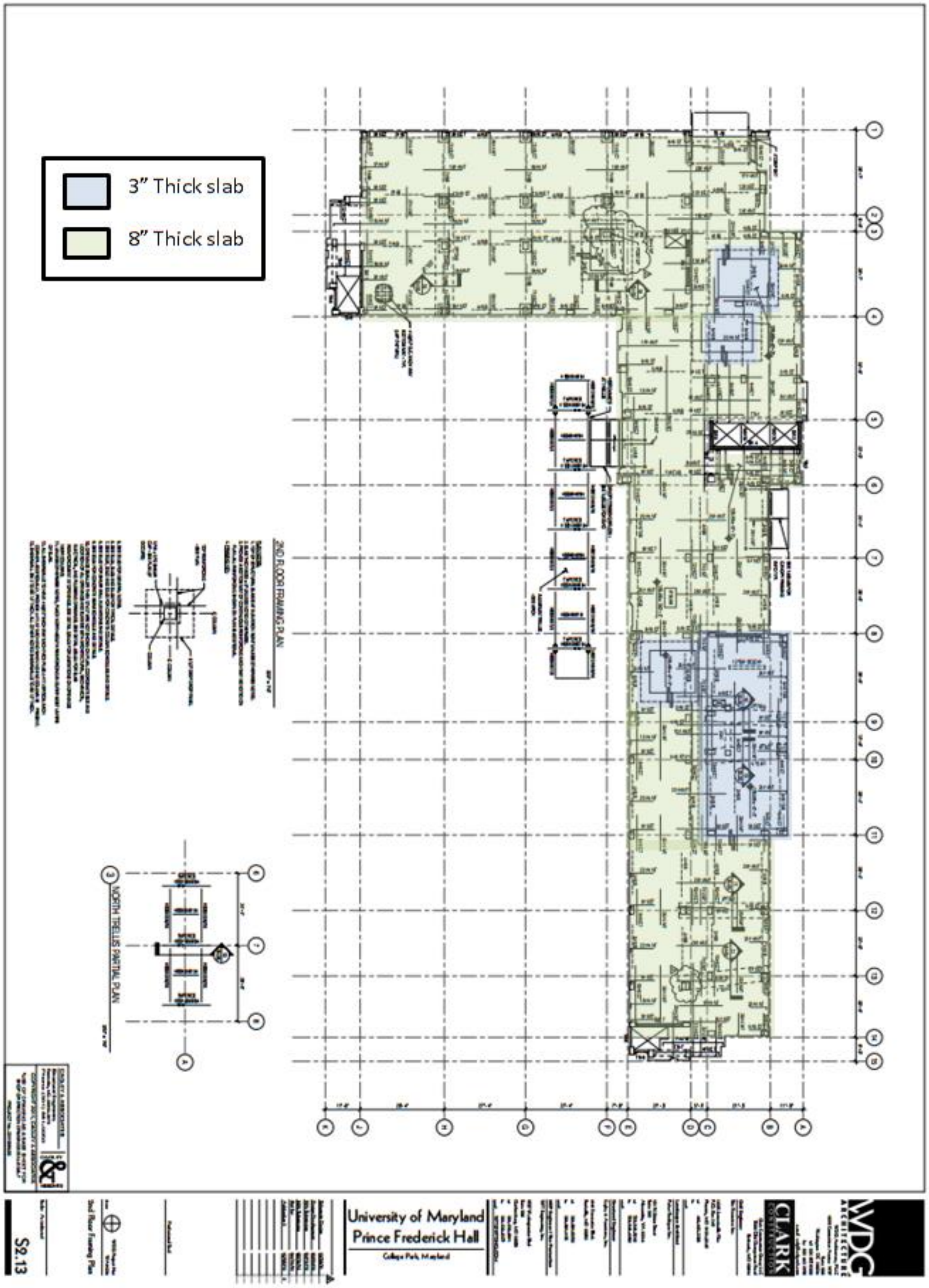

3" Thick slab
8" Thick slab
University of Maryland
Prince Frederick Hall
CLARK
S2.13

Figure 30

The roof slab is 8 inches thick and is not to exceed 14 inches. The given range of thickness is to allow for a slope in the slab to drain water off of it (drainage system).

From the slabs, the loads travel in two directions to meet the concrete columns which transfer the loads to the foundation. There are a few typical sizes for the columns: 30x 18, 18x24, 24x30, and 24x36. Each column retains its size as it elevates from the foundation. The column schedule works with the grid given on the structural documents and shows the size of each column per floor. At the bottom of the schedule is the working load that is transferred from the foundation to the ground.

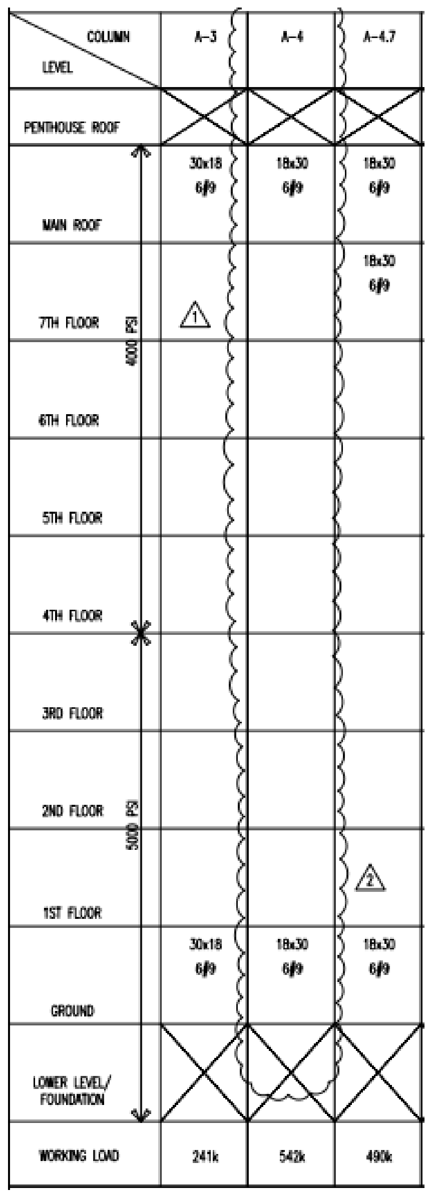


Figure 32

Lateral System

The lateral system of PFH consists of seven shear walls which act together to resist lateral, horizontal, and shear forces. The first shear wall (SW1) is located in the far south side of the building apart of the stairwell. Shear wall number 2 (SW2) is located near the main entrance and it connected to the first floor multipurpose room. Shear wall 3,4, and 5 wrap around the main elevator system and together create a "C" shape. Shear wall 6 is located in the east wing and touches the main wash rooms on the residential floors. Shear wall 7 (SW7) is located at the far east end and touches the other stairwell. The diagram below shows the location of the shear walls on the first floor plan, these shear walls extend from the ground to the roof.

Figure 33

At the base of the shear walls, standard ninety degree hooks from the foundation connect the two together allowing for a moment connection. The following detail is the typical layout of the shear walls with openings.

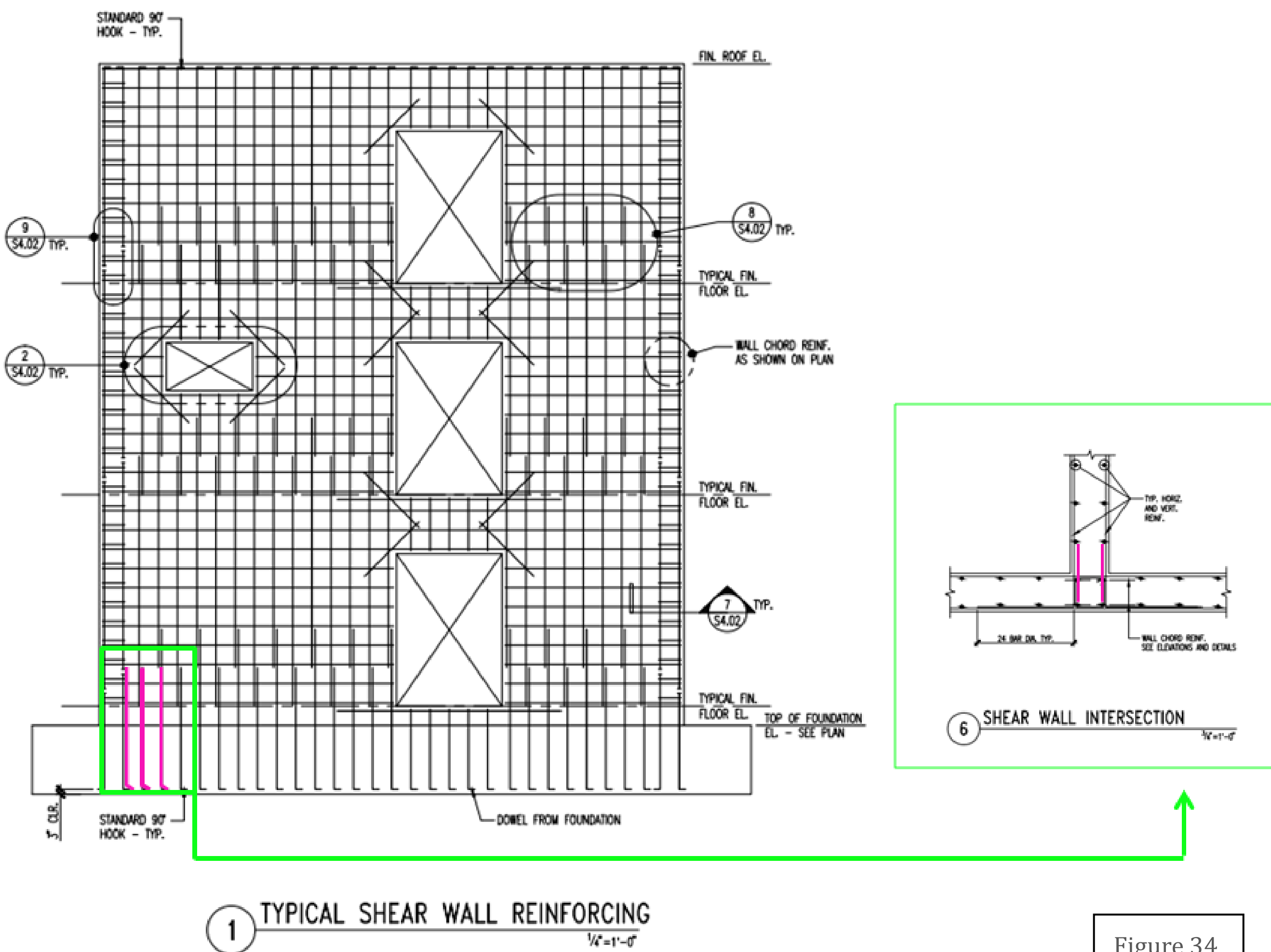


Figure 34

Roof

The main roof is home to mechanical systems and cooling towers disguised by short screens. The short screens on the roof allow for the mechanical systems to be out of the line of view. These screens are significant to the structure of the building because they are subjective to gravity, wind and seismic loads. As wind blows, the short screens are subjected to downward forces and uplift.

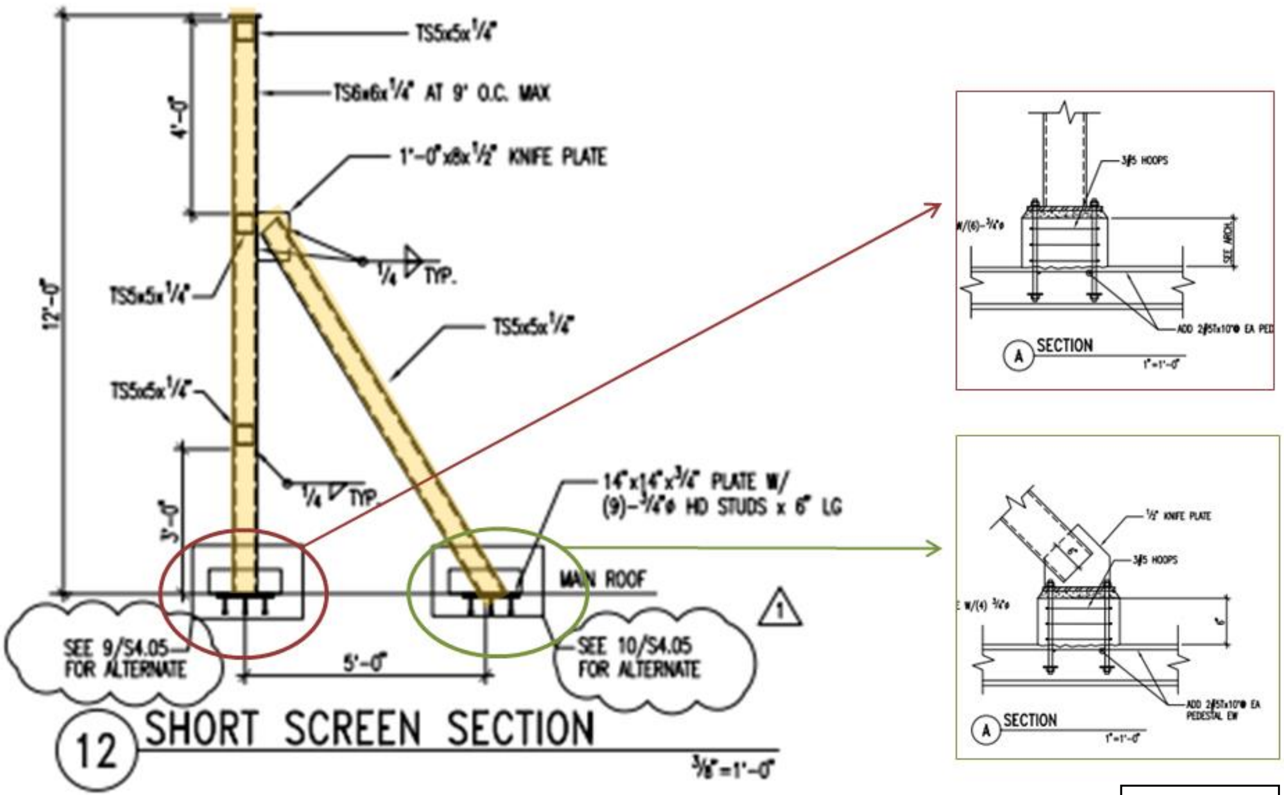


Figure 35

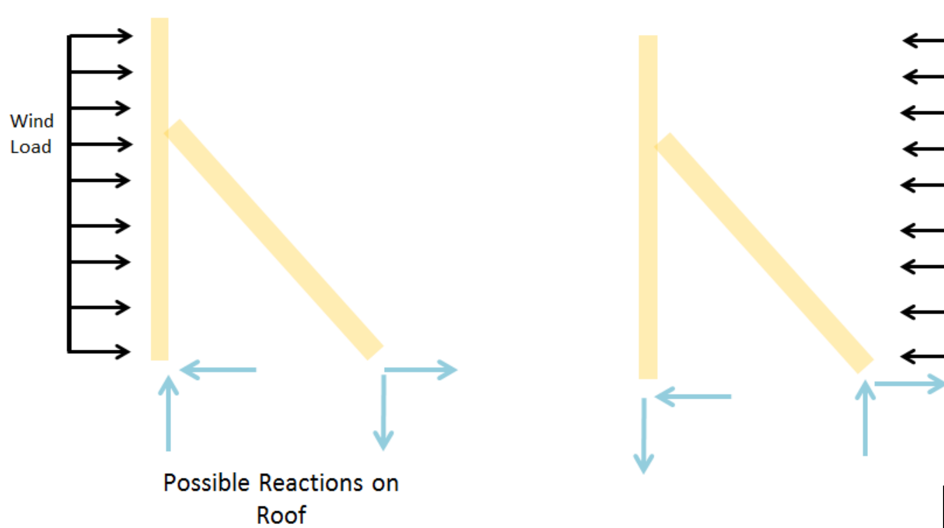


Figure 36

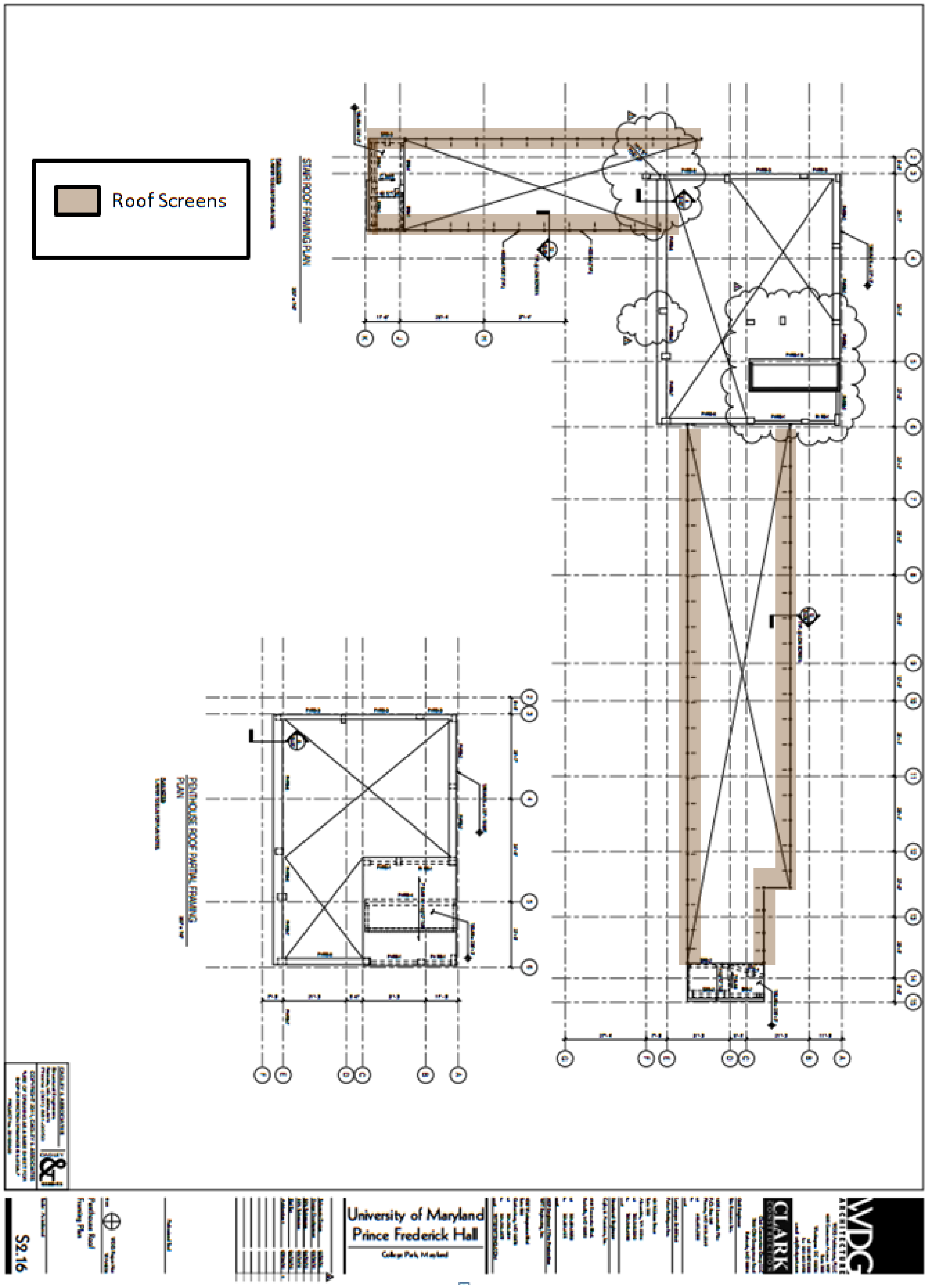

Roof Screens
University of Maryland
Prince Frederick Hall
S2.16
CLARK

Figure 37

Joint Details

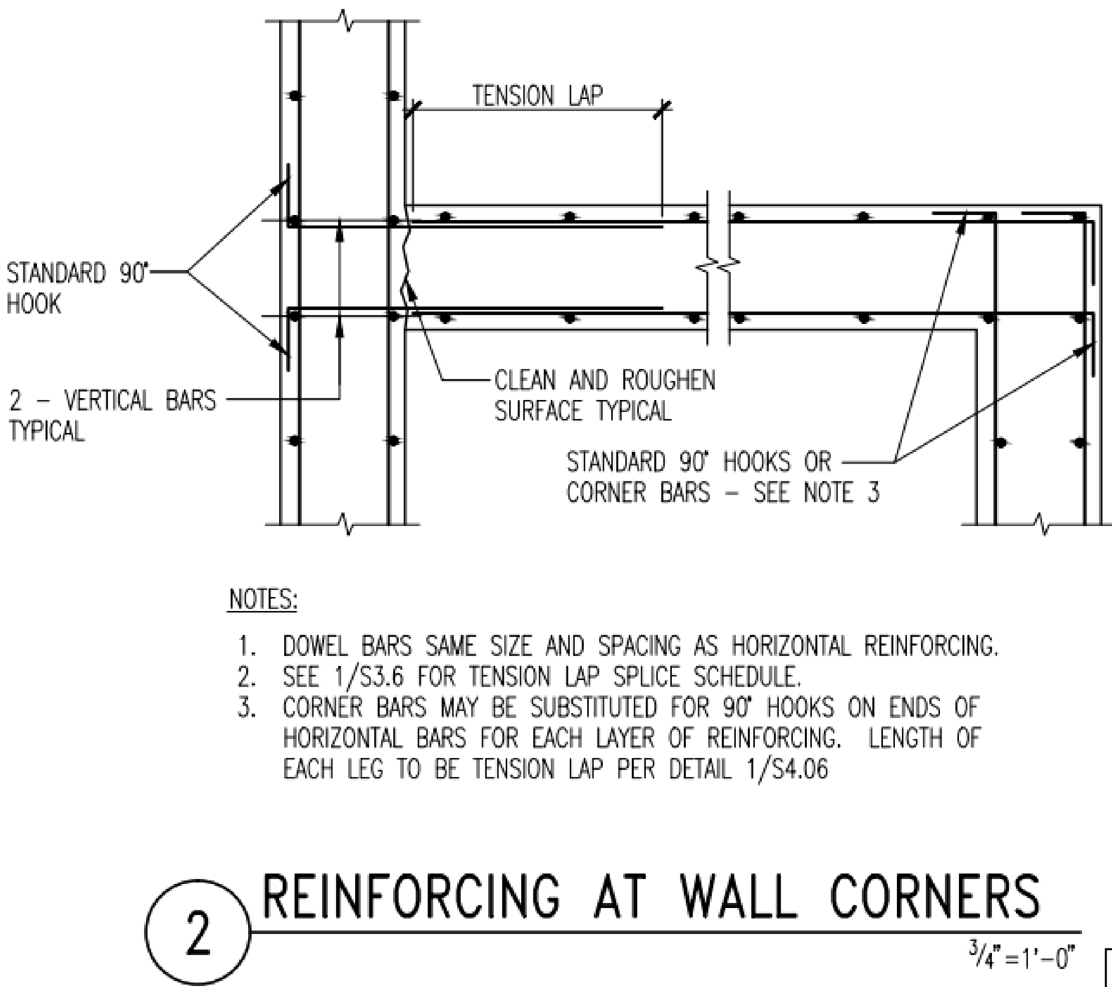


Figure 38

Figure 38 is a diagram of typical reinforcing at a wall corner where a beam meets the edge column. This cast in place connection uses standard 90 degree hooks to extend from the beam to the column making sure all development lengths are met. The two sets of parallel bars are spaced a minimum distance and are placed 1.5” from cover according to IBC 318-11. More joint details can be found throughout the document, ie: lateral systems.

Building Loads and Paths

SUPERIMPOSED DEAD LOADS

Area	PSF
floors	5
roof	10

All loads were found on the general notes of the structural documents.

FLOOR LIVE LOADS

Uneducable loads are followed by U

Area	PSF
seminar rooms at ground floor	100 (U)
corridors (serving private rooms)	40
corridors (serving public rooms)	100
apartments	40 + 10 partitions
lobbies	100
marquees and canopies	75
mechanical rooms	150(U)
bike storage (first floor)	100
study rooms above first floor	60
stairs and exit ways	100(U)

ROOD LIVE LOADS

Area	PSF
roof	30 min (ponding or snow load is used when greater than 30psf)

SNOW LOAD INFOMATION	
ground snow load	25 PSF
snow exposure factor	1.0
snow load importance factor	1.0
flat roof snow load	17.5 plus unbalanced

The load path for dead and live loads are very trivial in PFH. Starting from the roof, loads are distributed through the two way slabs. These loads consist of mechanical equipment, human live load, and even wind load. The loads are transferred from the slabs to the columns and are dropped to the foundation. Similar set up happens for every other floor and in the end all loads end up in the foundation. Tributary area works for the distribution of loads on the slabs and their transference to the columns. The wind and seismic loads are transferred through the building to the shear walls. For instance, the wind load will act upon the façade and the load is transferred through the slab. From the slab the loads are distributed minimally to the columns and primarily to the shear walls. That load is changed from lateral to vertical and extended down to the foundation.

WIND LOAD INFORMATION	
basic wind speed	(3sec gust) 90 MPH
site exposure category	B
wind importance factor	1.0
net wind uplift	20psf

SEISMIC LOAD INFORMATION	
soil site class	D
seismic importance factor	1.0
seismic use group	I
seismic design category	B
basic seismic force resisting system	ordinary moment frames
response modification factor	3
seismic response coefficient	0.026
design base shear	782K
analysis procedure	equivalent lateral force procedure

Conclusion

After a complete and in-depth analysis of the design of Prince Frederick Hall, this document elaborates the existing conditions. The foundations, gravity systems, lateral systems, and roof screens were examined and explained. This report begins with the basic architectural features and works its way to becoming a complete analysis of each floor and their structural design. It looks at the importance of economics and describes the decisions of the engineers.

Some interesting features that may cause problems down the road are the foundation system, the double thickness slabs, and the roof screens. The foundation system is not set up on a grid and some of the pads are angled, this feature does not seem to be the most economical or efficient. More research will need to be done to determine the actual reason for these off-set pads. The double thickness slabs will pose difficulty in stress and strain computations. The roof screens are going to cause the wind calculations to be much more challenging causing uplift on the roofs slab and adding extra height to the building.