Technical Report I

Timothy Bailiff | Structural Option

SUSQUEHANNA CENTER EXPANSION AND RENOVATION, HARFORD COMMUNITY COLLEGE

* Picture taken from Turner website

Executive Summary

The purpose of Technical Report I is to perform analysis on a number of elements and different types of loads to gain an understanding of how the structural and lateral systems in the Susquehanna Center work. The report begins with illustrations and descriptions of the foundation, floor systems, lateral systems and roof systems. The basis of the report is to elaborate on design codes, materials used and the checking of the gravity and lateral loads acting on the building.

The wind, seismic and snow loads were calculated using ASCE 7-10 as a reference. This report consists of basic lateral load calculations to gain an understanding of how the building acts as a whole against lateral movement. After calculation a force of 901 k was found as the base shear. A more detailed and elaborate analysis will be assisted in future Tech Reports.

<u>Building Introduction:</u> Susquehanna Center Renovation and Expansion

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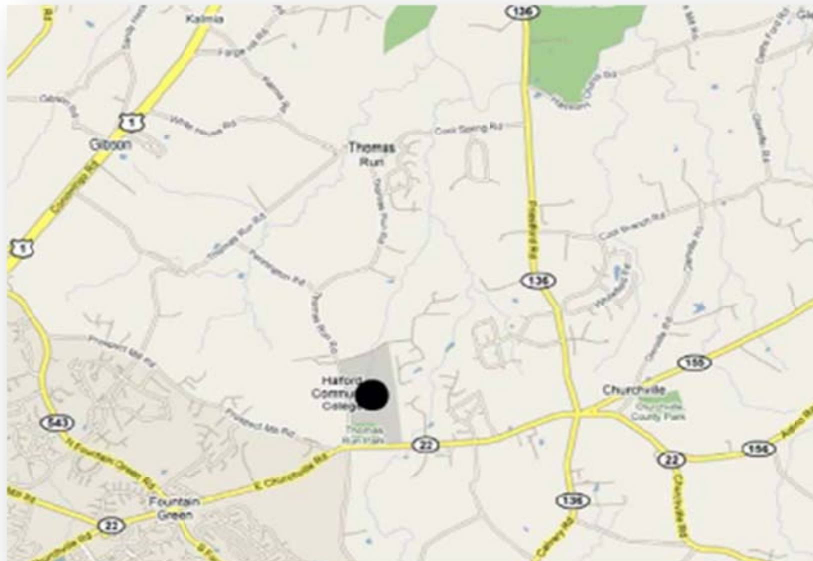


The Susquehanna Center Renovation and Expansion at Harford Community College is located on 401 Thomas Run Road in Bel Air, MD. The project will be constructed in August 2010 in collaboration with hord | coplan | macht as the architect, Site Resources, Inc. as the civil engineer, CMJ Structural Engineering, Inc. as the structural engineer, Burdette, Koehler, Murphy & Associates, Inc. as the mechanical electrical engineer and Counsilman Hunsaker as the natatorium consultant.

ı Map

The Susquehanna Center consists of a renovated arena, pool and a fitness center. The center is 49,150 SF which will be totally interiorly renovated and the expansion will include a new 37,460 SF arena, which will expand the total area of the building to 86,610 SF. The project will also include a new parking lot of 160 spaces, a new loop around the building and realigning of the entrances at the entrance drive.

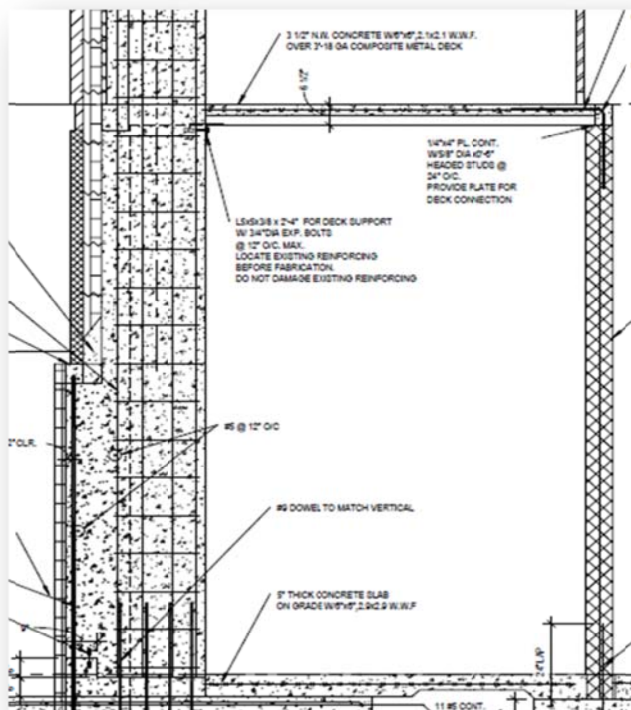
Structural Systems

Figure 1: Main Floor Framing Plan

Floor Systems

A typical floor in the expansion consists of 3 ½” N.W. concrete with 6”x6”, 2.1x2.1 W.W.F. over 3”-18 gage composite metal deck. The arena floor consists of a 5” thick slab on grade.

Framing Systems



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All of the structural columns in the expansion are 28” x 28” cast-in-place concrete columns which extend from the foundation to the full height of the building.

Lateral System

The lateral system contains concrete moment frames consisting of concrete wall beams and interior beams.

Roof Systems

The roof system in the expansion was erected using 96SLHSP joists spaced at 8’-0” o.c. and span the length of the arena.

Building Materials Used

The following tables provided will list the materials used in construction of the building, which were located in the structural drawings and the specifications.

Concrete		
Usage	Weight	Strength (PSI)
Spread Footing Foundations	Normal	4000
Retaining Walls	Normal	4000
Slab on Grade	Normal	4000
Elevated Slab	Normal	4000

Table 1: Concrete Materials

Steel		
Usage	Standard	Grade
W-Shaped Structural Steel	ASTM 992 A	50
Steel Pipe	ASTM A 501	B
Steel Tube	ASTM A 500	B
Steel Deck	ASTM A 611/ASTM A 446	N/A
Bolts, Nuts, and Washers	ASTM A 325/ASTM F 1852	N/A
Welded Wire Fabric	ASTM A 615	65
Reinforcing Bars	ASTM A 615/A 615M	60

Table 2: Steel Materials

Design Codes

All of the structural design and construction of the Susquehanna Center Renovation and Expansion shall comply with the all of the articles and sections of the following codes in compliances with all Federal, State, County, and Local ordinances and regulations:

- 2006 International Building Code (IBC)
- National Electrical Code (NEC)
- Uniform Plumbing Code (UPC)
- National Sanitation Foundation (NSF)
- Building Code Requirements for Reinforced Concrete (ACI 318-08)
- American Society of Civil Engineers (ASCE 7-10)

Gravity Loads

This report includes calculated dead, live and snow loads. These calculations were compared to the actual calculations in the structural drawing and general notes.

Dead and Live Loads

Superimposed Dead Loads	
Description	Loads
Roof	
Insulation	3 PSF
Structural Framing	15 PSF
Ceiling	2 PSF
MEP	15 PSF
Miscellaneous	15 PSF
Total	50 PSF
Floor	
Structural Framing	66 PSF
Ceiling	2 PSF
MEP	5 PSF
Miscellaneous	5 PSF
Total	78 PSF
Snow	30 PSF

Table 3: Design Dead Loads

Description	Quantity (SF)
Main Level	78670
Arena Level	39760
Roof	78670

Table 4: Typical Floor Area

Design Live Loads	
Description	Design Loads
Roof	30 PSF
Floor	100 PSF

Table 5: Design Live Loads

Lateral Loads

In this report, wind and seismic loads will be partially analyzed to create a more accurate sense of how the lateral resisting system (moment frames) reacts under these loads. A complete and more detailed analysis will be composed in Tech II and III.

Wind Loads

To accurately portray the transfer of lateral loads in the ground, E-W wind pressures will be applied to the building and an analysis will be performed.

Wind Design Criteria		
Design Wind Speed (V)	90 MPH	ASCE 7-10, Fig. 6-1
Directional Factor (Kd)	0.85	ASCE 7-10, Table 6-4
Importance Factor (I)	1.10	ASCE 7-10, Table 6-1
Exposure Category	C	ASCE 7-10, 6.5.6.2 and 6.5.6.3
Topography Factor (Kzt)	1.00	ASCE 7-10
Internal Pressure (GCpi)	0.18	ASCE 7-10

Table 6: Wind Design Values

External Pressure Coeff. (Cp)		
Description	N/S Wind	E/W Wind
L/B	0.531	1.88
Windward Wall	0.80	0.8
Leeward Wall	-0.50	-0.324
h/L	0.169	0.089
Roof Windward	-0.3	-0.3
Roof Leeward	-0.18	-0.18

Table 7: External Pressure Coefficient

Velocity Pressure Coefficient and Velocity Pressure			
Level	Elevation	Kz	Qz
Arena	0'-0"	0.85	16.5
Main	15'-0"	0.85	16.5
Roof	34'-91/2"	1.04	20.2

Table 8: Velocity Pressure Coefficient and Velocity Pressure

Seismic Loads

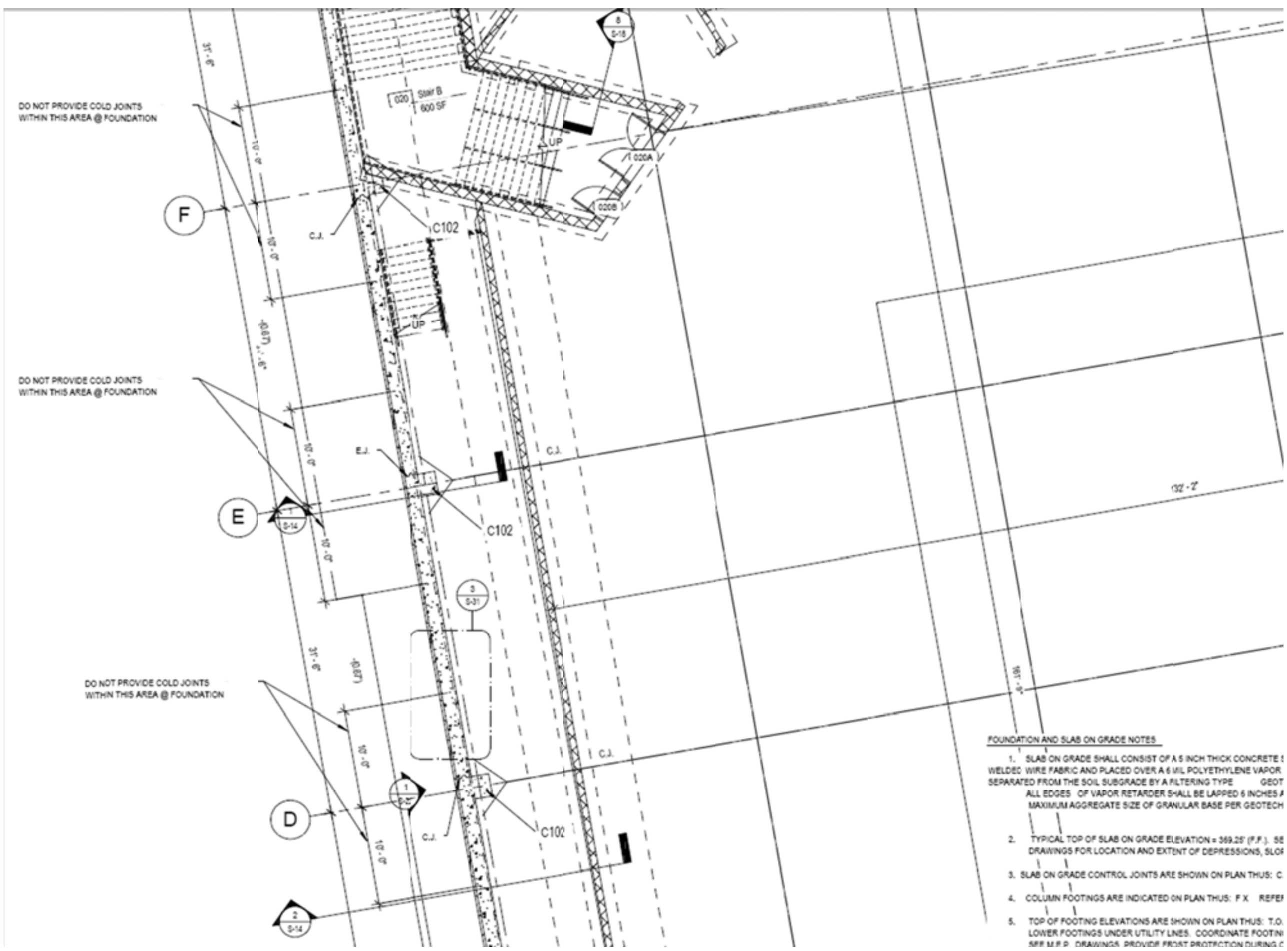
A seismic ground motion was calculated in this report per ASCE 7-10 and the force equaled 901 k. The design values that were calculated are located in the table.

Seismic values	
Ss	0.20g
S1	0.053g
Sms	0.24
Sm1	0.0901
SDS	0.16
SD1	0.06
Ie	1.25
R	3
CT	0.016
x	0.9
T	0.39
Cs	0.066
k	1.00
w	13647 k
V	901 k

Table 9: Seismic Design Values

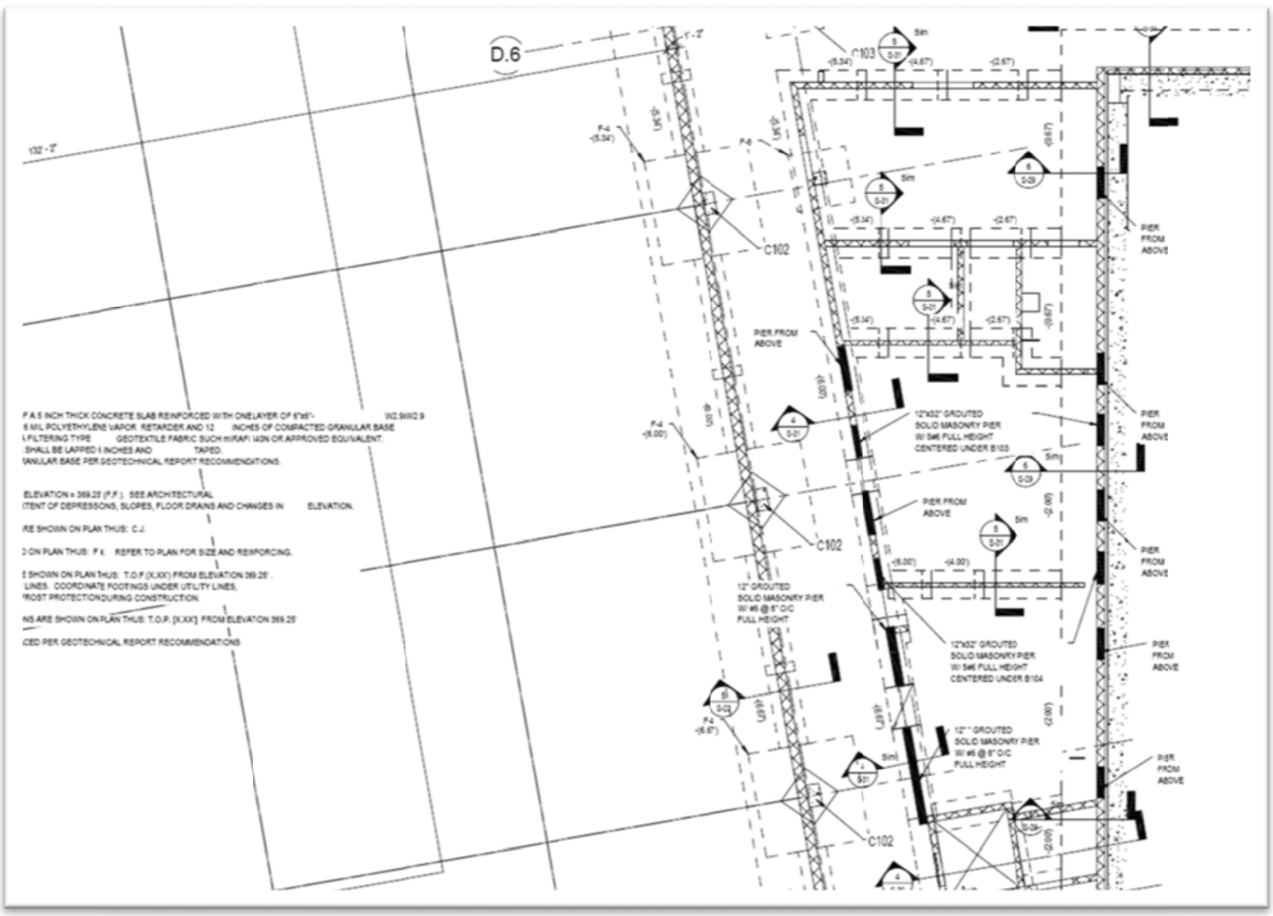
Column C102 Exterior

A gravity spot check was calculated for Column C102 which is located on the exterior wall of the new arena expansion. After the analysis it was determined that the column was over-designed. The assumption was made on the basis of the more than adequate strength to take the maximum axial load. It is determined that other elements affected the over-designing such as lateral loads. The figure below shows the column in its relative position in the building.



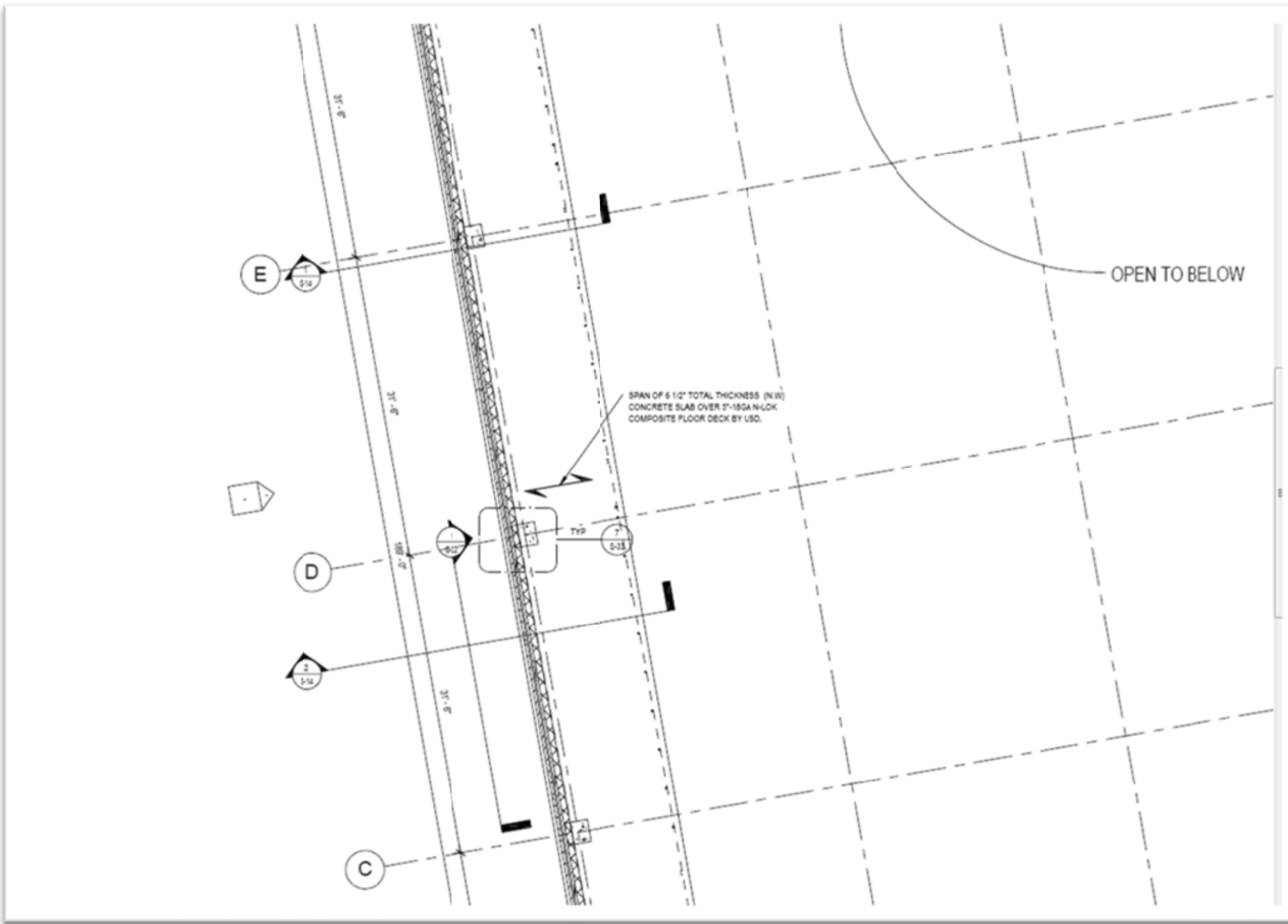
Column C102 Interior

A gravity sot check was calculated for column C102 interior which is located on the east side of the new expansion arena. After the analysis it was determined that the column was also over-designed. The assumption was made on the basis of the more than adequate strength to take the maximum axial load. It is determined that other elements affected the over-designing such as lateral loads. The figure below shows the column in its relative position in the building.



Composite Deck Spot Check

A gravity load spot check was calculated on a composite deck which is located on the main level in the new expansion arena. After analysis the deck is adequately designed for the loads on it. Below is the location of the deck relative to the building.

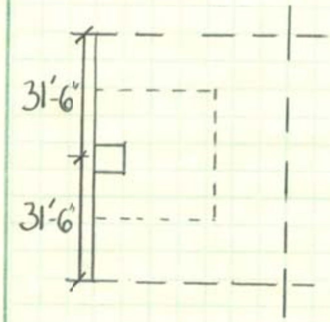


Appendix

Appendix A: Gravity Load Calculations

column spot check | AE Senior Thesis | Timothy Bailiff

Column E, S-3



Tributary Area = 14.5' x 31.5' = 457 ft²

457 ft² ≥ 400 ft², Reduce LL

$LL = \max \begin{cases} 100 \\ 100(.25 + 15/\sqrt{4(457)}) \end{cases} = 60.1 \text{ PSF}$

Total Floor DL:

Structural Framing	66 PSF
Ceiling	2 PSF
MEP	5 PSF
Misc.	5 PSF
	78 PSF

Total Roof DL:

Insulation	3 PSF
Structural Framing	15 PSF
Ceiling	2 PSF
MEP	15 PSF
Misc.	15 PSF
	50 PSF

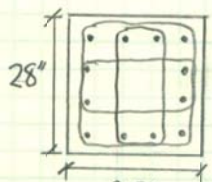
$P_L = (60.1 + 30)(457) = 41.2K$

$P_D = (78 + 50)(457) = 58.5K$

$P_u = 1.2(58.5) + 1.6(41.2) = 136K$

column spot check | AE Senior Thesis | Timothy Bailiff

actual design:



(12) #9 vertical bars $F_y = 60\,ksi$

#4 ties @ 12" o.c. min cover = 1½"

$f'_c = 4000\,psi$

$A_{st} = 12\,in^2$

$\phi P_{n,max} = 0.80\phi[0.85f'_c(A_g - A_{st}) + f_y A_{st}]$ (eq. 10-2 ACI 318-08)

$\phi P_{n,max} = 0.80(0.65)[0.85(4)(28" \times 28" - 12) + 60(12)]$

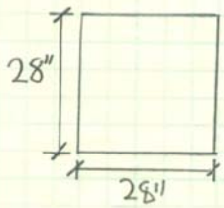
$\phi P_{n,max} = 1739.3K$

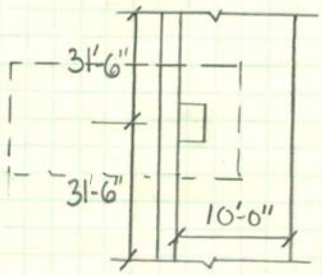
$P_u = 136K < \phi P_n = 1739.3K$ ✓ OK

* Columns are designed to support lateral loads.

Timothy Bailiff | AE Senior Thesis | Interior Column Spot check

Column C102





Tributary Area:

$= (31.5)(19.5') = 614\ ft^2$

$614\ ft^2 \geq 400\ ft^2$, Reduce LL

$LL = \max \begin{vmatrix} 100 \\ 100(.25 + 15/\sqrt{4(614)}) = 55.3\ PSF \end{vmatrix}$

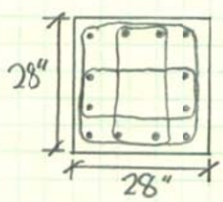
Total Floor DL = 78 PSF

Total Roof DL = 50 PSF

$P_L = (55.3 + 30)(614) = 52.4K$

$P_D = (78 + 50)(614) = 78.6K$

$P_u = 1.2(78.6) + 1.6(41.2) = 160.2K$



(12)-#9 vertical bars $F_y = 60ksi$

#4 @ 12" O.C.

$f'_c = 4000psi$

$A_{ST} = 12 in^2$

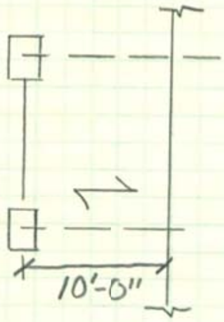
$\phi P_{n,max} = 0.80\phi[0.85f'c(A_g - A_{st}) + f_y A_{st}]$

$\phi P_{n,max} = 0.80(0.65)[0.85(4)(28'' \times 28'' - 12) + 60(12)]$

$\phi P_{n,max} = 1739.3K$

$\boxed{P_u = 160.2K < \phi P_n = 1739.3K}$ ok✓

Timothy Bailiff | AE Senior thesis | Composite Deck check



3"-18GA Composite Floor Deck
6-1/2" Total thickness
f'c = 4000 psi
3 span condition
Loads:
LL = 100 psf, DL = 69 + 12 = 81 psf (69 = slab/deck weight)
Total = 181 psf

Vulcraft Decking Catalog

2VLI18: check unshored length
10'-11" > 10' span   ok for unshored length
Check Superimposed LL
10'-0" clear span
222 PSF > 181 psf ∴ ok for Loading
Reinforcing: 6x6-W2.1xW2.1
*This slab is adequatly designed for the loads above.

2VLI18 deck OK ✓

Appendix B: Wind Load Calculations

Wind Analysis | AE Senior Thesis | Timothy Bailiff

Location: Bel Air, MD

Basic Wind Speed - 90 MPH (Fig 6-1)

Wind Load Importance Factor (I) - 1.10

Wind Exposure Category "C" (6.5.6.2 and 6.5.6.3)

<u>Velocity Pressure</u>:

$q_z = 0.00256 K_z K_{zt} K_d V^2 I$

Level	Height Above Grade	K_z
Arena	0'-0"	0.85
Main	15'-0"	0.85
Roof	34'-9 1/2"	1.04

K_{zt} = 1.0 for homogeneous topography

K_d = 0.85, Building main wind Force Resisting System Components and Cladding (Table 6-4)

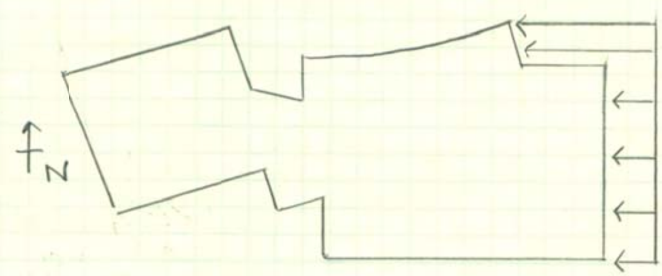
V = 90 MPH (Fig 6-1a)

I = 1.10 (Table 6-1)

$q_{z\,Arena} = 0.00256(0.85)(1.0)(0.85)(90)^2(1.10) = 16.5$ PSF

$q_{z\,Main} = q_{z\,Arena}$ because h = 15 ft.

$q_h = 0.00256(1.04)(1.0)(.85)(90)^2(1.10) = 20.2$ PSF



Wind Analysis | AE Senior Thesis | Timothy Bailiff

Internal Pressure Coefficient: C_p

East/West

Windward: $C_p = 0.8$

Leeward: $L/B = 388'/206' = 1.88$

$C_p = -0.324$

North/South

Windward: $C_p = 0.8$

Leeward: $L/B = 206'/388' = 0.531$

$C_p = -0.5$

Wind Pressure:

$p = qGC_p - q_i(GC_{pi})$

$G = 0.85$, (6.5.8.1)

$(GC_{pi}) = +0.18$ and -0.18 for enclosed buildings

E/W

$p_z = (16.5)(.85)(0.8) - (20.2)(-.18) = 14.86$ PSF

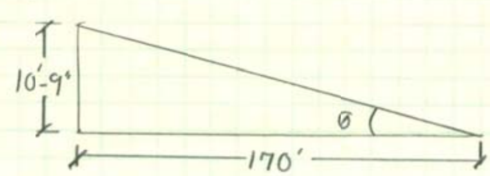
$p_h = (20.2)(.85)(-.324) - (20.2)(.18) = -9.2$ PSF

N/S

$p_z = (16.5)(.85)(.8) - (20.2)(-.18) = 14.86$ PSF

$p_h = (20.2)(.85)(-.5) - (20.2)(.18) = -12.22$ PSF

Roof:



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E/W

Normal to ridge for Ø<10

$h/L = 34.79/388 = 0.089 \leq 0.5$, Horiz. distance from windward edge $>2h$

Windward: $C_p = -0.3$

Leeward: $C_p = -0.18$

$p_z = (20.2)(.85)(-.3) - (20.2)(-.18) = -1.52$ PSF

$p_h = (20.2)(.85)(-0.18) - (20.2)(.18) = -6.73$ PSF

N/S

$h/L = 34.75/206' = 0.169 \leq 0.5$

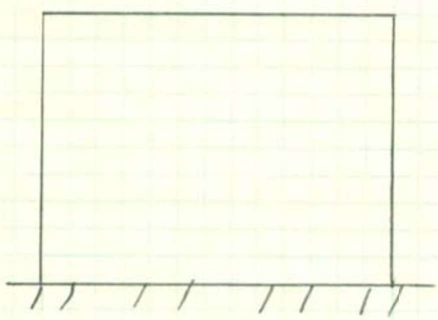
Horiz. distance from windward edge $>2h$

Windward: $C_p = -0.3$

Leeward: $C_p = -0.18$

p_z and p_h same as E/W direction perviously calculated

Force



Appendix C: Seismic Load Calculations

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Seismic Site Class "C"

$I = 1.25$

Occupancy Category III

$S_s (0.2\,sec) = 0.20$, $S_{ds} = 0.16$

$S_1 (1.0\,sec) = 0.053$, $S_{d1} = 0.060$

Seismic Design Category = A

$S_{MS} = F_a S_s$ (11.4.3)

$F_a = 1.2$, with $S_s \leq 0.25$ and Site Class "C"

$S_{MS} = (1.2)(0.20) = 0.24$

$S_{M1} = F_v S_1$

$F_v = 1.7$, with $S_1 \leq 0.1$ and Site Class "C"

$S_{M1} = (1.7)(.053) = .0901$

$S_{DS} = 2/3 S_{MS}$
$S_{D1} = 2/3 S_{M1}$ } (11.4.4)

$S_{DS} = 0.16$

$S_{D1} = 0.060$

$I = 1.25$ for Occupancy Category III (Table 11.5-1)

$S_{DS} = 0.16$ and OC III ⇒ SDC = "A" (Table 11.6-1)

$V = C_s W$ (Eq. 12.8-1)

$R = 3$, for ordinary concrete moment frames

$T = C_T h_n^x$ (Eq. 12.8-7)

$C_T = 0.016$, $x = 0.9$ for moment-resisting concrete frames that carries 100% of the lateral load

$h_n = 34.79'$

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$T = (0.016)(34.79)^{0.9} = 0.39\ sec$

$T_L = 8\ sec$, from (Fig. 22-15)

$C_S = \frac{S_{DS}}{(R/I)} = \frac{0.16}{(3/1.25)} = 0.066$

$T = 0.39\ sec \leq T_L = 8\ sec$

C_S should be $< \frac{S_{D1}}{(R/I)T} = \frac{0.06}{(3/1.25)(0.39)} = 0.064$ N.G.

$C_S = 0.066 > 0.01 \Rightarrow$ OK ✓

Total Dead Load W:

ASCE 7-05 states W as DL + 20% roof snow load for $P_g \geq 30$ PSF

Roof DL

Structural Framing	15 PSF
Ceiling	2 PSF
MEP	15 PSF
Misc.	15 PSF
Insulation	3 PSF
	50 PSF

Floor DL

Structural Framing	66 PSF
Ceiling	2 PSF
MEP	5 PSF
Misc.	5 PSF
	78 PSF

Seismic Analysis | AE Senior Thesis | Timothy Bailiff

Floor	Floor Area
Arena Level	39760
Main Level	78670
Roof	78670

$W_{rf} = (50)(78670) + 0.2(78670)(30) = 4410\text{ K}$

$W_{AL} = (78)(78670) = 6136\text{K}$

$W_{ML} = (78)(39760) = 3101\text{ K}$

$W_T = 13647\text{ K}$

$V = C_s W = (.066)(13647) = 901\text{ K}$

Vertical Distrubtion of seismic Forces

$F_x = C_{vx} V,\ C_{vx} = \frac{w_x h_x^k}{\Sigma w_i h^k} \quad K = 1.0,\ T \leq 0.5\text{ sec}$

$C_{RL} = \frac{4410(34.7916)^{1.0}}{(3101)(15)^{1.0} + (4410)(34.7916)^{1.0}} = 0.767$

$C_{ML} = \frac{3101(15)^{1.0}}{(3101)(15)^{1.0} + (4410)(34.7916)^{1.0}} = 0.233$

$\Sigma = 1.0$ ✓

$F_{RL} = (901)(0.767) = 691\text{K}$

$F_{ML} = (901)(0.233) = 210\text{K}$

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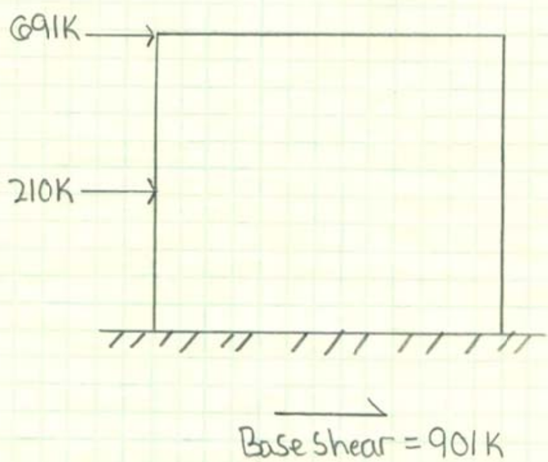
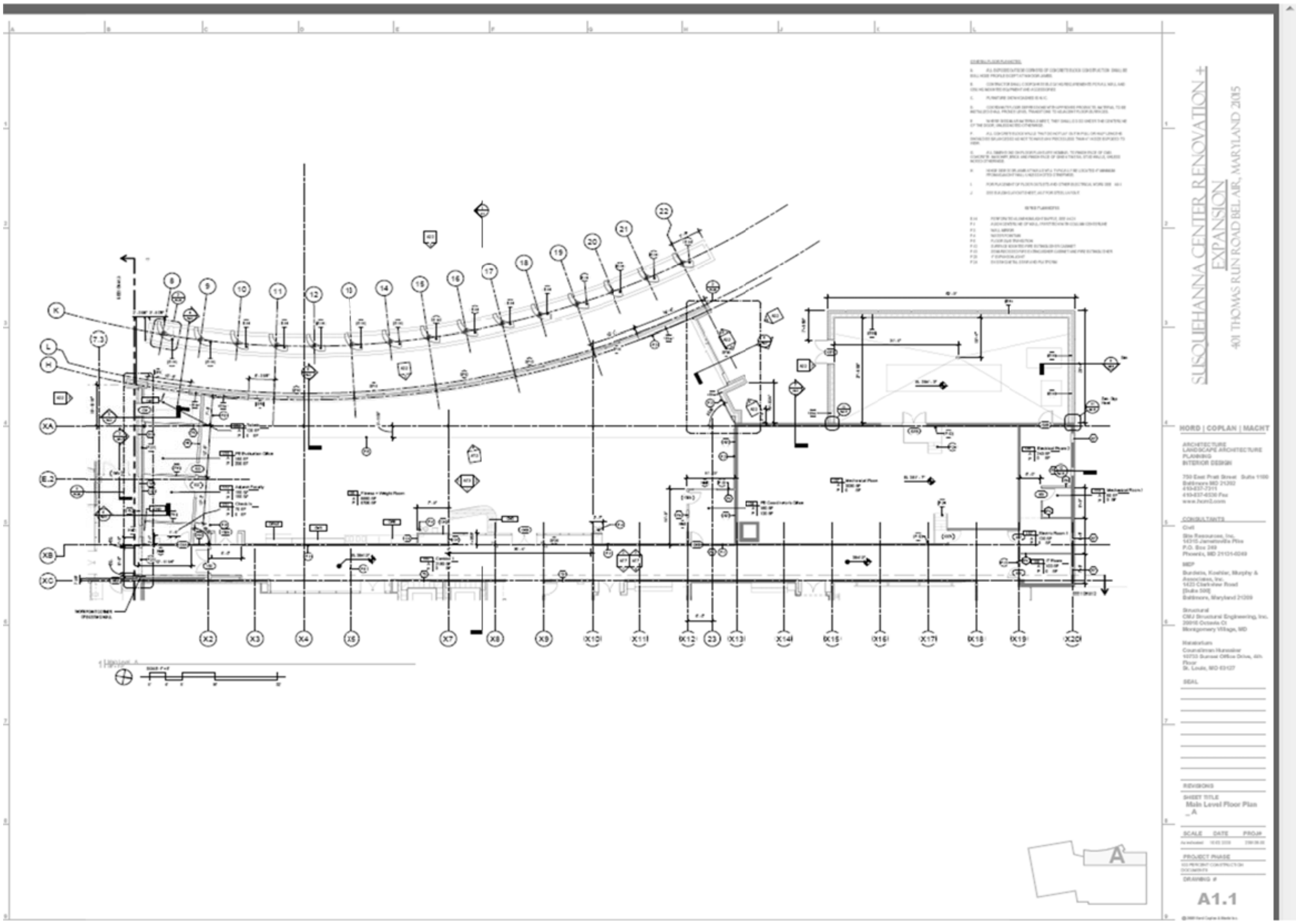
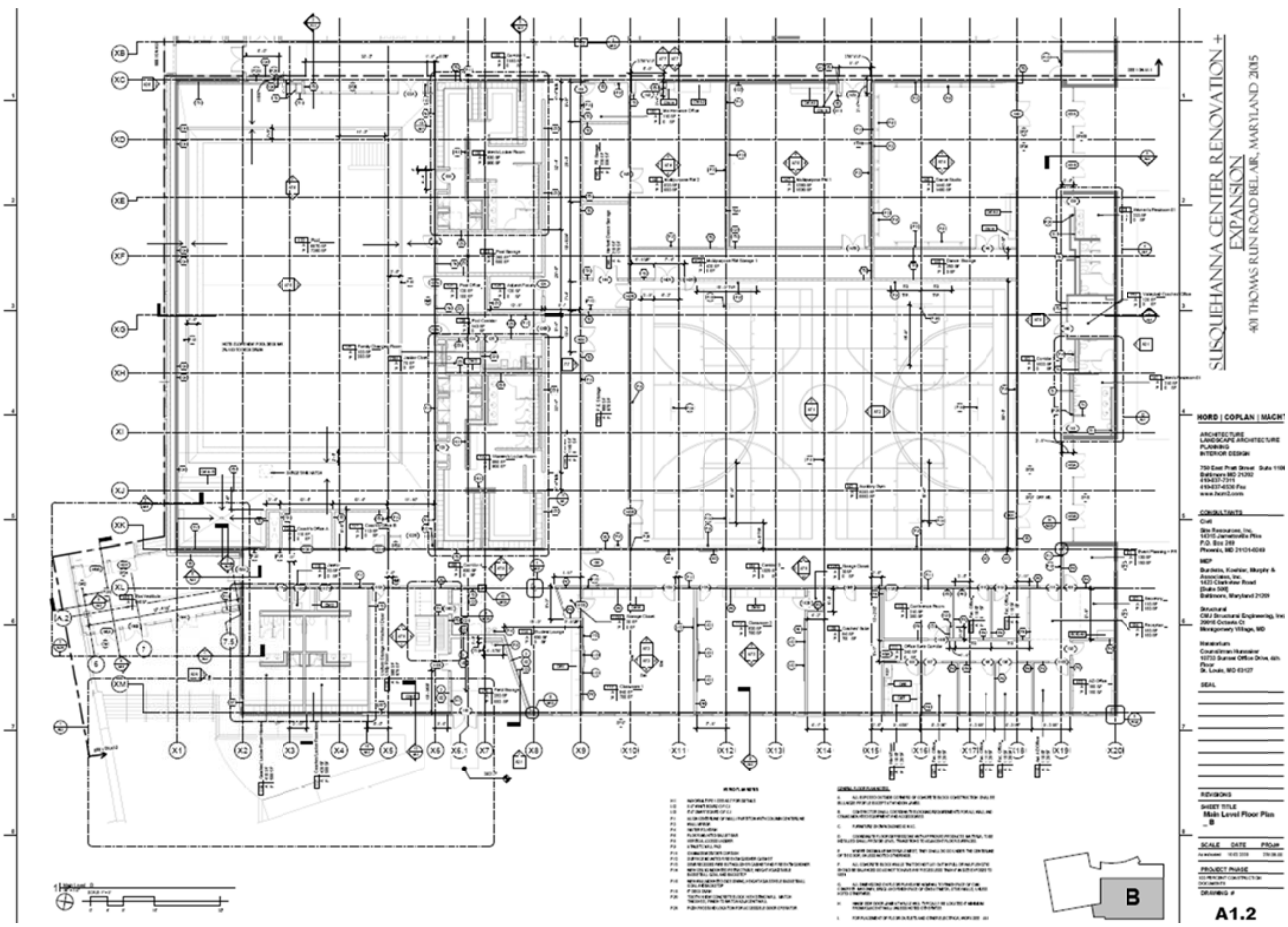
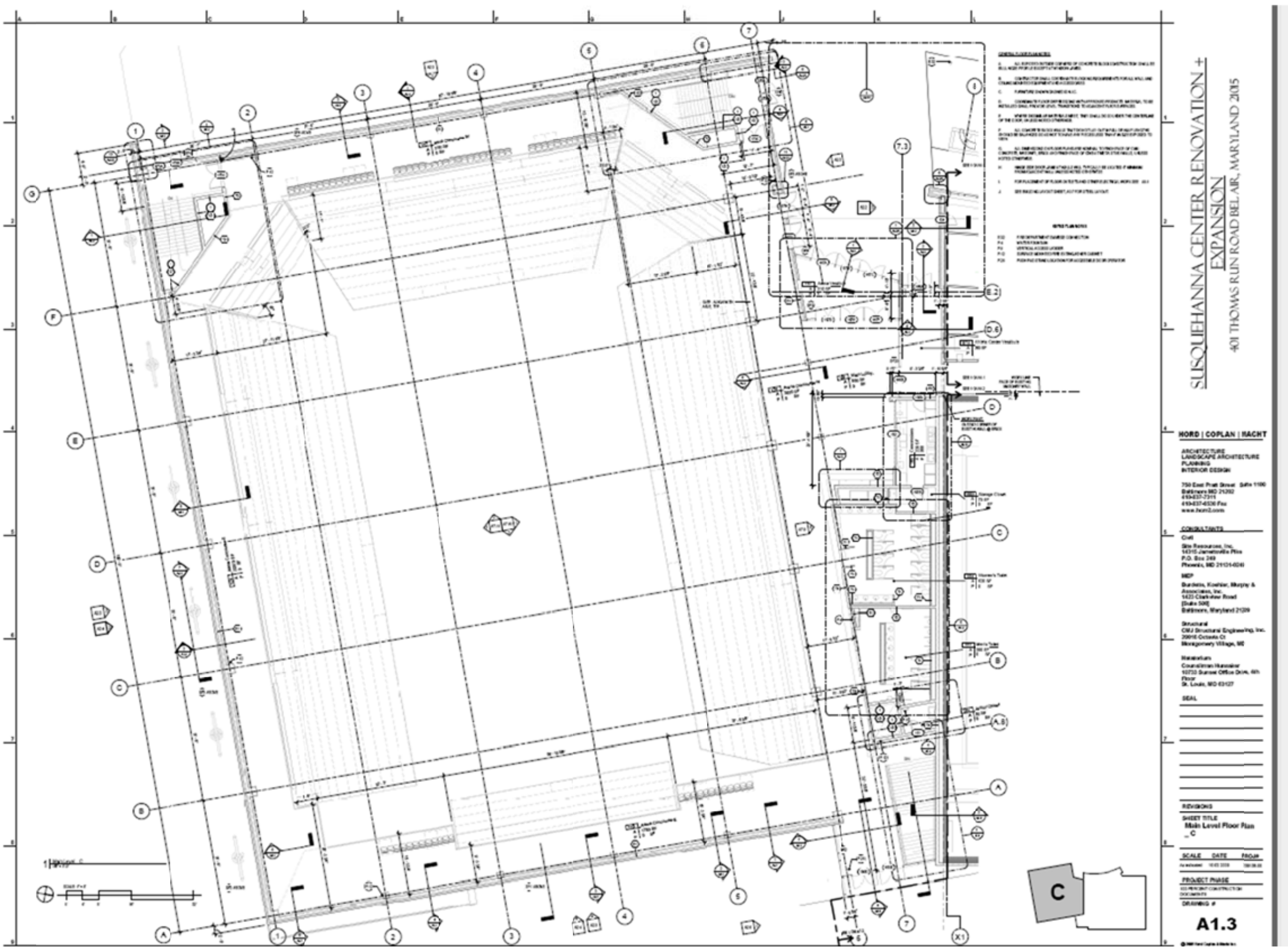
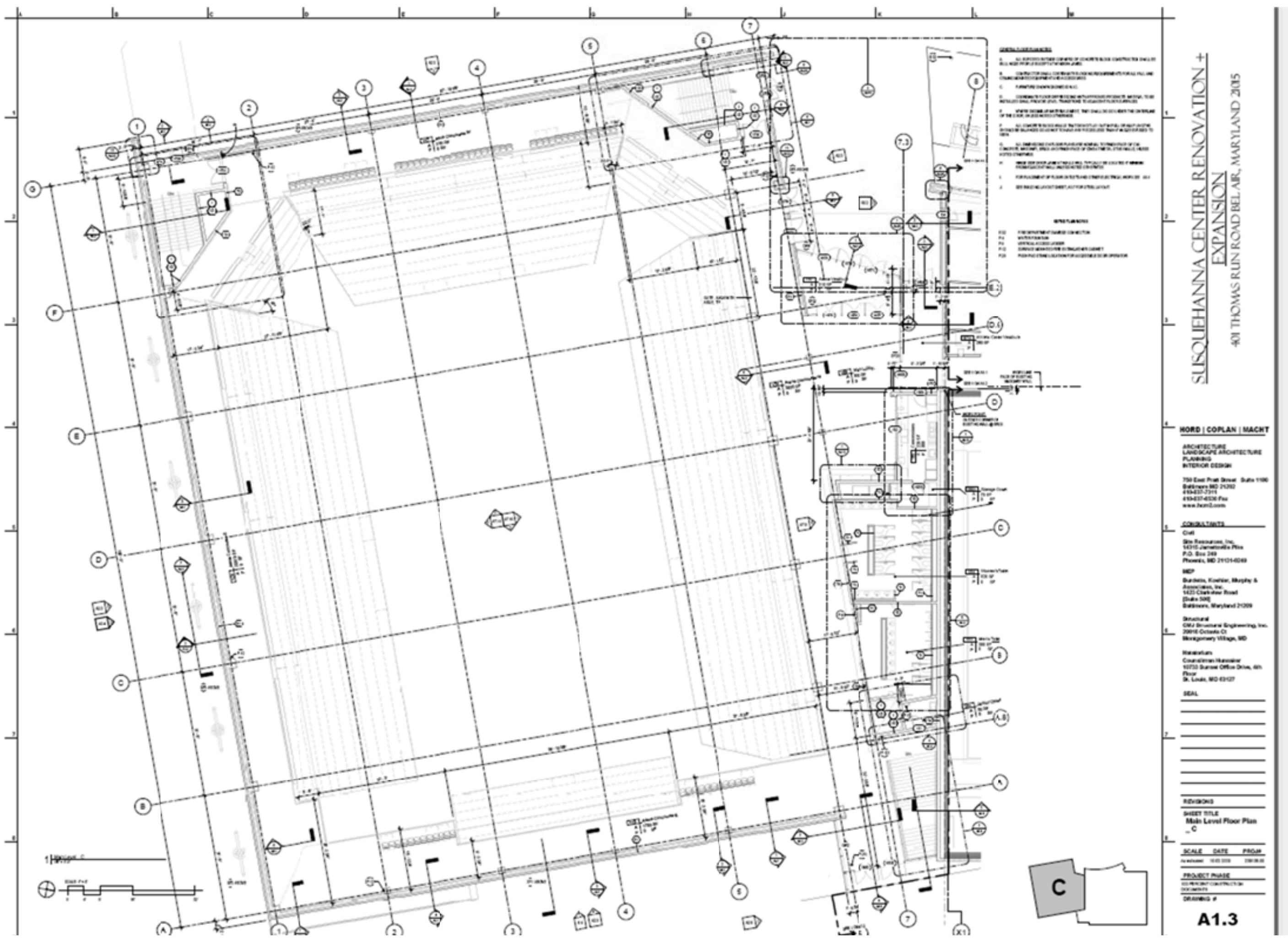


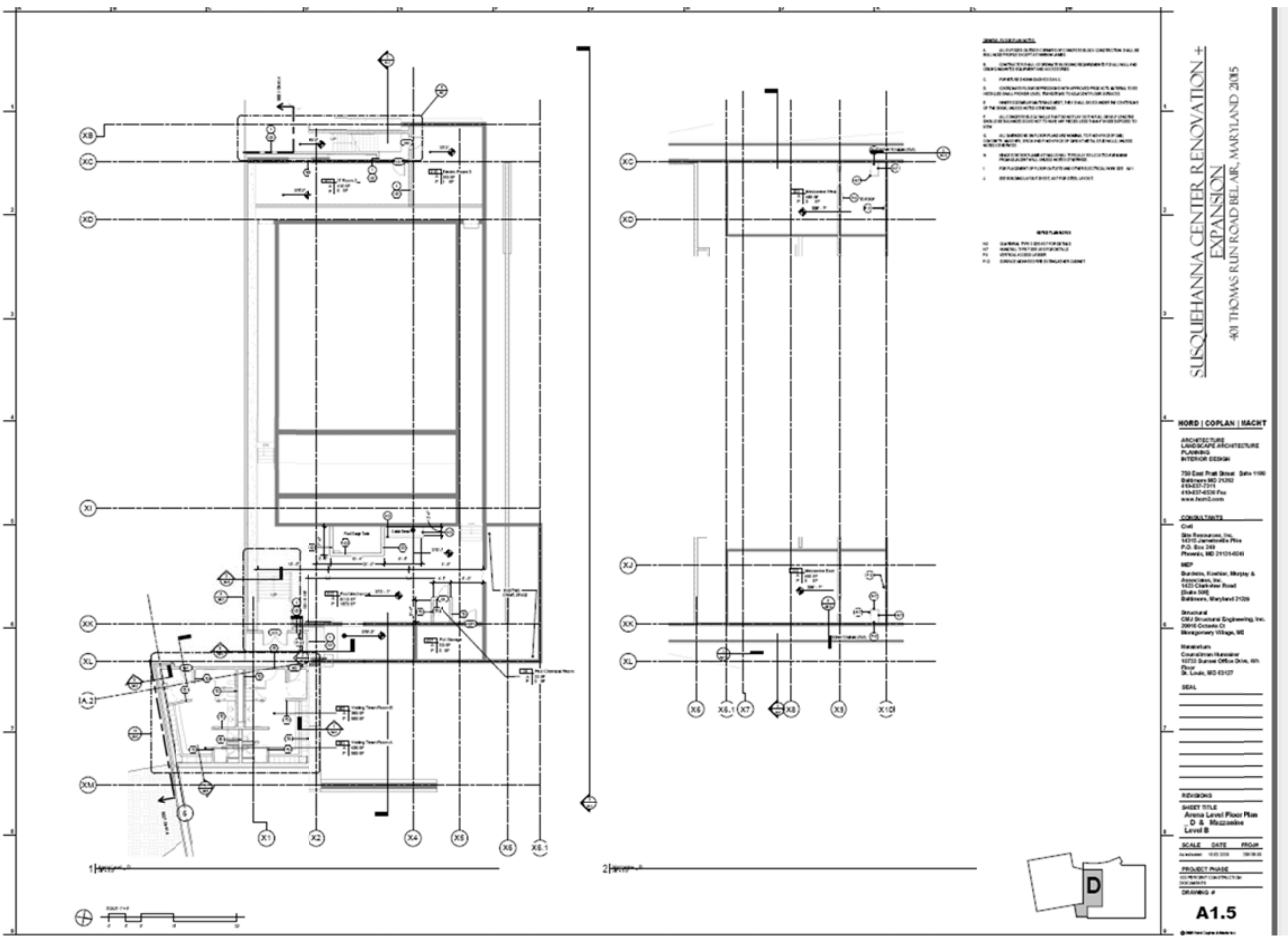
Appendix D: Typical Floor Plans




SUSQUEHANNA CENTER RENOVATION + EXPANSION
401 THOMAS RUN ROAD BEL AIR, MARYLAND 2015
HORD | COPLAN | MACHT
B
A1.2


SUSQUEHANNA CENTER RENOVATION + EXPANSION
401 THOMAS RUN ROAD BEL AIR, MARYLAND 2015
HORD | COPLAN | MACHT
Main Level Floor Plan
A1.3


SUSQUEHANNA CENTER RENOVATION + EXPANSION
401 THOMAS RUN ROAD BEL AIR, MARYLAND 2015
HORD | COPLAN | MACHT
Main Level Floor Plan
A1.3
C


SUSQUEHANNA CENTER RENOVATION +
EXPANSION
401 THOMAS RUN ROAD BEL AIR, MARYLAND 21015
HORD | COPLAN | MACHT
Arena Level Floor Plan
D & Mezzanine
Level B
D
A1.5