THE ODYSSEY
ARLINGTON, VA

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Structural Technical Report I

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Structural Concepts / Structural Existing Conditions Report

Introduction:

The Odyssey is a 475,650 SF luxury residential complex located in Arlington, Virginia. It features 2- 3 story townhouses adjacent to 3 levels of underground parking and towers clad with glass curtain walls and brick. There are 16 stories of apartments with suites located on the top floors and retail space on the ground floors.

The first technical report introduces the existing structural conditions of the Odyssey through detailed descriptions of the foundation, floor, column, and lateral systems. Preliminary analysis of design loads and lateral forces are spot checked on a typical column and shear wall for discrepancies in design criteria. The preliminary analysis provides better understanding into loading and code assumptions made in analysis through ASCE7-02 provisions. Structural advantages in post-tensioned slab design were observed in a comparison to a conventional 2-way system and will be addressed in further analysis of the floor system. Analysis calculations and observations can be found in Appendices A - G as well as descriptive figures of preliminary design component and typical floor plan.

Structural Systems:

Foundation

The primary foundation structures of the Odyssey are concrete footings of various sizes, depths, and reinforcement spread throughout the lower garage level footprint. Individual column footings are typical, however mat footings spread over larger areas are found at locations supporting larger gravitational and lateral loads. Mat-1 spans over numerous columns which support shear walls beginning on the 1st floor of the building. A second mat footing supports the lateral load through shear walls (A&B), located around the central elevator shafts at the core of the adjoining towers. The larger mat footings, compared to the typical column footings, distribute the lateral loads into the foundation more effectively over a similar area. Continuous strip footings typically sized at 2’-0” x 1’-4”, support a perimeter bearing wall surrounding the lower garage levels.

Floor Systems

The floor systems found throughout the Odyssey seemingly vary as much as the space usage in the building. Three distinct systems are noted in the following sections on account of size, loading, and use of the space supported:

<u>Basement Garage:</u>

The lower garage level (B3) floor is composed of 4” concrete slab (f’c=5ksi) on grade reinforced with 6x6 – w1.4 x w1.4 wire mesh on 6mil vapor barrier over 6” on compacted gravel with a capacity of 5,500psf.

The remaining lower garage levels through the first floor are primarily 8.5” conventionally reinforced 2-way concrete slab system with bottom reinforcement of #4 bars @ 13” o.c. Additional top and bottom reinforcement is specified as needed throughout the floor #bar sizes varying at given spacing. Drop panels are also included at specified columns and typically extend 4-1/2” below slab, and some up to 6-1/4” or 8” below slab. Also found on these floors are reinforced edge beams around larger spans for loading docks, mechanical spaces/shafts, and retail space located on both the upper garage and 1st floors. Typical bays sizes for the reinforced 2-way slab system are 25’x25’ and 17’x25’.

<u>Tower:</u>

2nd – 15th

The Odyssey tower is mostly an 8” 2-way post tensioned flat concrete slab (f’c=5ksi) with continuous bottom reinforcement of #4 bars @ 24” o.c in each direction. Negative moment reinforcement of the slab at column junctions is typically #4 bars expanding $.33l_n$ in both span directions. Added reinforcement at slab openings in the long direction of specified bays is also typically #4 bars. Floor bays vary in size but 25’x 22’ and 25’x 28’ are typical with a variation on the 14th floor plan that has post tensioned beams integrated into the 2-way slab to support the rooftop swimming pool.

16th & Roof

The roof and upper floor system of the western portion of the Odyssey’s tower is similar to that of the lower floors, however reinforced concrete edge beams and interior post tensioned beams were included to properly support excess loads from mechanical equipment. Both size and reinforcement vary between beams and post tension loading varies depending on span and location in the system. The east tower on the 16th level support the pool terrace and is a 11” 2-way post tensioned flat slab(f’c=5ksi) with #5 bars @ 24” o.c. each way and specified areas with added bottom reinforcement typically #5 and #6 bars. Typical floor bay sizes vary with 25’x 22’ and 25’x 28’ most common throughout these levels.

Townhouses

Townhouses which span the length of the sight on the east are built integrally with the lower garage levels but do not share the same floor system. The system is 8.5" one-way concrete slab conventionally reinforced with #4 bar @ 13" o.c. and built-in reinforced edge beams typically 24"x18" and 26"x16" with #6 and #11 reinforcement. Two floor bay sizes are split between the townhouses with 23'x 30' and 19'x 30' spanning the edge beams. The townhouse roof system is also split over the row with the typical one-way concrete slab or cantilevered 12" metal C-joists @ 24" o.c. with metal a soffit.

Columns:

Structural columns of the Odyssey are primarily a simple concrete structure with varied sizes, shapes, and reinforcement dependent on level and location throughout the building. The columns found in the tower of the Odyssey, levels 1-16, support the floor systems and are typically sized at 18"x 26" with #11 bar reinforcement. Round columns are found at the corners of the tower with primarily architectural design influences to not detract from symmetric corner windows with conventional rectangular columns integrated into apartment walls.

The columns located in the lower garage through 1st levels, and partially on 2nd and 3rd levels, serve a dual purpose in the structural design of the Odyssey. Rotated columns are oriented differently at floor slabs, typically rotating 90° from underside to the top side of the floor slab. These columns support the floor systems and are an architectural design to better fit apartment spaces.

Sloping columns are oriented differently from face to face of the slab on the same level. The purpose of these sloping columns is to effectively transmit lateral loads from shear walls and the building edge into the foundation. A further look into the integrated functioning of sloping column and foundation in regard to lateral distribution and moment may provide better analysis of the structures behavior. Both types of columns vary in size with a range in sizes from 18"x 26" to 26" x 42" with #11 bar reinforcement.

Column concrete strength varies from level to level:

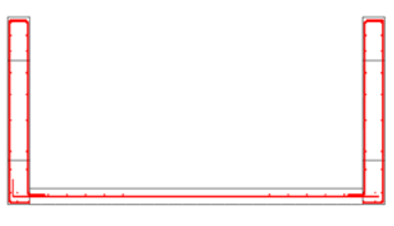
Levels B3-B1	: f'c = 6000psi
Levels 1-4	: f'c = 8000psi
Levels 5	: f'c = 6000psi
Levels 6-16	: f'c = 5000psi

Lateral Bracing:

The primary lateral resisting system of the Odyssey are groupings of shear walls placed throughout the floor plan. Locations on the exterior wings provide single lateral direction bracing while those at the core provide both primary directions. The building shape suggests that a detailed analysis would determine the control loading direction to be askew to primary directions and that the shear walls described below collectively distribute this case.

Shear wall A:

Resists both lateral load directions: North-South & East-West.
Location: Surrounds 2 central-north elevator shafts
Range: B3 - 4th level
Size: North-South walls - 1'-2" x 10'
Integrated into columns - 14"x 28"
Column Reinforcement – 6 #9 bars
East-West wall – 10"x20'-2"
Wall Reinforcement: #5 & #6 bars @ 12"

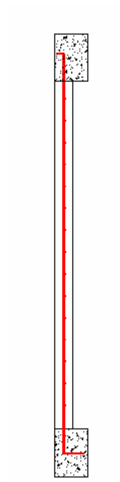


Shear wall B:

Resists both lateral load directions: North-South & East-West.
Location: Surrounds 2 central-south elevator shafts
Range: B3 - 4th level level
Size: North-South walls - 1'-2" x 10'
Integrated into columns - 14"x 28"
Column Reinforcement – 6 #9 bars
East-West wall – 10"x19'-4"
Wall Reinforcement: #5 & #6 bars @ 12"

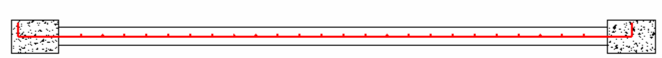
Shear wall C , C1:

Resists lateral load directions: North-South
Location: Surrounding West stair tower.
Range: 2nd - 16th level
C1 terminates at 10th level
Size: North-South walls - 10"x 13'-10.5"
Ends attached to columns – 18"x 26" and 24"x 24"
Column Reinforcement – (varies) #11 bars
Wall Reinforcement: #5 & #6 bars @ 12"



Shear wall E:

Resists lateral load directions: North West-South East
Location: Column line X4 - North side of East tower
Range: 2nd - 14th level
Size: North-South walls - 10"x 29'-5"
Ends attached to columns – 18"x 26"
Column Reinforcement – (varies) #11 bars
Wall Reinforcement: #5 & #6 bars @ 12"



Codes and Requirements:

The Odyssey is designed under:

The 1996 BOCA National Building Code
The 1996 Virginia Uniform Statewide Building Code with 2000 Amendments

Concrete construction in accordance with:

American Concrete Institute 318 – "Reinforced Concrete Design"
American Concrete Institute 301 – "Specification for Structural Concrete"
Building Officials and Code Administrators (BOCA) – Latest Edition

Steel construction in accordance with:

Building Officials and Code Administrators (BOCA)
American Institute of Steel Construction Manual – Allowable stress design (ASD)

Masonry construction in accordance with:

Building Officials and Code Administrators (BOCA)
"Building Code Requirements for Masonry Structures and Specifications for Masonry Structures" – ACI-530 / ACI-530.1

Material strength and details in accordance with:

ASTM Standards – Properties of Building Materials

Gravity and Lateral Loads:

The gravity and lateral loads for structural analysis were determined in accordance with ASCE7-02. General assumptions for several dead loads were made with interpretation of details and averages. Load factors and adjustments are used when appropriate according to provisions of ASCE7-02 in analyzing structural components and systems. Several gravity loads are listed below:

Gravity: (psf)

Floor Live:	
Residential Units & Corridors	40
Public Areas	100
Mech. Room	150
Pool Terrace	100
Parking Garage	50
Stairs and Exits	100
Roof Live:	
Min. Roof Live Load	30
Roof Snow:	
Roof Snow Load	21
Floor Dead:	
Concrete Slab	100 –150 (varied thickness 8"-12")
Partitions	8
Flooring	4
Ceiling	5
Mechanical	10
Beams/Columns	(*varies)

Lateral:

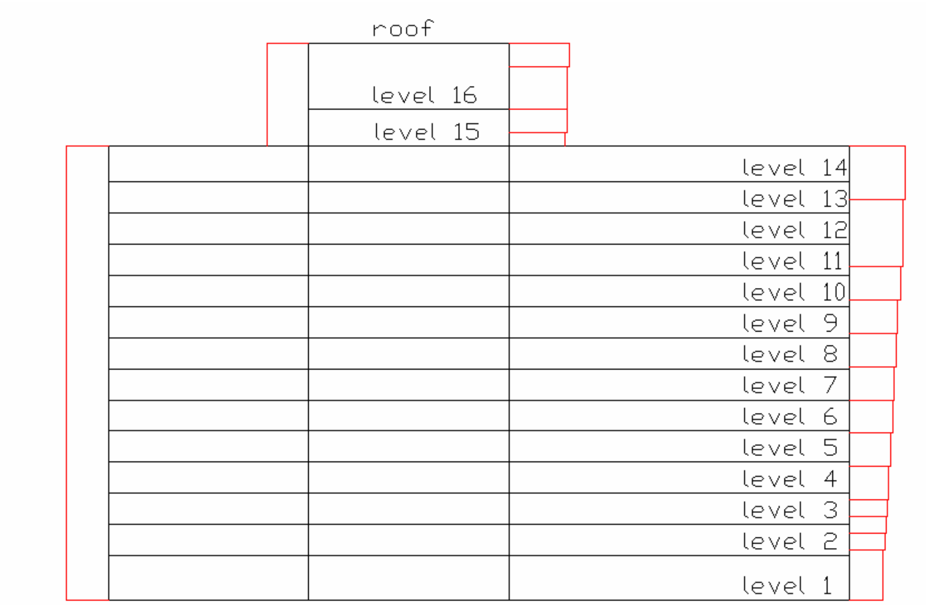
A summary of lateral loads calculated in accordance with ASCE7-02 design provisions are displayed in the following sections. Refer to Appendix – for a further detailed procedure of calculation and listed analysis including generalized assumptions.

Wind: ASCE7-02 Section 9

Wind Pressure Envelope

	Windward		Leeward		Total MWFRS	
Z(ft)	N-S	E-W	N-S	E-W	N-S	E-W
0-15	8.05	8.0495	-8.84434	-8.81247	16.89	16.86
20	8.43	8.4283	-8.84434	-8.81247	17.27	17.24
25	8.81	8.8071	-8.84434	-8.81247	17.65	17.62
30	9.09	9.0912	-8.84434	-8.81247	17.94	17.90
40	9.38	9.3753	-8.84434	-8.81247	18.22	18.19
50	9.85	9.8488	-8.84434	-8.81247	18.69	18.66
60	10.32	10.3222	-8.84434	-8.81247	19.17	19.13
70	10.70	10.7010	-8.84434	-8.81247	19.55	19.51
80	11.08	11.0798	-8.84434	-8.81247	19.92	19.89
90	11.36	11.3639	-8.84434	-8.81247	20.21	20.18
100	12.12	12.1215	-8.84434	-8.81247	20.97	20.93
120	12.78	12.7844	-8.84434	-8.81247	21.63	21.60
140	13.35	13.3526	-8.84434	-8.81247	22.20	22.17
160	13.92	13.9208	-8.84434	-8.81247	22.77	22.73
180	14.39	14.3943	-8.84434	-8.81247	23.24	23.21

N-S Distribution

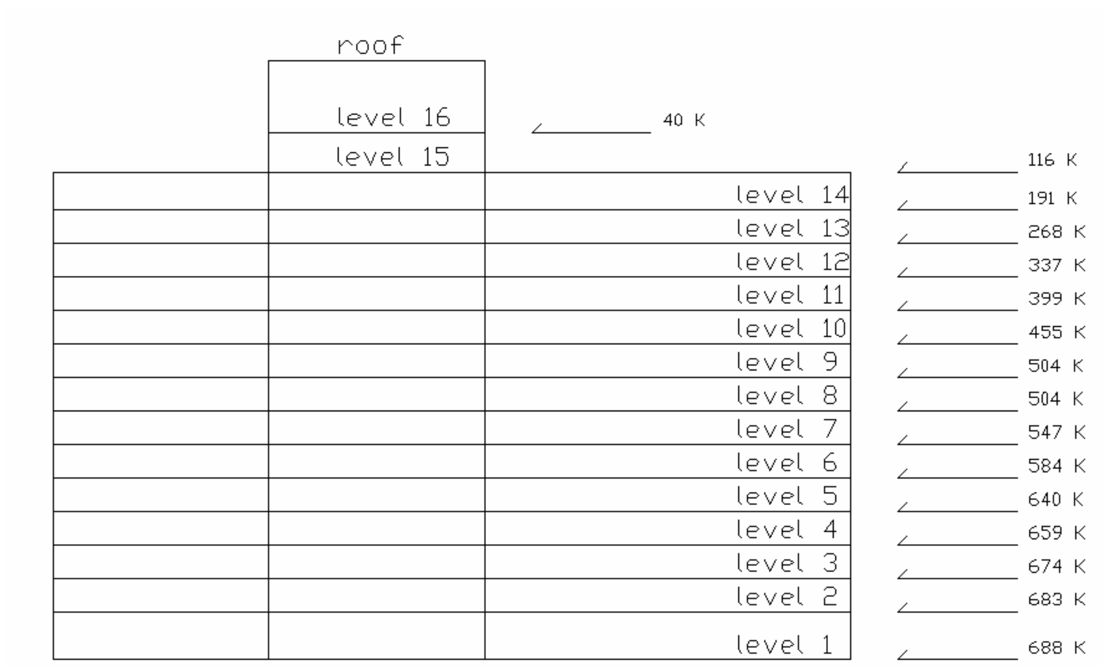


Seismic: ASCE7-02
Section 6

Vertical Distribution of Seismic

Level, x	w_x (kips)	h_x (ft)	$w_x h_x^k$	C_{vx}	F_x (kips)	V_x (kips)	M_x (ft-kips)
Roof	1533	167	769,202	0.058	40		6,665
16	3428	147.1	1,474,522	0.111	77	40	11,254
15	3681	136.1	1,440,838	0.109	75	116	10,175
14	4181	125.3	1,480,246	0.112	77	191	9,623
13	4118	116	1,327,438	0.100	69	268	7,989
12	4118	106.63	1,198,316	0.090	62	337	6,630
11	4118	97.3	1,072,148	0.081	56	399	5,413
10	4118	88	948,952	0.072	49	455	4,333
9	4118	78.64	827,760	0.062	43	504	3,377
8	4118	69.31	710,010	0.054	37	547	2,553
7	4118	60	595,870	0.045	31	584	1,855
6	4118	50.65	485,022	0.037	25	615	1,275
5	4118	41.32	378,732	0.029	20	640	812
4	4118	32	277,623	0.021	14	659	461
3	4118	22.66	182,532	0.014	9	674	215
2	4118	13.33	95,800	0.007	5	683	66
1						688	
	Σ =		Σ =	Σ =	Σ =		Σ =
	62240		13265012	1.000	688		72696

N-S Distribution



Preliminary Analysis / Spot Check Summary:

Gravity

Post-Tensioned 2-way Concrete Slab:

A preliminary structural analysis of this system was carried out under generalized assumptions to better understand the design effects of a post-tensioned 2 way concrete slab. An averaged interior floor bay was determined to be 25'x 22' with assigned loads of levels with the floor structure. Furthermore, the post-tensioning was removed from the system and will be integrated later for a complete analysis. Distinct advantages were observed and noted by comparing structural set design components to results obtained from the preliminary design. An immediate observation through the analysis was reduction of slab thickness to span. A reduction of slab thickness is integral in residential construction regarding occupancy and building height. By comparison the post-tensioning eliminated additional positive reinforcement by effective force distribution at tendon drape points in mid-span. Also, a discrepancy in minimum reinforcement suggests additional compressive forces provided by tendons increased resistance to flexural temperature and shrinkage effects. Details of findings are noted throughout the preliminary analysis, which is found in Appendix - .

Column:

The structural spot check was carried out with a typical 18"x 26" column on the 14th level. Loads were calculated through the remaining floors to the column including typical floor and roof loads. Appropriate live load reductions were calculated based on the provisions of ASCE7-02. The axial load resolved on the column was 611.7k and was determined as reasonable for design assumptions of building loads. A minimum ratio of reinforcement area in the column is found through axial-bending comparison in the column design table referenced in the calculations. The typical reinforcement design size in columns throughout the building is determined adequate for the spot check requirements.

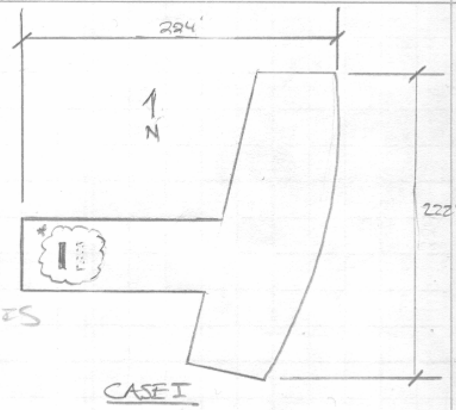
Lateral

Shear Wall:

A shear wall spot check was performed through a distribution of lateral loads over a tributary area. The loading was assumed over symmetry of general directional loading on the building in the North-South loading. Shear wall C was chosen on level 13 for the wind loading effects and structural spot check. Wind loading was analyzed based on a previous notion of a possible critical skew loading distribution from further investigation. An accumulated level line shear of 1klf was analyzed over shear wall C resulting in minimum reinforcement over the wall length with typical shear reinforcement at 12" o.c

Appendix – A WIND ANALYSIS

* NOTE: WIND LOADING CASE I ASSUMED FOR PRELIMINARY ANALYSIS OF SHEARWALLS (C)



BUILDING DESCRIPTION:

LOCATION: ARLINGTON, VA.
MWFRS: N-S : SHEARWALLS
E-W : SHEARWALLS
OCCUPANCY: CATEGORY II

* PRELIMINARY DESIGN ANALYSIS ASSUMPTIONS:
- ASSUME GENERAL SHAPE FOR ANALYSIS
- DISREGARD CURVED FACADE.

BUILDING DESIGN PROPERTIES:

BASIC WIND SPEED: $V = 80$ MPH — 6.5.4

WIND DIRECTIONALITY FACTOR: $K_d = 0.85$ — 6.5.4.4

IMPORTANCE FACTOR: $I = 1.0$ — 6.5.5
* NOTED ON STRUCTURAL SET ; APPLY TO ASCE 7-02 FOR ANALYSIS.

EXPOSURE CATEGORY: B — 6.5.6

TERRAIN EXPOSURE CONSTANTS: — 6.5.6

EXPOSURE	α	z_g (ft)	$\hat{a}$	$\hat{b}$	$\bar{\alpha}$	$\bar{b}$	c	ℓ (ft)	$\bar{\epsilon}$	z_{min} (ft)*
B	7.0	1200	1/7	0.84	1/4.0	0.45	0.30	320	1/3.0	100.2

* z_{MIN} = GREATER OF { 0.6h ; 30' }

VELOCITY PRESSURE EXPOSURE COEFFICIENT:
* COEFFICIENT TABLE UNDER VELOCITY PRESSURE.

TOPOGRAPHIC FACTOR $K_{zt} = 1.0$ — 6.5.7
* ASSUME TOPOGRAPHIC SLOPE INSIGNIFICANT
* ASSUME OBSTRUCTIONS OF SIMILAR HT. @ 2 MILE RADIUS

GUST EFFECT FACTOR — 6.5.8
* ASSUME RIGID STRUCTURE : CONCRETE

g_Q, g_v	3.40
$\bar{z}$	100.20
$I_{\bar{z}}$	0.25
$L_{\bar{z}}$	463.38
Q	0.80
G	0.85

g_Q, g_v - CONSTANTS
$\bar{z}$ - TABLE 6.2
$I_{\bar{z}}$ - EQ 6-5
$L_{\bar{z}}$ - EQ 6-7
Q - EQ 6-6
G_f - EQ 6-4

NOTE: CALCULATED IN SPREADSHEET.

ENCLOSURE CLASSIFICATION: ENCLOSED — 6.5.9

INTERNAL PRESSURE COEFFICIENT: — 6.5.11.1
$GC_{pi} = \pm 0.18$

EXTERNAL PRESSURE COEFFICIENT: — 6.5.11.2
WINDWARD: $C_p = 0.8$
$L/B \rightarrow (0-1) \rightarrow$ N-S LEEWARD : $C_p = -0.5$
$L/B \rightarrow (0-1) \rightarrow$ E-W LEEWARD : $C_p = -0.5$

VELOCITY PRESSURE

6.5.10
EQ 6-15

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

VELOCITY PRESSURE EXPOSURE COEFFICIENT

6.5.6.6

∘ EXPOSURE B CASE II

K_z and q_z		
Z(ft)	K_z	q_z
0-15	0.85	11.8374
20	0.89	12.3945
25	0.93	12.9516
30	0.96	13.3693
40	0.99	13.7871
50	1.04	14.4835
60	1.09	15.1798
70	1.13	15.7368
80	1.17	16.2939
90	1.20	16.7117
100	1.28	17.8258
120	1.35	18.8006
140	1.41	19.6362
160	1.47	20.4718
180	1.52	21.1681
200	1.56	21.7252
167	1.4875	20.7155

DESIGN WIND LOAD

6.5.12.2

$$P_z = q_z(G_f C_p)$$

	Windward		Leeward		Total MWFRS	
Z(ft)	N-S	E-W	N-S	E-W	N-S	E-W
0-15	8.05	8.0495	-8.84434	-8.81247	16.89	16.86
20	8.43	8.4283	-8.84434	-8.81247	17.27	17.24
25	8.81	8.8071	-8.84434	-8.81247	17.65	17.62
30	9.09	9.0912	-8.84434	-8.81247	17.94	17.90
40	9.38	9.3753	-8.84434	-8.81247	18.22	18.19
50	9.85	9.8488	-8.84434	-8.81247	18.69	18.66
60	10.32	10.3222	-8.84434	-8.81247	19.17	19.13
70	10.70	10.7010	-8.84434	-8.81247	19.55	19.51
80	11.08	11.0798	-8.84434	-8.81247	19.92	19.89
90	11.36	11.3639	-8.84434	-8.81247	20.21	20.18
100	12.12	12.1215	-8.84434	-8.81247	20.97	20.93
120	12.78	12.7844	-8.84434	-8.81247	21.63	21.60
140	13.35	13.3526	-8.84434	-8.81247	22.20	22.17
160	13.92	13.9208	-8.84434	-8.81247	22.77	22.73
180	14.39	14.3943	-8.84434	-8.81247	23.24	23.21
200	14.77	14.7731	-8.84434	-8.81247	23.62	23.59
167	14.0866	14.0866	-8.84434	-8.81247	22.93	22.90

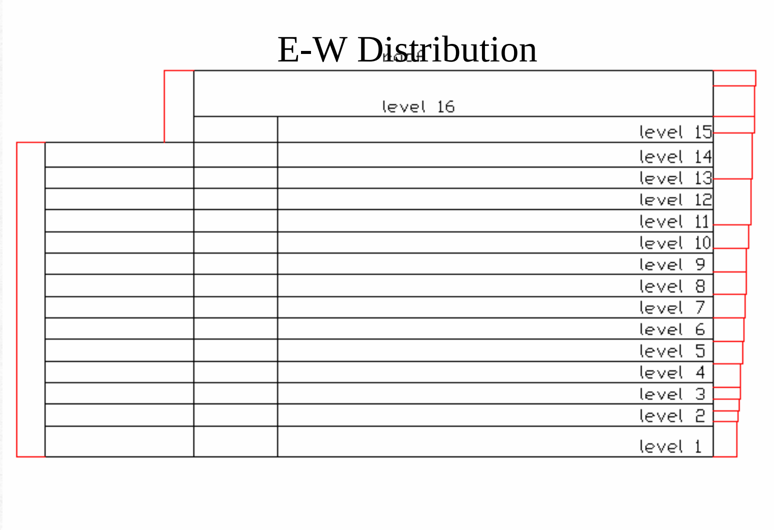
WIND SHEAR ON LEVEL

NOTE: SIMPLIFIED ASSUMPTIONS TAKEN FOR DISTRIBUTION OVER EACH LEVEL.

- LEVEL HEIGHTS TAKEN AS TRIBUTARY HT/LEVEL
- WIND LOAD DISTRIBUTION TAKEN AS AVERAGE OVER LEVEL.

Level	h/floor (ft)	Z (ft)
Roof	4	162.95
16	16	146.95
15	11	135.95
14	10.66	125.29
13	9.33	115.96
12	9.33	106.63
11	9.33	97.30
10	9.33	87.97
9	9.33	78.64
8	9.33	69.31
7	9.33	59.98
6	9.33	27.99
5	9.33	41.32
4	9.33	31.99
3	9.33	22.66
2	9.33	13.33
1	13.33	0.00

	N-S	E-W
Shear @ Roof	0.232	0.232
Shear @16	0.540	0.539
Shear @15	0.780	0.779
Shear @14	0.996	0.995
Shear @13	1.192	1.190
Shear @12	1.388	1.386
Shear @11	1.576	1.574
Shear @10	1.762	1.759
Shear @9	1.948	1.945
Shear @8	2.136	2.133
Shear @7	2.322	2.319
Shear @6	2.501	2.497
Shear @5	2.676	2.671
Shear @4	2.845	2.841
Shear @3	3.007	3.002
Shear @2	3.198	3.193
Shear @1	-	-
Base Shear	29.099	29.055



Appendix – B SEISMIC ANALYSIS

EQUIVALENT LATERAL FORCE PROCEDURE

ASCE7-02
SECTION 9

SEISMIC DESIGN PARAMETERS

LOCATION: ARLINGTON, VA
OF STORIES: N = 16
INTER STORY HT: h_s = (VARIES)* TYP. - 9'-4"
BUILDING HT: h_n = 167' *LEVELS 1-16
SEISMIC USE GROUP: I = I
OCCUPANCY IMPORTANCE FACTOR: 1.00
SITE CLASSIFICATION: A
ACCELERATIONS:
0.2S: S_S = 0.19 g-s
1S: S_1 = 0.06 g-s
SITE CLASS FACTOR: F_a = 0.80
SITE CLASS FACTOR: F_V = 0.80
ADJUSTED ACCELERATIONS:
$S_{MS} = F_a S_S$ → S_{MS} = 0.148 g-s
$S_{M1} = F_V S_1$ → S_{M1} = 0.050 g-s
DESIGN SPECTRAL RESPONSE ACCELERATIONS:
$S_{DS} = (2/3) S_{MS}$ → S_{DS} = 0.099 g-s
$S_{D1} = (2/3) S_{M1}$ → S_{D1} = 0.033 g-s
SEISMIC DESIGN CATEGORY: **A**

SEISMIC BASE SHEAR COEFFICIENT
N-S & E-W DIRECTIONS *(SHEAR WALLS & CONVENTIONAL MOMENT FRAME)
RESPONSE MODIFICATION FACTOR: R = 3
SEISMIC RESPONSE COEFFICIENT:
$C_S = S_{DS}/(R/I)$ → C_S = 0.033
C_T = 0.02
x = 0.75
APPROXIMATE PERIOD OF STRUCTURE:
$T = C_T h_n^x$ → T = 0.93
C_S, NOT GREATER THAN:
$C_{S,MAX} = S_{D1}/T(R/I)$ → 0.012 * CONTROLS (USE)
$C_{S,MIN} = 0.044 I S_{DS}$ → 0.0043

LOADING CHARACTERISTICS (CONT. ON NEXT PAGE)

NOTES:
- LOADS BASED ON ASSUMPTION/INTERPRETATION OF ASCE7-02 SECTION C3.0 - TABLES C3-1.
- STRUCTURAL DEAD LOADS BASED ON AVERAGES OF SYSTEMS OVER ROUGH FLOOR AREA.
- LIVE LOADS BASED ON STRUCTURAL SET INFORMATION.
  * POOL LOAD/STRUCTURE DISREGARDED

ROOF: MAIN ROOF AREA: 6100 SF (ROUGH TAKE OFF)
PERIMETER: 502 FT (ROUGH TAKE OFF)

DEAD:

GRAVEL: 12 PSF
RIGID INSULATION: 0.75 PSF
MEMBRANE: 1 PSF
CONCRETE: 100 PSF (BASED ON 8" CONCRETE SLAB)
CONCRETE BEAMS: 63 PSF (ASSUMED AVG. SIZE: $W_{AVG.} = 1^{KLF}$
½" GYP. CEILING: 5 PSF * PSF BASED OFF CUM. LENGTH OF BEAMS OVER AVG. FLOOR AREA.)
MEP: 10 PSF
TOTAL q_{ROOF}: 191.75 PSF

ROOF: 15th LEVEL - POOL TERRACE AREA: 10000 SF (EXCLUDING POOL)
PERIMETER: 515 FT.

DEAD

TILE PAVERS: 15 PSF
MEMBRANE: 1 PSF
CONCRETE: 112.5 PSF (BASED ON AVG.(t) [VARIES FROM 8" & 11"])
½" GYP CEILING: 5 PSF
MEP: 10 PSF
TOTAL q'_{roof}: 143.5 PSF

FLOOR: 16th LEVEL AREA 9700 SF (ROUGH TAKE OFF)
PERIMETER: 502 ft (ROUGH TAKE OFF)

DEAD:

FLOORING: 4 PSF
MECH YARD/PARTITIONS: 8 PSF
CONCRETE SLAB: 150 PSF (BASED ON 12" CONCRETE SLAB)
CONCRETE BEAMS: 30 PSF
½" GYP CEILING: 5 PSF
MEP: 10 PSF

LIVE:

PUBLIC AREA: 100 PSF (STRUCTURAL SET)
TOTAL q_{16th}: 307 psf

FLOOR: 15th LEVEL AREA: 9700 SF (ROUGH TAKE-OFF)
PERIMETER: 502 FT (ROUGH TAKE-OFF)

DEAD:

FLOORING: 4 PSF
PARTITIONS: 8 PSF
CONCRETE SLAB: 112.5 (BASED ON AVG.(t) [VARIES FROM 8" & 11"])
½" GYP CEILING: 5 PSF
MEP: 10 PSF

LIVE:

APARTMENT & CORRIDOR: 40 PSF
TOTA q_{15th}: 179.5 psf

REMAINING FLOORS: (1-14) LEVELS AREA: 22,000 PSF *(AVG.)

PERIMETER: 850 FT. *(ROUGH TAKE OFF)

DEAD:

- FLOORING: 4 PSF
- CONCRETE SLAB: 100 PSF (BASED ON 8" LW SLAB)
- PARTITIONS: 8 PSF
- 1/2 GYP CEILING: 5 PSF
- MEP: 10 PSF

LIVE:

- APT & CORRIDOR: 40 psf (STRUCTURAL SET)
- TOTAL q floor 167 psf

PERIMETER WALL:

DEAD:

- EXTERIOR WALL: q_{wall}: 56.0 psf (STUD/BRICK VENEER/WINDOW SYSTEM)

SNOW LOAD:

- SNOW: q_{snow}: 4.2 psf (20% OF FLAT ROOF LOAD)

	Area	Perimeter	Total q	Weight (w_x)	
	(SF)	(ft)	(PSF)	(Kips)	
Roof: Main Roof	6100	502	191.75	1532.639	
Roof: Level 15	10000	515	143.5	1630.7172	
Floor: Level 16	9700	502	307	3427.692	
Floor: Level 15	9700	502	179.5	2050.382	
Floor: Level 14	22000	850	167	4181.416	w/floor 2-13
Floor: Levels 2-13	22000	850	167	44532.108	4118.108
Floor: Level 1	22000	850	167	-	
			W = Σ w =	57354.9542	

	hs
Level	(ft)
1	13.33
2 - 13	9.33
14	10.66
15	11
16	16
Roof	4

	w_x	h_x	$w_x h_x^k$	C_{vx}	F_x	V_x	M_x
Level, x	(kips)	(ft)			(kips)	(kips)	(ft-kips)
Roof	1533	167	769,202	0.058	40		6,665
16	3428	147.1	1,474,522	0.111	77	40	11,254
15	3681	136.1	1,440,838	0.109	75	116	10,175
14	4181	125.3	1,480,246	0.112	77	191	9,623
13	4118	116	1,327,438	0.100	69	268	7,989
12	4118	106.63	1,198,316	0.090	62	337	6,630
11	4118	97.3	1,072,148	0.081	56	399	5,413
10	4118	88	948,952	0.072	49	455	4,333
9	4118	78.64	827,760	0.062	43	504	3,377
8	4118	69.31	710,010	0.054	37	547	2,553
7	4118	60	595,870	0.045	31	584	1,855
6	4118	50.65	485,022	0.037	25	615	1,275
5	4118	41.32	378,732	0.029	20	640	812
4	4118	32	277,623	0.021	14	659	461
3	4118	22.66	182,532	0.014	9	674	215
2	4118	13.33	95,800	0.007	5	683	66
1						688	
	Σ =		Σ =	Σ =	Σ =		Σ =
	62240		13265012	1.000	688		72696

exp. K
k=1+(T-0.5)/(2.5-0.5)
1.215

Base Shear
(Kips)
V = Cs * W
688.259

Appendix – C SNOW LOAD

ROOF SNOW LOAD

ASCE7-02
SECT 7

GROUND SNOW LOAD:	$P_g = 30$ PSF	7.2
THERMAL FACTOR:	$C_t = 1.0$	7.3.2
SNOW EXPOSURE FACTOR:	$C_e = 0.7$	7.3.1
IMPORTANCE FACTOR: * CATEGORY: II	$I = 1.00$	7.3.3
FLAT ROOF SNOW LOADS: $P_f = 0.7 C_e C_t I P_g$	$P_f = 14.7$ psf	7.3

* STRUCTURAL SET DESIGNED: $P_f = 21$ psf

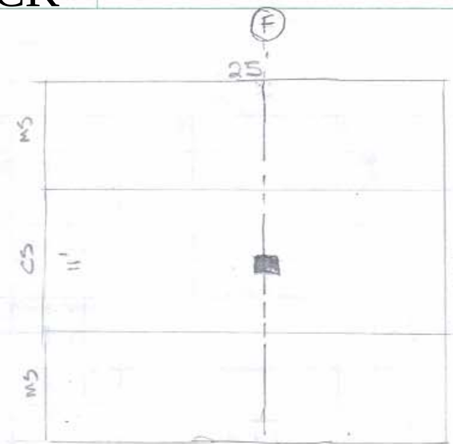
* ASSUME DESIGN ANALYSIS ASCE7-02 DIFFERS FROM CODE ANALYSIS PER BOCA 1996

* USE $P_f = 21$ PSF FOR ACCURATE STRUCTURAL ANALYSIS.

Appendix – D GRAVITY CHECK

COLUMN: CHECK.

LOCATION: 14th LEVEL
SIZE: 18"x26"
f'_c : 5 KSI
REBAR : 4 #11
f_y : 60 KSI
P : 660 KIPS (STRUCTURAL SET)



LOADS:

- 15th LEVEL:

DEAD:

	8"-11" CONC SLAB	120 PSF
	PARTITIONS	20 PSF
	CEILING	5 PSF
	FLOORING	4 PSF
@ (11')	COLUMN	9.75
	MEP	10 PSF
		156.75 psf

LIVE:

PUBLIC	100 PSF
	40 psf

- 16th LEVEL:

DEAD

	12" CONC SLAB	150 psf
	"	"
@ (16')	COLUMN	17 psf
		194 psf

LIVE

MECHANICAL	150 psf
	40 psf

- ROOF LEVEL

DEAD L

8" CONC SLAB	100 psf
BEAMS	25 psf
COVER	5 psf
MEP	10 psf
	140 psf

LIVE

ROOF	30 psf
MECH	150 psf

*INTEGRATED COLUMN DESIGN.

C.S. MOMENT: $l_1 = 25'$

$W_U = 1.2(D) + 1.6(L) = 266.5\text{psf}$

$M_O = W_U l_2 l_n^2/9$ (INT SUPPORT)

$= 407\text{k-ft}$

INT COLUMN C.S. M_O

$M_{CS} = (0.75)(0.65) M_O$

$= 198.5\text{k-ft}$

DESIGN GUIDES: (REF NEXT PAGE)

$K_n = P_n / f'_c A_g = 0.26$

$R_n = M_{CS} / f'_c A_g h = 0.0047$

$\rho_g = 0.01$

$A_{S,REQ'D} = 4.68\text{in}^2$

4#11 $A = 6.24\text{in}^2 > A_{SREQ'D}$

NOTE: RESULTING FROM LOADING ASSUMPTIONS AND ROUGH M_O ANALYSIS, - REINFORCEMENT ACCEPTABLE FOR COLUMNS.

*ASSUMPTION

*(STRUCTURAL SET) *IGNORE L_r

LIVE LOAD REDUCTION.

$L = L_o\left(0.25 + \frac{4.57}{\sqrt{K_{LL} A_T}}\right)$ $\therefore A_T > 400\text{SF}$

$K_{LL} = 4$ INT COL.

$L = L_o .35 < L_o .4$

$* \text{USE}(.4L_o)$

$W_n = 1.2(D) + 1.6(.35L_o)$

$P_n = W_n A_T$

$\boxed{P_n = 611.7\text{ KIPS}}$ < 10% DIFF *

*NOTE: ASSUMPTIONS OR DISREGARD OF MISC. DEAD LOADS MAY ACCOUNT FOR P DIFFERENCE.

Appendix – E SLAB COMPARISON

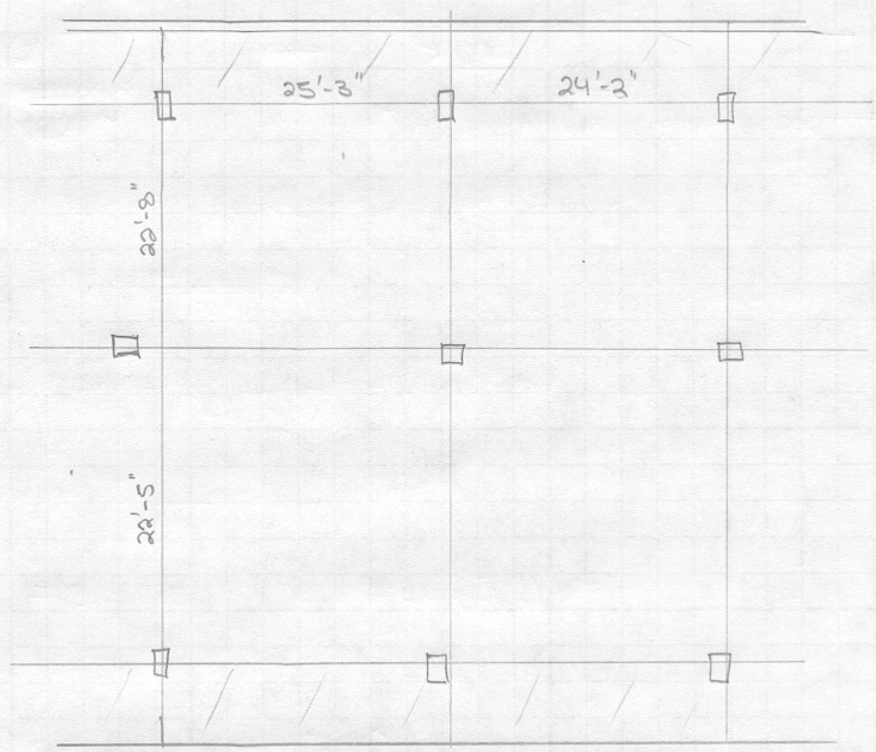
CONCRETE SLAB: CHECK

NOTES: PRELIMINARY ANALYSIS OF A TYPICAL BAY SHALL BE DESIGNED BY THE EQUIVALENT FRAME METHOD (ACI 318-05) WITH LOADING ASSUMPTIONS ACCORDING TO ASCE7-02.

POST-TENSIONING SHALL BE INTEGRATED IN FUTURE ANALYSIS REGARDING STRUCTURAL SLAB SYSTEMS AND DIFFERENTIATION BETWEEN DESIGNS REGARDING REINFORCEMENT IS A RESULTANT OF MOMENT DISCREPENCIES OF SYSTEMS FOR LACK OF POST-TENSION FORCES UPON SLAB.

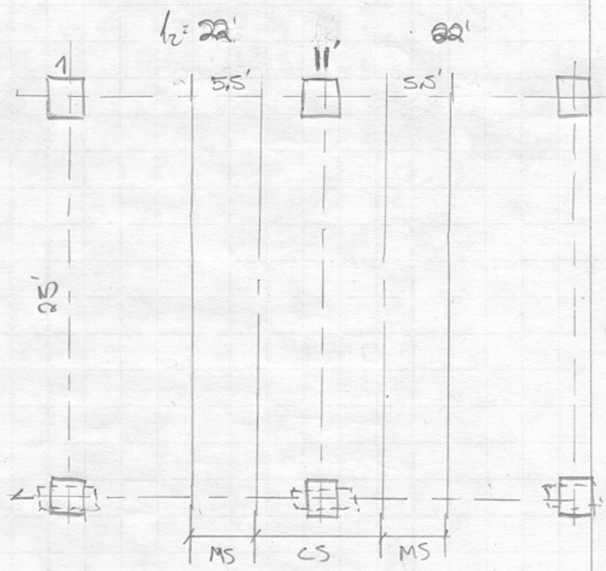
TYPICAL BAYS SHALL BE SIMPLIFIED TO DISREGARD EXTERIOR CANTILEVERED SECTIONS BASED ON REACTIONS OF THE EXTERIOR WALL LINE-LOADS TO POST TENSIONING FORCES.

TYPICAL BAY:



NOTE: PRELIMINARY ANALYSIS WILL CONSIDER A TYPICAL BAY OF 22' x 25' OVER AVERAGING FLOOR BAYS AND COLUMN ALIGNMENT

CONCRETE SLAB: CHECK



DESCRIPTION: *(STRUCTURAL SET)

SLAB: (2-WAY) INTERIOR

f'_c = 5000 psi

#4 @ 24 oc MAT

6-#4 @ MIDSPAN #4 @ COLUMN

COLUMNS:

18"x26" (← 18" ORIENTATION)

f'_c = 5000 psi

l_n = 22.83" COL-COL

REINFORCEMENT:

$f_y = 60^{ksi}$

MINIMUM THICKNESS OF SLAB

$h_{min} = l_n/33 = 9''$

** STRUCTURAL SET: t_{slab} = 8" SUBJECTED TO POST-TENSIONING.

LOADING DESCRIPTION:

9" DEAD:		8" DEAD:	
SLAB:	112.5 PSF	SLAB:	100 PSF
SUPER IMPOSED:	27 PSF	SUPER IMPOSED:	27 PSF
(Σ: FLOOR (4), CEILING (5), MEP (10), PART (8))	139.5 PSF	(Σ: ", ", ", ")	127 PSF
LIVE:		LIVE:	
RES UNIT & CORRIDORS:	40 PSF	RES UNIT & CORRIDORS:	40 PSF

DESIGN LOAD: $W_u = 1.2(D) + 1.6(L)$

$W_{u9''}$ = 231.4 PSF $W_{u8''}$ = 216.4 PSF

MIN REINFORCEMENT: SHRINKAGE & TEMPERATURE *(S_{max} = 18" 7.12.2.2)

$A_{s9} = 0.0018 A_g = 0.389\ in^2$ – #4 @ 24" EACH WAY

$A_{s8} = 0.0018 A_g = 0.173\ in^2$ – #4 @ 24" EACH WAY

NOTE: STRUCTURAL SET @ 24" O.C. – POST-TENSIONING IN CONCRETE INCREASES COMPRESSION NEGATING SHRINKAGE & TEMPERATURE EFFECTS OF REGULAR REINFORCED SLAB

NOTE: THE PRELIMINARY ANALYSIS SHALL COMPARE RESULTS WITH SET DESIGN PER PREVIOUS ASSUMPTIONS ∴ 9" SLAB

$W_u = 231.4$ PSF

STATIC MOMENT:

$M_0 = W_u l_2 l_n^2 / 8 = 331.8$ ft-k

LOCATION	STRIP	TOTAL M_0 (ft-k)	TOTAL WIDTH (ft)	MOMENT/ft OF WIDTH (ft-k/ft)
INT SUPPORT $0.65M_0$	C.S. (75%)	161.75	11'	14.70
	M.S. (25%)	53.90	11'	4.90
MIDSPAN $0.35M_0$	C.S. (60%)	69.68	11'	6.33
	M.S. (40%)	46.45	11'	4.22

NEGATIVE MOMENT CHECK

INT SUPPORT: * (AS PER SET DESIGN)

C.S. - #4 @ 16" $A_s = 0.15$ in²/ft

$d = 9" - 0.75 - 0.5 - 0.25 = 7.5"$

$$a = \frac{A_s f_y}{0.85 f'_c b'} = \frac{(0.15)(60)}{0.85(5)(12")} = 0.176"$$

$$\phi M_n = \phi A_s f_y (d - a/2) = (0.9)(0.15)(60)\left(7.5" - \frac{0.176}{2}\right) = 5 \frac{ft\text{-}k}{ft}$$

NOTE: STRUCTURAL SET. INT SUPPORT REINFORCEMENT INADEQUATE FOR C.S. MOMENT, HOWEVER WORKS FOR M.S. POST-TENSION THROUGH C.S. WOULD ADJUST THE REQUIRED REINFORCEMENT AT C.S. THEREBY ACCOUNTING SET REINFORCING #4

POSITIVE MOMENT CHECK

MIDSPAN: * (AS PER SET DESIGN)

C.S + M.S - #4 @ 12" $A_s = .2$ in²/ft $d = 7.5"$

$$a = \frac{(0.2)(60)}{0.85(5)(12")} = 0.235"$$

$$\phi M_n = (0.9)(0.2)(60)\left(7.5 - \frac{0.235}{2}\right) = 6.64 \frac{ft\text{-}k}{ft}$$

NOTE: SET DESIGN REINFORCEMENT YIELDS ADEQUATE FOR PRELIMINARY DESIGN MOMENTS IN MIDSPAN C.S & M.S, THESE ARE SPECIFIED BAYS WITH ADDED BOTTOM REINFORCEMENT FOR ADDITIONAL STRENGTH AT SLAB OPENINGS.

* TYPICAL BAYS WITHOUT ADDED REINFORCEMENT SEE A MAXIMUM POST-TENSIONING FORCE AT MIDSPAN THEREBY NEGATING A NEED FOR ADDITIONAL REINFORCMENT.

Appendix – F LATERAL LOAD RESISTANCE CHECK

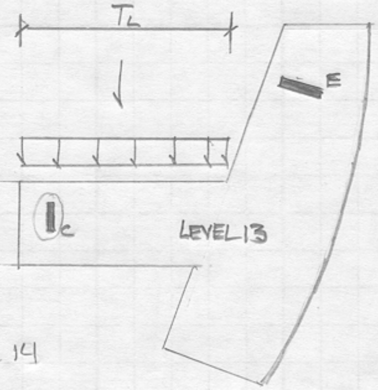
LATERAL LOAD RESISTANCE: CHECK

DISTRIBUTION OF LATERAL LOADS BY TRIBUTARY AREA.

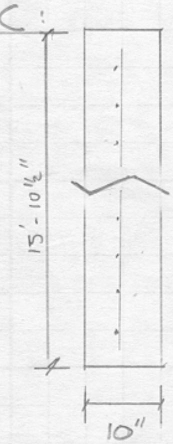
NOTE: GENERAL DISTRIBUTION ASSUMPTIONS MADE ON SHEAR WALLS AT GIVEN LEVEL BASED ON SYMMETRY TO LATERAL DIRECTIONAL LOADING.

TRIBUTARY LENGTH:
$T_L = 132'$

LEVEL HEIGHT:
$h_t = 9'\text{-}4''$



SHEAR WALL C:
WIDTH: 10"
LENGTH: 15'-10½"
$f'_c = 4^{ksi}$
$f_y = 60^{ksi}$
STRUCTURAL SET:
REINFORCEMENT
#5 @ 12"
$S_{SET} = 12''$



$W_{13} = 1.00$ KLF
* WIND SHEAR @ LEVEL 14

$P = W_{13}(T_L) = 132^k$

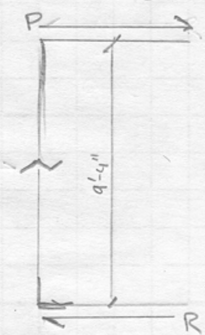
$V_u = 132^k$

$d = 0.8 l_w = 12.7'$

$V_c = \frac{1}{2}(2)\sqrt{f'_c}\, b_w d \quad \leftrightarrow \quad V_u > \frac{\phi V_c}{2}$

$= 96.4^k$

* ASSUME FOR MIN. REINFORCING.



$\phi V_n \geq V_u \qquad V_n = V_c + V_s \qquad V_s = \frac{A_{v,min} f_y d}{s}$

$\frac{V_u}{0.75} = V_c + \frac{A_{v,min} f_y d}{s}$

- $A_{v,min} = \left(\frac{V_u}{0.75} - V_c\right)\left(\frac{s}{f_y d}\right) = 0.104 \text{ in}^2$

- $A_{v,min} = 50 \frac{b_w s}{f_y} = 0.1 \text{ in}^2$

#5 @ 12" $\qquad A_v = 0.31 \text{ in}^2/\text{BAR}$

SPACING CHECK:

$V_s = \frac{V_u}{\phi} - V_c = 79.6^k$

$S_{MIN} = \frac{A_{v,min} f_y d}{V_s} = 11.5'' \rightarrow$ USE 12" o.c.

$S_{SET} = 12''$ o.c. NOTE: FLEXURE TO BE ANALYZED IN FUTURE ANALYSES.

Appendix – G FLOOR PLAN