STRUCTURAL ANALYSIS REPORT

For

NM03XC067

ONE CITY CENTER

One City Center
Portland, ME 04101

Antennas on the Roof; Equipment inside the Penthouse

Prepared for:

Sprint VISION

1 INTERNATIONAL BLVD, SUITE 800
MAHWAH, NJ 07495
TEL: (800) 357-7641

Alcatel•Lucent

1 ROBBINS ROAD
WESTFORD, MA 01886
TEL: (978) 952-1600

Dated:
December 20, 2012

Prepared by:

Hudson Design Group LLC

STATE OF MAINE
DANIEL P. HAMM
No. 10344
LICENSED PROFESSIONAL ENGINEER

12-20-12

1600 Osgood Street Bldg. 20N Suite 3090
North Andover, MA 01845
(P) 978.557.5553 (F) 978.336.5586
www.hudsondesigngroupllc.com

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SCOPE OF WORK:

Hudson Design Group LLC (HDG) has been authorized by Sprint to conduct a structural evaluation of the structure supporting the proposed Sprint equipment located in the areas depicted in the latest HDG's construction drawings.

This report represents this office's findings, conclusions and recommendations pertaining to the support of Sprint's proposed equipment.

This office conducted an on-site visual survey of the above area on November 12, 2012. Attendees included Bradley Loeb (HDG-Field Technician).

CONCLUSION SUMMARY:

Building Plans prepared by William Dorsky Associates, Architects, Planner were available for our use. A limited visual survey of the structure was completed in or near the areas of the Proposed Work.

The structural analysis/PE certification completed by Hudson Design Group LLC (HDG) on behalf of ALU was inclusive of the equipment support structures, antenna masts, antenna mounts, and all other aspects of the structure applicable to the installation of the network vision antenna system and BTS and that the site will support the Sprint Network Vision Antennas and RRH's deployment for the interim and final equipment scenarios.

Existing Penthouse Floor:
Based on our evaluation, we have determined that the penthouse floor **IS CAPABLE** of supporting the proposed Sprint Equipment Cabinets.

Existing Antenna Mounts:
Based on our evaluation, we have determined that the penthouse roof **IS CAPABLE** of supporting the proposed Sprint Antennas and RRH's.

HDG recommends replacing the existing antenna support pipes (Alpha & Beta sectors) to accommodate the new larger antennas and RRH's. Reference the latest drawings for the new equipment locations.

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A summary of the proposed support types and attachment locations are as follows:

(3) New APXVSPP18-C-A20 (800/1900 MHz) RFS antennas (One per sector) (Wt. = 57 lbs. /each)... Supported by the new/existing steel pipes.

(3) FD-RRH-2x50-800 (1 per sector) (Wt. = 50 lbs. /each)... Mounted on new unistrut components.

(3) FD-RRH-4x40-1900 (1 per sector) (Wt. = 50 lbs. /each)... Mounted on new unistrut components.

(1) 60ECv2 Battery Back-Up Cabinet (Wt. = 2830 lbs.)... Mounted inside the existing penthouse.

(1) Alcatel-Lucent 9928 Outdoor Cabinet (Wt. = 1390 lbs.)... Mounted inside the existing penthouse.

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Referenced documents are attached.

DESIGN CRITERIA:

1. International Building Code 2009, ASCE 7-10 Minimum Design Loads for Buildings and Other Structures.

   Wind Analysis:

Reference Wind Speed:	100 MPH	(FIG 26.5-1C; ASCE 7-10)
Category:	C	(26.7.3; ASCE 7 -10)
Gust Effect Factor (G):	0.85	(26.9.1; ASCE 7-10)
Force Coefficient (Cf):	Varies	(FIG 29.5-1 thru 29.5-3; ASCE 7-10)
F = qz * G * Cf * Af:		(Equation 29.5-1; ASCE 7-10)

   Snow Loading:

Ground Snow Load (Pg):	50 psf	(FIG 7-1; ASCE 7-10)
Flat Roof Snow Load (Pf):	31.5 psf	

   Pf = 0.7 * Ce * Ct * I * Pg (Equation 7.3-1; ASCE 7-10)

   Ce=0.9; Ct=1.0; I=1.0

2. EIA/TIA -222- G Structural Standards for Steel Antenna Towers and Antenna Supporting Structures

County:	Cumberland
Wind Load:	100 mph

3. Approximate height above grade to antennas:

   163'-0" +/-

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PENTHOUSE FLOOR & ROOF CONSTRUCTION:

The penthouse floor and roof consists of a 7 ½" post tensioned concrete slab supported by reinforced concrete beams and columns. (See the attached building plans).

EQUIPMENT SUPPORT RECOMMENDATIONS:

HDG recommends that the Alcatel-Lucent 9928 Outdoor Cabinet and Battery Back-Up Cabinets be supported by the existing mechanical penthouse floor.

ANTENNA SUPPORT RECOMMENDATIONS:

- The new Gamma sector antenna is proposed to be supported by the existing steel pipe secured to the roof.
- The new Alpha and Beta sector antennas are proposed to be supported on new steel pipes and mounting brackets secured to the existing ballast mounts.

  See the attached calculations for ballast requirements.

RRH SUPPORT RECOMMENDATIONS:

- The new Gamma sector RRH's are proposed to be supported by new unistrut components secured to the parapet.
- The new Alpha and Beta sector RRH's are proposed to be supported by new unistrut components secured to the existing ballast mounts.

Limitations and assumptions:

1. Equipment and locations should not deviate from the construction drawings without written approval of the engineer of record.
2. HDG is not responsible for any modifications completed prior to and hereafter which HDG was not directly involved.
3. All structural members and their connections are assumed to be in good condition and are free from defects with no deterioration to its member capacities.
4. All antennas, coax cables and waveguide cables are assumed to be properly installed and supported as per the manufacturer's requirements.
5. All detail requirements will be designed and furnished in the construction drawings.
6. Mount all equipment per manufacturer's specifications.

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6. Mount all equipment per manufacturer's specifications.

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ANTENNA LOCATIONS:

Photo 1: Sample photo showing the existing antennas.

Photo 2: Sample photo showing the existing antenna.

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EXISTING EQUIPMENT:

Photo 3: Sample photo showing the existing Sprint equipment.

Photo 4: Sample photo showing the existing Sprint equipment.

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Calculations

Date: 12-20-12
Project Name: ONE CITY CENTER
Project Number: NM03XC067
Designed By: AA **Checked By**: MSC

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2.6.5.2 Velocity Pressure Coeff:

$K_z = 2.01\ (z/z_g)^{2/\alpha}$

z=	163	(ft)
z_g=	900	(ft)
α=	9.5	

K_z= 1.403

Kzmin ≤ Kz ≤ 2.01

Table 2-4

Exposure	Z_g	α	K_{zmin}	K_e
B	1200 ft	7	0.70	0.90
C	900 ft	9.5	0.85	1
D	700 ft	11.5	1.03	1.10

2.6.6.4 Topographic Factor:

Table 2-5

Topo. Category	K_t	f
2	0.43	1.25
3	0.53	2
4	0.72	1.5

$K_{zt} = [1+(K_e\ K_t/K_h)]^2$ $K_h = e^{(f*z/H)}$

K_{zt}= #DIV/0!

(If Category 1 then K_{zt}=1.0)

Category=	1

K_h=	#DIV/0!	
K_e=	0	(from Table 2-4)
K_t=	0	(from Table 2-5)
f=	0	(from Table 2-5)
z=	163	
H=	0	(Ht. of the crest above surrounding terrain)
K_{zt}=	1.00	

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2.6.7 Gust Effect Factors

2.6.7.1 Self Supporting Lattice Structures

Gh = 1.0 Latticed Structures > 600 ft

Gh = 0.85 Latticed Structures 450 ft or less

Gh = 0.85 + 0.15 [h/150 - 3.0] h= ht. of structure

h= 163 Gh= 0.563

2.6.7.2 Guyed Masts Gh= 0.85

2.6.7.3 Pole Structures Gh= 1.1

2.6.7.4 Structures Supported on Other Structures
(Cantilivered tubular or latticed spines, pole, structures on buildings (ht. : width ratio > 5)

Gh= 1.35 **Gh= 1.35**

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2.6.8 Design Ice Thickness:

$t_{iz} = 2.0*t_i*I*K_{iz}*(K_{zt})^{0.35}$

t_i=	1
I=	1
K_{iz}=	1.17
K_{zt}=	1

t_{iz}= 2.35

$K_{iz} = [z/33]^{0.10} \leq 1.4$

K_{iz}= 1.17

Calculating the weight of ice, the cross-sectional area of ice shall be determined by:

$A_{iz} = \pi*t_{iz}*(D_c + t_{iz})$

Dc= 72 (in) Largest Dim of Member

A_{iz} = 548.03

2.6.9 Design Wind Load:

F= qz*Gh*(EPA's)

$q_z = 0.00256*K_z*K_{zt}*K_d*V_{max}^2$

K_z=	1.403
K_{zt}=	1
K_d=	0.95
V_{max}=	100

q_z= 34.11

Table 2-2

Structure Type	Wind Direction Probability Factor, Kd
Latticed structures with triangular, square or rectangular cross sections	**0.85**
Tubular pole structures, latticed structures with other cross sections, appurtenances.	**0.95**

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Determine Cf:

If lattice Structure See Manual

If Tubular Pole Structure, Use Corrected Value from Table 2.7 Below

C mph.ft	Round	18 Sided	16 Sided	12 Sided	8 Sided
< 32 (Subcritical)	1.2	1.2	1.2	1.2	1.2
32 to 64 (Transitional)	$38.4/C^{1.0}$	$25.8/C^{0.885}$	$12.6/C^{0.678}$	$2.99/C^{0.263}$	1.2
> 64 (Supercritical)	0.6	0.65	0.75	1	1.2

$C = (I*K_{zt}*K_z)^{0.5}*V*D$

Dp = Outside Diameter or Out to Out: 0.2 feet

C= **23.69** **Cf=** 1.2

Appurtenances	Height	Width	Depth	Flat Area	Force Per Appurtenance
Antenna	72	11.8	7	5.90	**326.07** (lbs)
RRH 1900	25.1	11.1	10.69	1.93	**106.93** (lbs)
RRH 800	19.7	13	10.9	1.78	**98.29** (lbs)
Item No.4	0	0	0	0.00	**0.00** (lbs)
Item No.5	0	0	0	0.00	**0.00** (lbs)

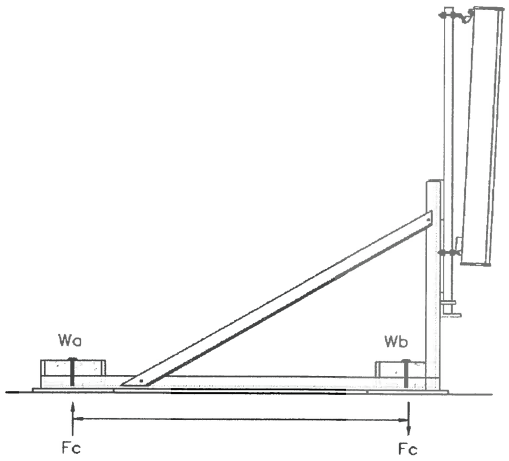
Site Name: ONE CITY CENTER
Site No. NM03XC067
Done by: AA **Checked by:** MSC
Date: 12/20/2012

Calculate Total Ballast Required for Ballast Mount

Alpha & Beta Sectors (Sled 1)

WIND FORCES

F antenna =	326.7	lbs.
F RRH =	106.93	lbs.
F RRH	98.29	lbs.
Antenna Height =	7	ft
RRH & Surge Height =	4	ft



Length = 7 ft

Overturning at Ballast

Moment =	3729.336 lbs.-ft		S.F.
			1.2
Hold Down Force =	532.76 lbs.	Per Side	

Wa Ballast

Equipment

Frame =	150	lbs.

Total Ballast Required Wa= **382.76** lbs.

Blocks Required Wa = **11** Assumed 38lbs Block (4"x8"x16" Solid)

Wb Ballast

Equipment

Frame	150	lbs.
Antennas	57	lbs.
RRH	50	lbs.
RRH	50	lbs.
Total =	307	lbs.

Total Ballast Required Wb = **225.76** lbs.

Blocks Required Wb= **6** Assumed 38lbs Block (4"x8"x16" Solid)

AREA/LOAD = $\frac{(17 \times 38\,\text{LBS}) + 150\,\text{LBS} + 307\,\text{LBS}}{8\,\text{FT} \times 8\,\text{FT}} = \frac{1103\,\text{LBS}}{64\,\text{FT}} = 17.23\,\text{PSF}$

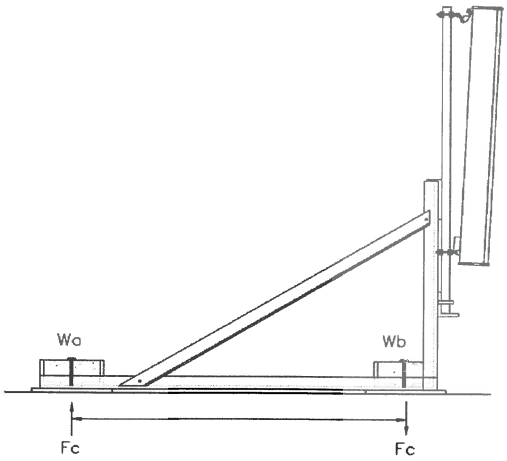
Site Name: ONE CITY CENTER
Site No. NM03XC067
Done by: AA **Checked by:** MSC
Date: 12/20/2012

Calculate Total Ballast Required for Ballast Mount

Alpha & Beta Sectors (Sled 2)

WIND FORCES

F antenna =	326.7	lbs.
F RRH =	0	lbs.
F RRH	0	lbs.
Antenna Height =	7	ft
RRH & Surge Height =	4	ft



Length = 7 ft

Overturning at Ballast

Moment =	2744.28	lbs.-ft	S.F. 1.2
Hold Down Force =	392.04	lbs.	Per Side

Wa Ballast

Equipment

Frame =	150	lbs.

Total Ballast Required Wa= **242.04** lbs.

Blocks Required Wa = 7 Assumed 38lbs Block (4"x8"x16" Solid)

Wb Ballast

Equipment

Frame	150	lbs.
Antennas	57	lbs.
RRH	0	lbs.
RRH	0	lbs.
Total =	207	lbs.

Total Ballast Required Wb = **185.04** lbs.

Blocks Required Wb= 5 Assumed 38lbs Block (4"x8"x16" Solid)

$$\text{AREA/LOAD} = \frac{(12 \times 38\ \text{LBS.}) + 150\ \text{LBS} + 207\ \text{LBS.}}{8\text{FT} \times 8\text{FT}} = 12.7\ \text{PSF}$$

Project: NM03XC067

Location: Antenna Support Pipe (Gamma Sector)
Multi-Loaded Multi-Span Beam
[2009 International Building Code(AISC 13th Ed ASD)]
Pipe 3 Std. x 10.0 FT (10 + 0) / ASTM A53-GR.B
Section Adequate By: 43.6%
Controlling Factor: Moment

Andres Agudelo
Hudson Design Group LLC
1600 Osgood Street, Suite 3090, Bldg. 20N
North Andover, MA 01845

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DEFLECTIONS

Live Load	
Dead Load	
Total Load	

Live Load Deflection Criteria: L/360 Total Load Deflection Criteria: L/240

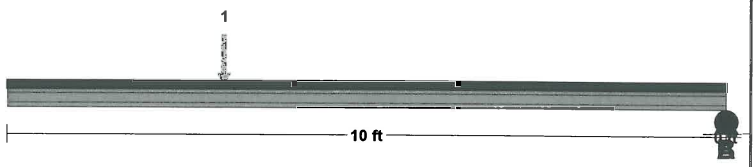
REACTIONS

	A	
Live Load	326	lb
Dead Load	76	lb
Total Load	402	lb
Bearing Length	0.40	in

BEAM DATA

	Left	
Span Length	10	ft
Unbraced Length-Top	0	ft
Unbraced Length-Bottom	10	ft

LOADING DIAGRAM



UNIFORM LOADS

	Left	
Uniform Live Load	0	plf
Uniform Dead Load	0	plf
Beam Self Weight	8	plf
Total Uniform Load	8	plf

POINT LOADS - LEFT SPAN

Load Number	One	
Live Load	326.1	lb
Dead Load	0	lb
Location	3	ft

STEEL PROPERTIES
Pipe 3 Std. - A53-GR.B

Properties:

Steel Yield Strength:	Fy =	35	ksi
Modulus of Elasticity:	E =	29000	ksi
Tube Steel Section (X Axis):	dx =	3.5	in
Tube Steel Section (Y Axis):	dy =	3.5	in
Tube Steel Wall Thickness:	t =	0.201	in
Area:	A =	2.08	in2
Moment of Inertia (X Axis):	Ix =	2.85	in4
Section Modulus (X Axis):	Sx =	1.63	in3
Plastic Section Modulus:	Z =	2.19	in3

Design Properties per AISC 13th Edition Steel Manual:

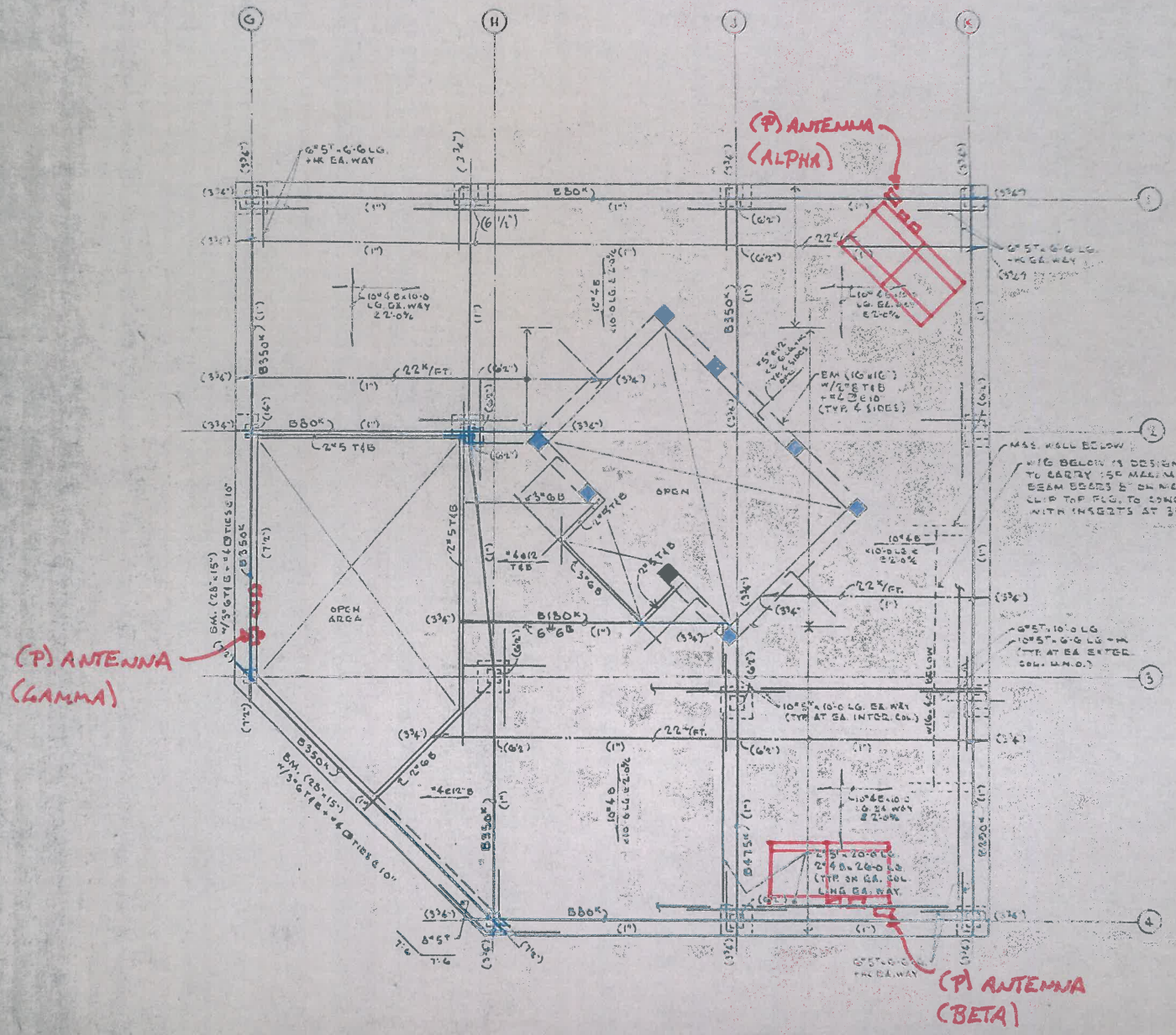
Flange Buckling Ratio:	FBR =	17.41	
Allowable Flange Buckling Ratio:	AFBR =	58	
Allowable Flange Buckling Ratio non-compact:	AFBR_NC =	256.86	
Nominal Flexural Strength w/ Safety Factor:	Mn =	3825	ft-lb
Controlling Equation:	F8-1		
Shear Buckling Stress Coefficient Eqn. G6-2a:	Fcr =	21	ksi
Nominal Shear Strength w/ Safety Factor:	Vn =	13078	lb

Controlling Moment: -2663 ft-lb
Over right support of span 1 (Left Span)
Created by combining all dead loads and live loads on span(s) 1

Controlling Shear: -402 lb
At right support of span 1 (Left Span)
Created by combining all dead loads and live loads on span(s

Comparisons with required sections:	Req'd	Provided
Moment of Inertia (deflection):	0 in4	2.85 in4
Moment:	-2663 ft-lb	3825 ft-lb
Shear:	-402 lb	13078 lb

NOTES



FRAMING PLAN LEVEL '15' (PENTHOUSE ROOF)

SCALE 1/8"=1'-0

ROOF CONSTRUCTION : 7½" RT. SLAB.

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- CHECK ROOF REINFORCED CONCRETE SLAB:

  - SLAB DESCRIPTION: (PER ATTACHED BUILDING PLANS)

    - THICKNES: 7 1/2"
    - STEEL BARS: #4 @ 2'-0" O.C ; EACH WAY
    - f'_c = 4000 PSI
    - f_y = 60,00 PSI
    - LENGTH = 16 FT (WORSE CASE)

$$\rho = \frac{A_s}{bd} = \frac{0.2\ IN^2}{(12")(7.5")} = 0.0022$$

$$\frac{M_u}{\phi bd^2} = 129.4\ PSI \rightarrow \text{FROM TABLES.}$$

$$M_u = (129.4\ PSI)(0.9)(12")(7.5")^2 = 78,610.5\ IN\text{-}LBS$$

$$= 6.55\ FT\text{-}K$$

$$M_u = \frac{w_u l^2}{8}$$

$$w_u = \frac{8 M_u}{l^2} = \frac{(8)(6.55\ FT\text{-}K)}{(16FT)^2} = 204.68\ LB/FT$$

$$w_u = \frac{204.68\ LB/FT}{1\ FT} = \underline{\underline{204.68\ PSF}}$$

  - DEAD LOADS:

    - WEIGHT OF SLAB: 7 1/2"/12 x 150 PCF = 93.75 PSF
    - MISCELLANEOUS = 10 PSF

  - LIVE LOAD → SNOW = 31.5 PSF

- NET LOAD = 93.75 PSF + 10 PSF + 17.23 PSF + 31.5 PSF

  = 152.48 PSF < 204.68 PSF ∴ O.K!

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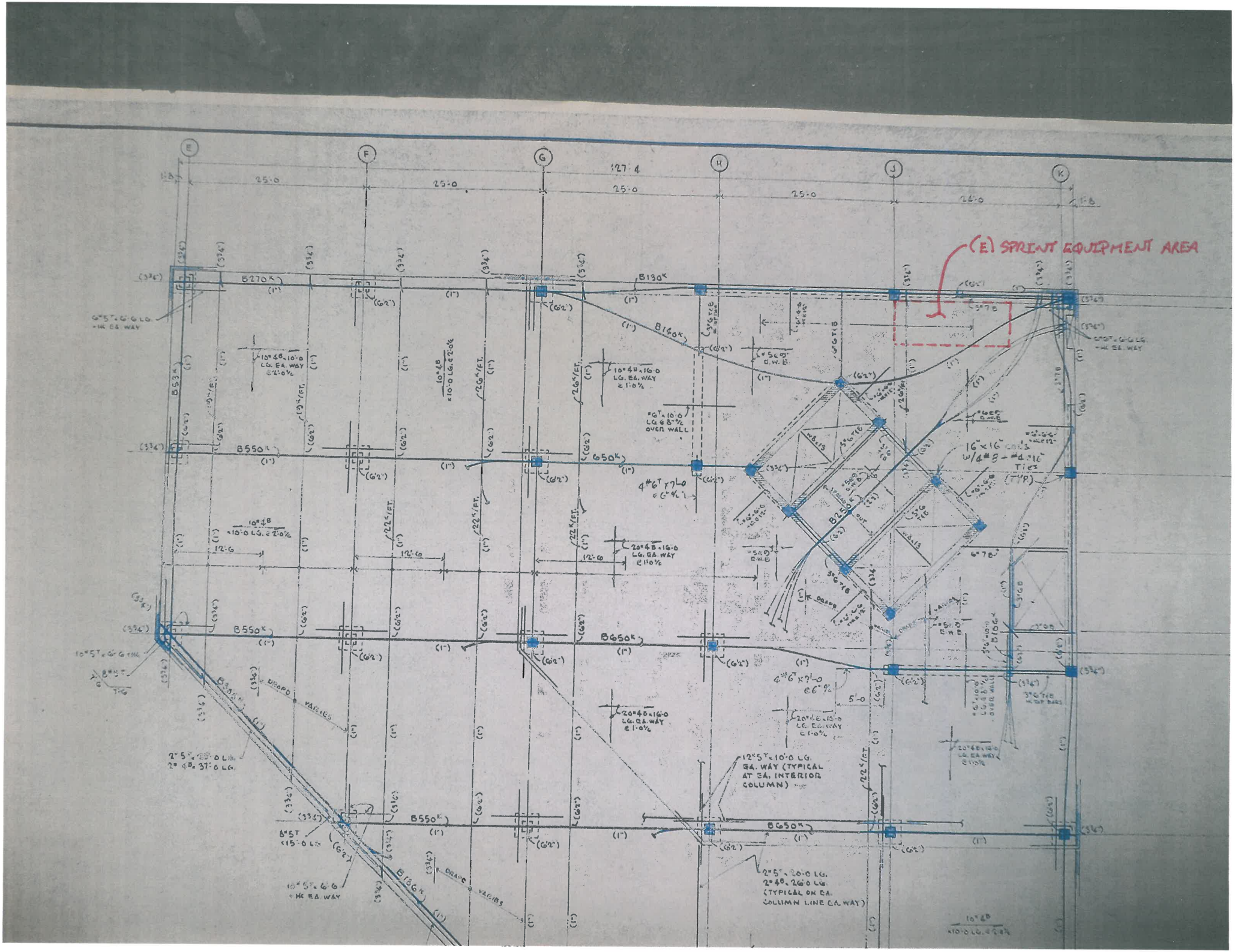
(E) SPRINT EQUIPMENT AREA
E
F
G
H
J
K
127'-4
25'-0
B270K
B130K
B160K
B550K
B650K
B250K
B534
B336K
16"x16" COL'S W/ #8 - #3 TIES (TYP)
4#6 T x 7'-0 @ 6'-0" C
20"x48"x16"-0 LG. EA. WAY @ 1'-0" C
10"x48"x10'-0 LG. EA. WAY @ 2'-0" C
12"x5T"x10'-0 LG. EA. WAY (TYPICAL AT EA. INTERIOR COLUMN)
2"x5T"x20'-0 LG. 2"x48"x26'-0 LG. (TYPICAL ON EA. COLUMN LINE EA. WAY)
DRAPE VARIES

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- CHECK PENTHOUSE FLOOR

  - DEAD LOADS

    - WEIGHT OF SLAB : 7½"/12 x 150 PCF = 93.75 PSF

    - MISCELLANEOUS : 10 PSF

    - PROPOSED EQUIPMENT :

	WEIGHT (LBS.)
(1) ALCATEL-LUCENT 9928 CABINET	= 1390
(1) 60ECV2 BATTERY BACK-UP CABINET	= 2830
(1) FIBER DISTRIBUTION BOX	= 100
(1) TRANSFORMER	= 300
	= 4620

  - EQUIPMENT AREA 8'X12' = 96 FT²

  - AREA LOAD = $\frac{4620 \text{ Lbs.}}{96 \text{ FT}^2}$ = 48.13 PSF

  - NET LOAD = 93.75 PSF + 10 PSF + 25 PSF (SERVICE) + 48.13 PSF

= 176.87 PSF < 204.68 PSF ∴ O.K!

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Reference Documents

8"x5T
7'-6
7'-6
2"x5"x20'-0 LG.
2"x4"x26'-0 LG.
(TYPICAL AT ALL EDGES OF SLAB U.N.O.)
12"x5Tx6'-6 LG.+HK
6"x5"x10'-0 LG.
(TYPICAL AT EA. EXTERIOR COL. U.N.O.)

FRAMING PLAN LEVEL '14' (ROOF & MECH. FL.)

NORTH

SCALE 1/8"=1'-0

FINISH FLOOR ELEVATION 206.7'

FLOOR CONSTRUCTION:

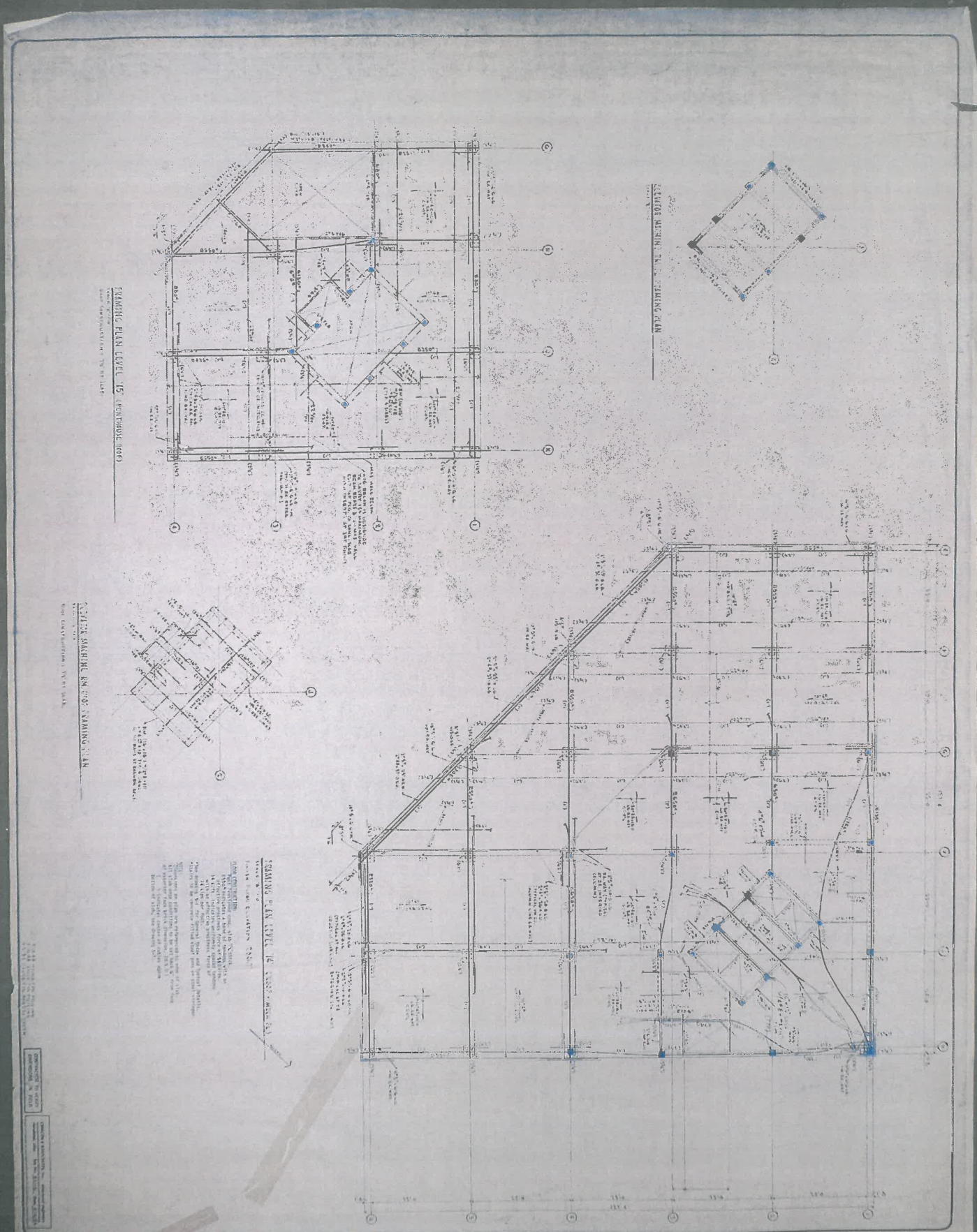
Post Tensioned conc. slab 7½" thick.
B350K indicates a band of tendons with an effective prestress force of 350 kips.
14 k/ft. indicates uniformly spaced tendons with an effective prestress force of 14 kips per foot.
*See drawing S-1 for General Notes and Typical Details.
*Stairs to be concrete filled steel pans on steel stringer.

NOTE:
*Dimensions on plan are referenced to edge of slab.
*All slab edge conditions to be set back 6" from face of exterior face brick dimension. (U.N.O.)
( ) indicates center of cables above bottom of slab, see drawing S-1.

(2)

16') W/2"8 T&B
0" TYP. 4 SIDES.
RS AT CORNER COLS.

PLAN



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S-11

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PORTLAND, MAINE

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