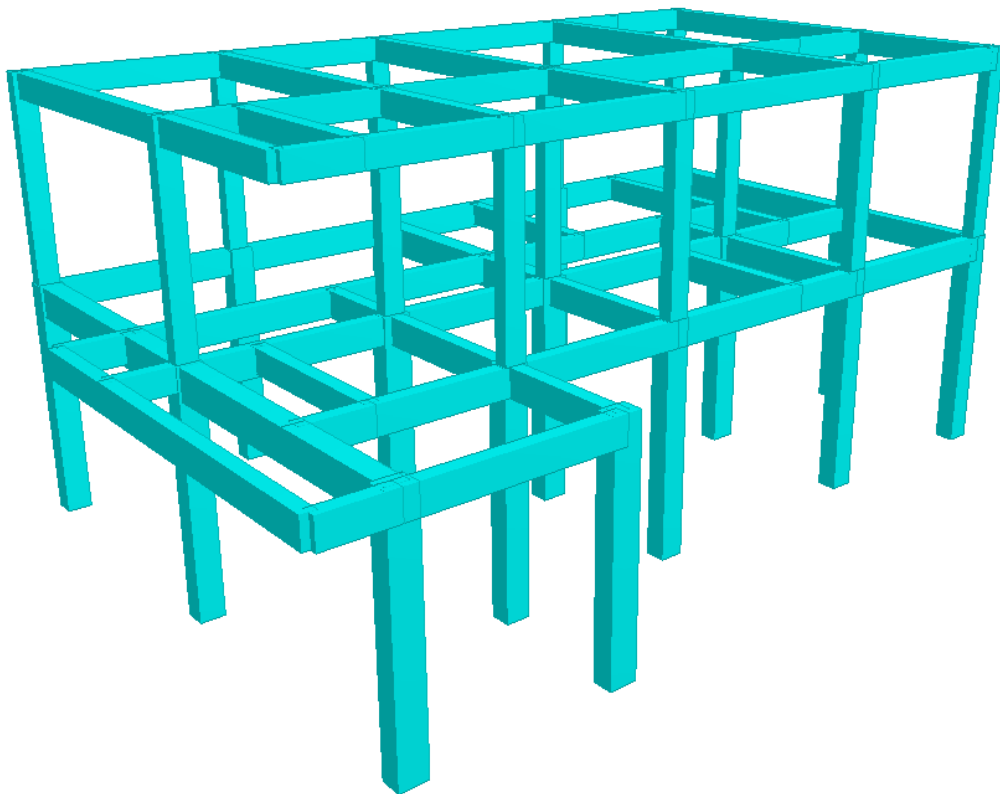


STRUCTURAL ANALYSIS AND DESIGN REPORT

PROPOSED TWO STOREY RESIDENTIAL BUILDING



Signed by:

Licensed Civil Engineer

I. Codes and References

- A. National Structural Code of the Philippines (NSCP), 7th Edition, 2015
- B. American Concrete Institute (ACI) 318-11
- C. AISC Manual of Steel Construction (AISC) LRFD
- D. American Society of Civil Engineers (ASCE) 7-10
- E. Uniform Building Code (UBC) 1997

II. Material Specifications

A. Structural Concrete

i. Compressive Strength

Suspended Beams, Column	$f_c' = 21 \text{ MPa (3000 psi)}$
Suspended Slab	$f_c' = 21 \text{ MPa (3000 psi)}$
Slab on Grade	$f_c' = 21 \text{ MPa (3000 psi)}$
Footing, Pedestal, Footing Tie Beam	$f_c' = 21 \text{ MPa (3000 psi)}$

B. Reinforcing Bar

- | | |
|----------------------------------------------|--------------------------------------|
| i. $\Phi 12\text{mm}$ and below | $f_y = 228 \text{ MPa (33,000 psi)}$ |
| ii. $\Phi 14\text{mm}$ to $\Phi 18\text{mm}$ | $f_y = 276 \text{ MPa (40,000 psi)}$ |

III. Loads

A. Dead Load

- | | |
|-------------|------------------------|
| i. Concrete | 23.56 kN/m^3 |
| ii. Steel | 77.00 kN/m^3 |
| iii. Soil | 17.00 kN/m^3 |

B. Superimposed Dead Load

- | | |
|---------------------------------------------------------------------------|--------------------|
| i. Ceiling / Fixtures, ME / EE Utilities | 0.5 kPa |
| ii. Roofing | 1 kPa |
| iii. Concrete Topping / Finishes | 0.5 kPa |
| iv. CHB Masonry Walls (150mm thick)
- Full Grout & Both Face Plastered | 3.2 kPa |
| v. CHB Masonry Walls (100mm thick)
- Full Grout & Both Face Plastered | 3.1 kPa |
| vi. Cement finish (25 mm) on stone-concrete fill | 1.53 kPa |

C. Live Load

Residential (NSCP 2015 Table 205.1)

- | | |
|---------------------|----------------------------|
| i. Basic Floor Area | 2 kPa |
| ii. Stairs | 2 kPa (by tributary width) |

D. Wind Load

Wind loads will be calculated based on the recommendation of NSCP 2015.

- Basic Wind Speed

$$V = 260 \text{ km/h (NSCP 2015)}$$

- Exposure Category

Exposure B - Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

- Wind Pressure, p in (kPa) for Buildings of all Heights

$$p = qGC_p - q_h (GC_{pi}) \text{ (Eq. 207B.4-1)}$$

where:

p = Design Wind Pressure, in kPa

q_h = Velocity pressure evaluated at height h

q_z = $0.613 K_z K_{zt} K_d V^2$ (Equation 207D.3-1)
= Velocity pressure evaluated at height z

K_z = Velocity pressure exposure coefficient evaluated at height z
(Table 207E.3-1)

K_{zt} = Topographic Factor
= 1.0

K_d = Wind Directional Factor
= 0.85

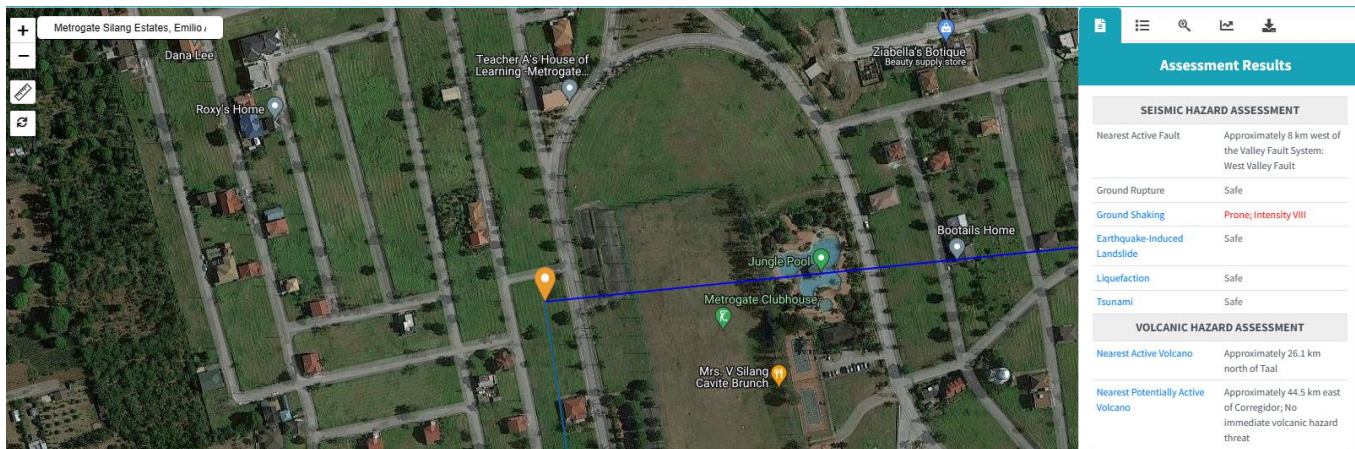
GC_{pi} = Product of internal pressure coefficient and gust effect factor to be used in the determination of wind loads for buildings
(Table 201A.11-1)

E. Seismic Load

Seismic forces were determined based on the equivalent static force procedure and computed following the provisions of NSCP 2015 Chapter 2 Section 208. Structures or part of the structure were analyzed to resist minimum total service forces assumed to act non-concurrently in the direction of each of the main axes of the structure.

The site is approx. **8 km** from the nearest fault which is **West Valley Fault**.

The table below shows the Seismic Load Design Criteria used in the design.



Design Parameter	Values	Reference
Seismic Importance Factor, I	1.0	NSCP 2015 Table 208-1
Soil Profile Type	S _D	NSCP 2015 Table 208-2
Seismic Zone Factor, Z	0.4	NSCP 2015 Table 208-3
Seismic Source Type	Type A	NSCP 2015 Table 208-4
Near Source Factor, Na (used 5 km)	1.2	
Near Source Factor, Nv (used 5 km)	1.6	
Resistance Factor, R (Intermediate Moment Resisting Frame)	5.5	NSCP 2015 Table 208-11B

IV. Load Combination

A. Strength Design or Load and Resistance Factor Design (NSCP 2015 - 203.3)

*For Reinforced Concrete Structure & Steel Structure (Basic Load Combinations)
(NSCP 2015 - 203.3.1)*

- Eq. 203-1: $U = 1.4 D$
- Eq. 203-2: $U = 1.2 D + 1.6 L + 0.5 (L_r \text{ or } R)$
- Eq. 203-3: $U = 1.2 D + 1.6 (L_r \text{ or } R) + (f_1 L \text{ or } 0.5 W)$

DESIGN CRITERIA

PROPOSED TWO STOREY RESIDENTIAL BUILDING

- iv. Eq. 203-4: $U = 1.2 D + 1.0 W + f_1 L + 0.5 (L_r \text{ or } R)$
- v. Eq. 203-5: $U = 1.2 D + 1.0 E_m + f_1 L$
- vi. Eq. 203-6: $U = 0.9 D + 1.0 W$
- vii. Eq. 203-7: $U = 0.9 D \pm 1.0 E_m$

B. Allowable Stress or Allowable Strength Design (NSCP 2015 - 203.4)

Basic Load Combinations (Serviceability & Drift Check) (NSCP 2015 - 203.4.1)

- i. Eq. 203-8: $U = 1.0 D$
- ii. Eq. 203-9: $U = 1.0 D + 1.0 L$
- iii. Eq. 203-10: $U = 1.0 D + 1.0 (L_r \text{ or } R)$
- iv. Eq. 203-11: $U = 1.0 D + 1.0 H + 1.0 F + 0.75 [L + T (L_r \text{ or } R)]$
- v. Eq. 203-12: $U = 1.0 D + 1.0 F + (0.6 W + 1.0 E_m)$

Where:

$$E_m = E_h + E_v$$

$$E_v = .5 C_a I D$$

$$f_1 = 1.0, \text{ if } L \geq 4.8 \text{ kPa}$$

$$= 0.5, \text{ if } L < 4.8 \text{ kPa}$$



Job Title:

Client:

Engineer:

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 17-Mar-24

END JOB INFORMATION

SET NL 100

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

33 -1 3.5 4.33; 34 -1 3.5 8.93; 35 0 3.5 2.83; 36 -1 3.5 2.83; 37 0 3.5 6.93;
38 1 3.5 4.33; 39 1 3.5 6.93; 40 3 3.5 2.83; 41 5.75 3.5 2.83; 42 7.65 3.5 0;
43 7.65 3.5 2.83; 44 10.9 3.5 0; 45 10.9 3.5 4.33; 46 9.45 3.5 2.83;
47 10.9 3.5 2.83; 48 8.22 3.5 4.33; 49 8.22 3.5 6.93; 66 0 6.5 6.93;
67 1 6.5 4.33; 68 1 6.5 6.93; 69 3 3.5 4.33; 70 9.45 3.5 6.93; 71 12.5 3.5 0;
72 12.5 3.5 6.93; 73 0 3.5 4.33; 74 5.75 3.5 4.33; 75 3 3.5 6.93;
76 0 3.5 8.93; 77 5.75 3.5 6.93; 78 3 3.5 8.93; 79 9.45 3.5 0;
80 9.45 3.5 4.33; 81 12.5 3.5 4.33; 82 0 3.5 0; 83 3 3.5 0; 84 5.75 3.5 0;
85 9.45 6.5 4.33; 86 3 6.5 6.93; 87 12.5 6.5 4.33; 88 9.45 6.5 0;
89 5.75 6.5 4.33; 90 5.75 6.5 6.93; 91 9.45 6.5 6.93; 92 3 6.5 4.33;
93 0 6.5 0; 94 12.5 6.5 6.93; 95 12.5 6.5 0; 96 3 6.5 0; 97 5.75 6.5 0;
98 0 6.5 4.33; 99 10.9 6.5 4.33; 100 10.9 6.5 0; 1001 0 0 0; 1002 0 0 4.33;
1003 0 0 8.93; 1004 3 0 0; 1005 3 0 4.33; 1006 3 0 6.93; 1007 3 0 8.93;
1008 5.75 0 0; 1009 5.75 0 4.33; 1010 5.75 0 6.93; 1011 9.45 0 0;
1012 9.45 0 4.33; 1013 9.45 0 6.93; 1014 12.5 0 0; 1015 12.5 0 4.33;
1016 12.5 0 6.93;

MEMBER INCIDENCES

26 82 83; 27 83 84; 28 84 42; 29 79 44; 30 82 35; 32 84 41; 34 71 81; 35 73 38;
36 69 74; 37 74 48; 38 80 45; 39 74 77; 40 80 70; 41 81 72; 42 75 77; 43 77 49;
44 70 72; 45 73 37; 46 76 78; 47 69 75; 48 75 78; 49 33 73; 50 34 76; 51 33 34;
52 35 73; 53 36 33; 54 36 35; 55 37 76; 56 37 39; 57 38 69; 58 39 75; 59 38 39;
60 41 74; 61 35 40; 62 40 41; 63 40 69; 64 42 79; 65 42 43; 66 44 71; 67 45 81;
68 44 47; 69 46 80; 70 47 45; 71 46 47; 72 41 43; 73 43 46; 74 48 80; 75 49 70;
76 48 49; 77 93 96; 78 96 97; 79 97 88; 80 88 100; 81 93 98; 82 96 92;
83 97 89; 84 88 85; 85 95 87; 86 98 67; 87 92 89; 88 89 85; 89 85 99; 90 89 90;
91 85 91; 92 87 94; 93 86 90; 94 90 91; 95 91 94; 96 98 66; 98 92 86;
101 66 68; 102 67 92; 103 68 86; 104 67 68; 105 1001 82; 106 82 93;
107 1004 83; 108 83 96; 109 1008 84; 110 84 97; 111 1011 79; 112 79 88;
113 1014 71; 114 71 95; 115 1002 73; 116 73 98; 117 1005 69; 118 69 92;
119 1009 74; 120 74 89; 121 1012 80; 122 80 85; 123 1015 81; 124 81 87;
125 1006 75; 126 75 86; 127 1010 77; 128 77 90; 129 1013 70; 130 70 91;
131 1016 72; 132 72 94; 133 1003 76; 134 1007 78; 135 37 66; 136 99 87;
137 100 95; 138 44 100; 139 45 99; 140 100 99;

START GROUP DEFINITION

FLOOR

_2F_2WAYSIBCEIL 28 29 32 34 TO 76

_2F_2WAY_RESID 28 29 32 34 TO 76



Job Title:

Client:

Engineer:

```
_2F_W2_23_CD 36 39 42 47
_RF_2WAY_CEIL 77 TO 96 98 101 TO 104 136 137
MEMBER
_W1 26 TO 30 35 41 TO 44 52 58 59 64 67 68 70 75
_W2 32 37 38 40 65 71 TO 74 76
_W3 77 TO 80 137
_W4 81 85 92 96
JOINT
_101 88 93 95 TO 97
_102 85 87 89 92 98
_103 66 86 90 91 94
END GROUP DEFINITION
DEFINE MATERIAL START
ISOTROPIC CONCRETE_21MPA
E 2.1538e+07
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-05
DAMP 0.05
G 9.28139e+06
TYPE CONCRETE
STRENGTH FCU 21000
ISOTROPIC DUMMY
E 200000
POISSON 0.3
ALPHA 1.2e-05
DAMP 0.03
G 70000
END DEFINE MATERIAL
MEMBER PROPERTY
117 119 121 123 PRIS YD 0.4 ZD 0.3
118 120 122 124 PRIS YD 0.3 ZD 0.2
105 107 109 111 113 115 125 127 129 131 PRIS YD 0.35 ZD 0.3
106 108 110 112 114 116 126 128 130 132 PRIS YD 0.3 ZD 0.2
133 134 PRIS YD 0.4 ZD 0.3
30 32 34 45 52 55 60 PRIS YD 0.45 ZD 0.3
26 TO 29 35 TO 44 46 TO 48 50 51 53 54 56 TO 58 61 TO 64 66 TO 75 -
76 PRIS YD 0.4 ZD 0.2
49 59 65 PRIS YD 0.35 ZD 0.2
77 TO 96 98 101 TO 104 136 137 PRIS YD 0.35 ZD 0.2
135 138 TO 140 PRIS YD 0.1
CONSTANTS
MATERIAL CONCRETE_21MPA MEMB 26 TO 30 32 34 TO 96 98 101 TO 134 136 137
MATERIAL DUMMY MEMB 135 138 TO 140
MEMBER CRACKED
```



Job Title:

Client:

Engineer:

105 TO 134 REDUCTION RIY 0.7 RIZ 0.7
26 TO 30 32 34 TO 96 98 101 TO 104 136 137 REDUCTION RIY 0.35 RIZ 0.35
MEMBER RELEASE
53 59 68 76 104 START MZ
51 59 71 76 104 END MZ
SUPPORTS
1001 TO 1016 FIXED
MEMBER OFFSET
30 32 34 45 52 55 60 START 0 -0.225 0
30 32 34 45 52 55 60 END 0 -0.225 0
26 TO 29 35 TO 44 46 TO 48 50 51 53 54 56 TO 58 61 TO 64 66 TO 75 -
76 START 0 -0.2 0
26 TO 29 35 TO 44 46 TO 48 50 51 53 54 56 TO 58 61 TO 64 66 TO 76 END 0 -0.2 0
49 59 65 77 TO 96 98 101 TO 104 136 137 START 0 -0.175 0
49 59 65 77 TO 96 98 101 TO 104 136 137 END 0 -0.175 0
105 107 109 111 113 START 0 0 0.05
105 107 109 111 113 END 0 0 0.05
125 127 129 131 133 134 START 0 0 -0.05
125 127 129 131 133 134 END 0 0 -0.05
DEFINE REFERENCE LOADS
LOAD R1 LOADTYPE Dead TITLE DL
SELFWEIGHT Y -1 LIST 26 TO 30 32 34 TO 96 98 101 TO 134 136 137
FLOOR LOAD
_2F_2WAYSIBCEIL FLOAD -4.5 GY
_RF_2WAY_CEIL FLOAD -1 GY
MEMBER LOAD
_W1 UNI GY -9.5
_W2 UNI GY -9.3
77 TO 80 137 UNI GY -3.15
_W4 UNI GY -1.6
JOINT LOAD
_101 FY -3 FZ 1.25
_102 FY -2.2
_103 FY -1.35
FLOOR LOAD
_2F_W2_23_CD FLOAD -3.4 GY
MEMBER LOAD
36 42 UNI GY -9.3 1.75 2.75
32 UNI GY -3.5 0 1.1
27 62 UNI GY -3.7 1.65 2.75
LOAD R2 LOADTYPE Live TITLE LL
FLOOR LOAD
_2F_2WAY_RESID FLOAD -2 GY
_RF_2WAY_CEIL FLOAD -0.5 GY
JOINT LOAD



Job Title:

Client:

Engineer:

_101 FY -2.5 FZ 1.1
_102 FY -1.7
_103 FY -1
MEMBER LOAD
32 UNI GY -2.75 0 1.1
27 62 UNI GY -3 1.65 2.75
LOAD R3 LOADTYPE Mass TITLE MASS
SELFWEIGHT X 1 LIST 26 TO 30 32 34 TO 96 98 101 TO 134 136 137
SELFWEIGHT Y 1 LIST 26 TO 30 32 34 TO 96 98 101 TO 134 136 137
SELFWEIGHT Z 1 LIST 26 TO 30 32 34 TO 96 98 101 TO 134 136 137
FLOOR LOAD
_2F_2WAYSILBCEIL FLOAD 4.5 GX
_2F_2WAYSILBCEIL FLOAD 4.5 GY
_2F_2WAYSILBCEIL FLOAD 4.5 GZ
FLOOR LOAD
_RF_2WAY_CEIL FLOAD 1 GX
_RF_2WAY_CEIL FLOAD 1 GY
_RF_2WAY_CEIL FLOAD 1 GZ
MEMBER LOAD
_W1 UNI GX 9.5
_W1 UNI GY 9.5
_W1 UNI GZ 9.5
MEMBER LOAD
_W2 UNI GX 9.3
_W2 UNI GY 9.3
_W2 UNI GZ 9.3
MEMBER LOAD
77 TO 80 137 UNI GX 3.15
77 TO 80 137 UNI GY 3.15
77 TO 80 137 UNI GZ 3.15
MEMBER LOAD
_W4 UNI GX 1.6
_W4 UNI GY 1.6
_W4 UNI GZ 1.6
JOINT LOAD
_101 FX 3
_101 FY 3
_101 FZ 3
JOINT LOAD
_102 FX 2.2
_102 FY 2.2
_102 FZ 2.2
JOINT LOAD
_103 FX 1.35
_103 FY 1.35



Job Title:

Client:

Engineer:

```
_103 FZ 1.35
FLOOR LOAD
_2F_W2_23_CD FLOAD 3.4 GX
_2F_W2_23_CD FLOAD 3.4 GY
_2F_W2_23_CD FLOAD 3.4 GZ
MEMBER LOAD
36 42 UNI GX 9.3 1.75 2.75
36 42 UNI GY 9.3 1.75 2.75
36 42 UNI GZ 9.3 1.75 2.75
MEMBER LOAD
32 UNI GX 3.5 0 1.1
32 UNI GY 3.5 0 1.1
32 UNI GZ 3.5 0 1.1
MEMBER LOAD
27 62 UNI GX 3.7 1.65 2.75
27 62 UNI GY 3.7 1.65 2.75
27 62 UNI GZ 3.7 1.65 2.75
END DEFINE REFERENCE LOADS
FLOOR DIAPHRAGM
DIA 1 TYPE RIG HEI 3.5 JOINT 33 TO 49 69 TO 81 84
CHECK SOFT STORY ASCE7
CHECK IRREGULARITIES CODE ASCE7
DEFINE UBC LOAD
ZONE 0.4 I 1 RWX 5.5 RWZ 5.5 STYP 4 NA 1.2 NV 1.6
REFERENCE LOAD Y
R1 1.0
DEFINE WIND LOAD
TYPE 1 WWX
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
ASCE-7-2010:PARAMS 260.000 KMPH 0 1 1 0 0.000 FT 0.000 FT 0.000 FT 1 2 8.500 -
M 12.500 M 9.030 M 2.000 0.010 0 0 0 0 0.686 1.000 1.000 0.850 0 0 0 0 -
0.870 0.800 -0.180
!> END GENERATED DATA BLOCK
INT 1.423 1.423 1.443 1.462 1.481 1.498 1.516 1.532 1.548 1.563 1.578 1.593 -
1.607 1.621 1.634 HEIG 0 4.572 4.874 5.176 5.478 5.781 6.083 6.385 6.687 -
6.989 7.291 7.594 7.896 8.198 8.5
TYPE 2 LWX
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
ASCE-7-2010:PARAMS 260.000 KMPH 0 1 1 0 0.000 FT 0.000 FT 0.000 FT 1 2 8.500 -
M 12.500 M 9.030 M 2.000 0.010 1 0 0 0 0.686 1.000 1.000 0.850 0 0 0 0 -
0.870 -0.423 0.180
!> END GENERATED DATA BLOCK
INT -1.02241 -1.02241 HEIG 0 8.5
TYPE 3 WWZ
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
```



Job Title:

Client:

Engineer:

```
ASCE-7-2010:PARAMS 260.000 KMPH 0 1 1 0 0.000 FT 0.000 FT 0.000 FT 1 2 8.500 -
M 9.030 M 12.500 M 2.000 0.010 0 0 0 0 0.686 1.000 1.000 0.850 0 0 0 0 -
0.864 0.800 -0.180
!> END GENERATED DATA BLOCK
INT 1.416 1.416 1.436 1.455 1.473 1.491 1.508 1.524 1.54 1.555 1.57 1.585 -
1.599 1.612 1.625 HEIG 0 4.572 4.874 5.176 5.478 5.781 6.083 6.385 6.687 -
6.989 7.291 7.594 7.896 8.198 8.5
TYPE 4 LWZ
<! STAAD PRO GENERATED DATA DO NOT MODIFY !!!
ASCE-7-2010:PARAMS 260.000 KMPH 0 1 1 0 0.000 FT 0.000 FT 0.000 FT 1 2 8.500 -
M 9.030 M 12.500 M 2.000 0.010 1 0 0 0 0.686 1.000 1.000 0.850 0 0 0 0 -
0.864 -0.500 0.180
!> END GENERATED DATA BLOCK
INT -1.14182 -1.14182 HEIG 0 8.5
LOAD 1 LOADTYPE None TITLE EQ +X
UBC LOAD X 1 DEC 1 ACC 0.05
PERFORM ANALYSIS
CHANGE
LOAD 2 LOADTYPE None TITLE EQ +Z
UBC LOAD Z 1 DEC 1 ACC 0.05
PERFORM ANALYSIS
CHANGE
LOAD 3 LOADTYPE Seismic-H TITLE RS +X
SPECTRUM CQC X 0.223 ACC SCALE 1 DAMP 0.05 LIN
0 5.18; 0.029 6.632; 0.058 8.084; 0.087 9.536; 0.116 11.009; 0.175 12.949;
0.233 12.949; 0.291 12.949; 0.582 12.949; 0.64 12.949; 0.727 12.949;
0.873 11.507; 1.164 8.63; 1.455 6.904; 1.745 5.757; 2.036 4.934; 2.327 4.317;
2.618 3.837; 2.909 3.453; 3.2 3.139; 3.491 2.878; 3.782 2.656; 4.073 2.466;
4.364 2.302; 4.655 2.158; 4.945 2.031; 5.236 1.919; 5.522 1.819; 5.818 1.727;
6.109 1.644; 6.4 1.57; 6.691 1.501; 6.982 1.439; 7.273 1.381; 7.564 1.328;
7.855 1.279; 8.145 1.233; 8.436 1.191; 8.727 1.151; 9.018 1.114; 9.309 1.079;
9.6 1.046; 9.891 1.016; 10.182 0.987; 10.473 0.959;
LOAD 4 LOADTYPE Seismic-H TITLE RS +Z
SPECTRUM CQC Z 0.201 ACC SCALE 1 DAMP 0.05 LIN
0 5.18; 0.029 6.632; 0.058 8.084; 0.087 9.536; 0.116 11.009; 0.175 12.949;
0.233 12.949; 0.291 12.949; 0.582 12.949; 0.64 12.949; 0.727 12.949;
0.873 11.507; 1.164 8.63; 1.455 6.904; 1.745 5.757; 2.036 4.934; 2.327 4.317;
2.618 3.837; 2.909 3.453; 3.2 3.139; 3.491 2.878; 3.782 2.656; 4.073 2.466;
4.364 2.302; 4.655 2.158; 4.945 2.031; 5.236 1.919; 5.522 1.819; 5.818 1.727;
6.109 1.644; 6.4 1.57; 6.691 1.501; 6.982 1.439; 7.273 1.381; 7.564 1.328;
7.855 1.279; 8.145 1.233; 8.436 1.191; 8.727 1.151; 9.018 1.114; 9.309 1.079;
9.6 1.046; 9.891 1.016; 10.182 0.987; 10.473 0.959;
LOAD 5 LOADTYPE Dead TITLE DL
REFERENCE LOAD
R1 1.0
```



Job Title:

Client:

Engineer:

```
LOAD 6 LOADTYPE Live TITLE LL
REFERENCE LOAD
R2 1.0
LOAD 7 LOADTYPE Wind TITLE WL +X
WIND LOAD X 1 TYPE 1
WIND LOAD -X 1 TYPE 2 YR 0 3.5
WIND LOAD -X 1 TYPE 2 XR 10.9 10.9 YR 3.5 7.5 ZR 0 4.33
WIND LOAD -X 1 TYPE 2 YR 3.5 7.5 ZR 4.33 6.93
LOAD 8 LOADTYPE Wind TITLE WL -X
WIND LOAD X -1 TYPE 1 YR 0 3.5
WIND LOAD X -1 TYPE 1 XR 10.9 10.9 YR 3.5 7.5 ZR 0 4.33
WIND LOAD X -1 TYPE 1 YR 3.5 7.5 ZR 4.33 6.93
WIND LOAD -X -1 TYPE 2
LOAD 9 LOADTYPE Wind TITLE WL +Z
WIND LOAD Z 1 TYPE 3
WIND LOAD -Z 1 TYPE 4
LOAD 10 LOADTYPE Wind TITLE WL -Z
WIND LOAD Z -1 TYPE 3
WIND LOAD -Z -1 TYPE 4
LOAD COMB 101 COMB - 1.2 DEAD + 0.5 WIND (1)
5 1.2 7 0.5
LOAD COMB 102 COMB - 1.2 DEAD + 0.5 WIND (2)
5 1.2 8 0.5
LOAD COMB 103 COMB - 1.2 DEAD + 0.5 WIND (3)
5 1.2 9 0.5
LOAD COMB 104 COMB - 1.2 DEAD + 0.5 WIND (4)
5 1.2 10 0.5
LOAD COMB 105 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (1)
5 1.2 6 0.5 7 1.0
LOAD COMB 106 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (2)
5 1.2 6 0.5 8 1.0
LOAD COMB 107 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (3)
5 1.2 6 0.5 9 1.0
LOAD COMB 108 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (4)
5 1.2 6 0.5 10 1.0
LOAD COMB 109 COMB - 1.2 DEAD + 0.5 LIVE + 1 SEISMIC-X + .3 SEISMIC-Z (1)
5 1.2 6 0.5 3 1.0 4 0.3
LOAD COMB 110 COMB - 1.2 DEAD + 0.5 LIVE + 1 SEISMIC-X - .3 SEISMIC-Z (2)
5 1.2 6 0.5 3 1.0 4 -0.3
LOAD COMB 111 COMB - 1.2 DEAD + 0.5 LIVE - 1 SEISMIC-X - .3 SEISMIC-Z (3)
5 1.2 6 0.5 3 -1.0 4 -0.3
LOAD COMB 112 COMB - 1.2 DEAD + 0.5 LIVE - 1 SEISMIC-X + .3 SEISMIC-Z (4)
5 1.2 6 0.5 3 -1.0 4 0.3
LOAD COMB 113 COMB - 1.2 DEAD + 0.5 LIVE + 1 SEISMIC-Z + .3 SEISMIC-X (5)
5 1.2 6 0.5 4 1.0 3 0.3
```



Job Title:

Client:

Engineer:

LOAD COMB 114 COMB - 1.2 DEAD + 0.5 LIVE + 1 SEISMIC-Z - .3 SEISMIC-X (6)
5 1.2 6 0.5 4 1.0 4 -0.3

LOAD COMB 115 COMB - 1.2 DEAD + 0.5 LIVE - 1 SEISMIC-Z - .3 SEISMIC-X (7)
5 1.2 6 0.5 4 -1.0 4 -0.3

LOAD COMB 116 COMB - 1.2 DEAD + 0.5 LIVE - 1 SEISMIC-Z + .3 SEISMIC-X (8)
5 1.2 6 0.5 4 -1.0 4 0.3

LOAD COMB 117 COMB - 0.9 DEAD + 1 WIND (1)
5 0.9 7 1.0

LOAD COMB 118 COMB - 0.9 DEAD + 1 WIND (2)
5 0.9 8 1.0

LOAD COMB 119 COMB - 0.9 DEAD + 1 WIND (3)
5 0.9 9 1.0

LOAD COMB 120 COMB - 0.9 DEAD + 1 WIND (4)
5 0.9 10 1.0

LOAD COMB 121 COMB - 0.9 DEAD + 1 SEISMIC-X + .3 SEISMIC-Z (1)
5 0.9 3 1.0 4 0.3

LOAD COMB 122 COMB - 0.9 DEAD + 1 SEISMIC-X - .3 SEISMIC-Z (2)
5 0.9 3 1.0 4 -0.3

LOAD COMB 123 COMB - 0.9 DEAD - 1 SEISMIC-X - .3 SEISMIC-Z (3)
5 0.9 3 -1.0 4 -0.3

LOAD COMB 124 COMB - 0.9 DEAD - 1 SEISMIC-X + .3 SEISMIC-Z (4)
5 0.9 3 -1.0 4 0.3

LOAD COMB 125 COMB - 0.9 DEAD + 1 SEISMIC-Z + .3 SEISMIC-X (5)
5 0.9 4 1.0 3 0.3

LOAD COMB 126 COMB - 0.9 DEAD + 1 SEISMIC-Z - .3 SEISMIC-X (6)
5 0.9 4 1.0 3 -0.3

LOAD COMB 127 COMB - 0.9 DEAD - 1 SEISMIC-Z - .3 SEISMIC-X (7)
5 0.9 4 -1.0 3 -0.3

LOAD COMB 128 COMB - 0.9 DEAD - 1 SEISMIC-Z + .3 SEISMIC-X (8)
5 0.9 4 -1.0 3 0.3

LOAD COMB 201 COMB - 1.4 DEAD
5 1.4

LOAD COMB 202 COMB - 1.2 DEAD + 1.6 LIVE
5 1.2 6 1.6

LOAD COMB 203 COMB - 1.2 DEAD + 0.5 LIVE
5 1.2 6 0.5

LOAD COMB 204 COMB - 1.2 DEAD + 0.5 WIND (1)
5 1.2 7 0.5

LOAD COMB 205 COMB - 1.2 DEAD + 0.5 WIND (2)
5 1.2 8 0.5

LOAD COMB 206 COMB - 1.2 DEAD + 0.5 WIND (3)
5 1.2 9 0.5

LOAD COMB 207 COMB - 1.2 DEAD + 0.5 WIND (4)
5 1.2 10 0.5

LOAD COMB 208 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (1)



Job Title:

Client:

Engineer:

5 1.2 6 0.5 7 1.0
LOAD COMB 209 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (2)
5 1.2 6 0.5 8 1.0
LOAD COMB 210 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (3)
5 1.2 6 0.5 9 1.0
LOAD COMB 211 COMB - 1.2 DEAD + 0.5 LIVE + 1 WIND (4)
5 1.2 6 0.5 10 1.0
LOAD COMB 212 COMB - 0.9 DEAD + 1 WIND (1)
5 0.9 7 1.0
LOAD COMB 213 COMB - 0.9 DEAD + 1 WIND (2)
5 0.9 8 1.0
LOAD COMB 214 COMB - 0.9 DEAD + 1 WIND (3)
5 0.9 9 1.0
LOAD COMB 215 COMB - 0.9 DEAD + 1 WIND (4)
5 0.9 10 1.0
LOAD COMB 216 COMB - 1.464 DEAD + 0.5 LIVE + 1 SEISMIC-X + .3 SEISMIC-Z (1)
5 1.464 6 0.5 3 1.0 4 0.3
LOAD COMB 217 COMB - 1.464 DEAD + 0.5 LIVE + 1 SEISMIC-X - .3 SEISMIC-Z (2)
5 1.464 6 0.5 3 1.0 4 -0.3
LOAD COMB 218 COMB - 1.464 DEAD + 0.5 LIVE - 1 SEISMIC-X - .3 SEISMIC-Z (3)
5 1.464 6 0.5 3 -1.0 4 -0.3
LOAD COMB 219 COMB - 1.464 DEAD + 0.5 LIVE - 1 SEISMIC-X + .3 SEISMIC-Z (4)
5 1.464 6 0.5 3 -1.0 4 0.3
LOAD COMB 220 COMB - 1.464 DEAD + 0.5 LIVE + 1 SEISMIC-Z + .3 SEISMIC-X (5)
5 1.464 6 0.5 4 1.0 3 0.3
LOAD COMB 221 COMB - 1.464 DEAD + 0.5 LIVE + 1 SEISMIC-Z - .3 SEISMIC-X (6)
5 1.464 6 0.5 4 1.0 3 -0.3
LOAD COMB 222 COMB - 1.464 DEAD + 0.5 LIVE - 1 SEISMIC-Z - .3 SEISMIC-X (7)
5 1.464 6 0.5 4 -1.0 3 -0.3
LOAD COMB 223 COMB - 1.464 DEAD + 0.5 LIVE - 1 SEISMIC-Z + .3 SEISMIC-X (8)
5 1.464 6 0.5 4 -1.0 3 0.3
LOAD COMB 224 COMB - 1.164 DEAD + 1 SEISMIC-X + .3 SEISMIC-Z (1)
5 1.164 3 1.0 4 0.3
LOAD COMB 225 COMB - 1.164 DEAD + 1 SEISMIC-X - .3 SEISMIC-Z (2)
5 1.164 3 1.0 4 -0.3
LOAD COMB 226 COMB - 1.164 DEAD - 1 SEISMIC-X - .3 SEISMIC-Z (3)
5 1.164 3 -1.0 4 -0.3
LOAD COMB 227 COMB - 1.164 DEAD - 1 SEISMIC-X + .3 SEISMIC-Z (4)
5 1.164 3 -1.0 4 0.3
LOAD COMB 228 COMB - 1.164 DEAD + 1 SEISMIC-Z + .3 SEISMIC-X (5)
5 1.164 4 1.0 3 0.3
LOAD COMB 229 COMB - 1.164 DEAD + 1 SEISMIC-Z - .3 SEISMIC-X (6)
5 1.164 4 1.0 3 -0.3
LOAD COMB 230 COMB - 1.164 DEAD - 1 SEISMIC-Z - .3 SEISMIC-X (7)
5 1.164 4 -1.0 3 -0.3



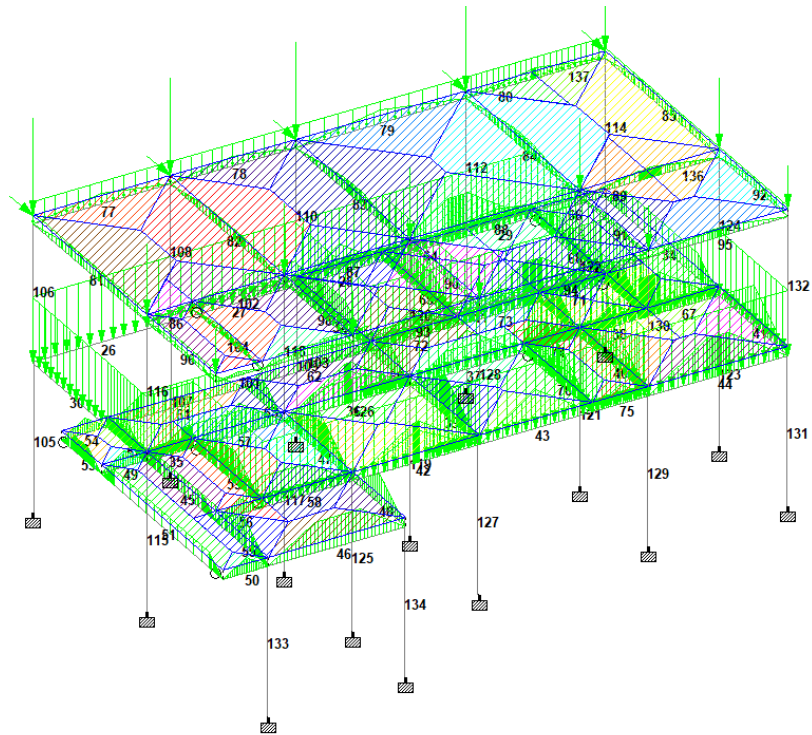
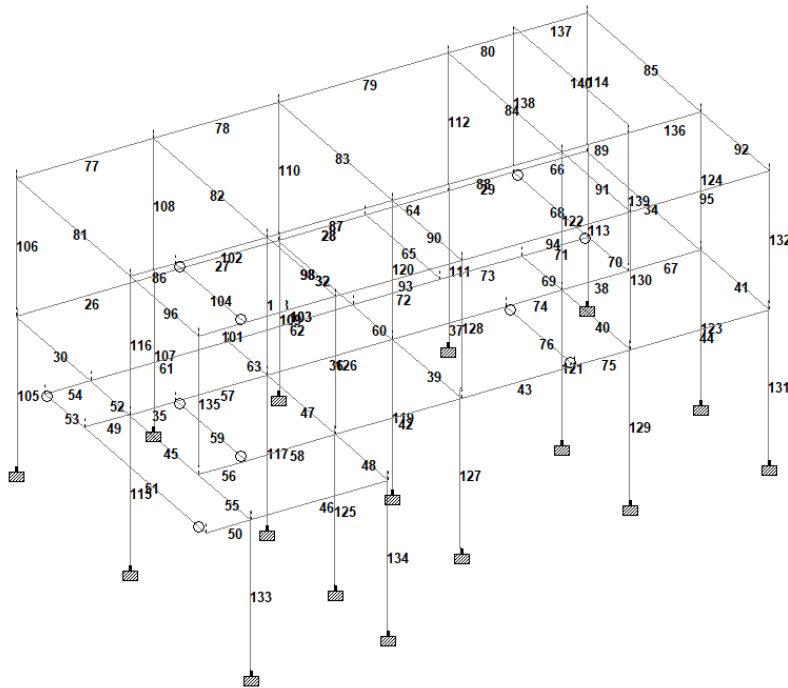
Job Title:

Client:

Engineer:

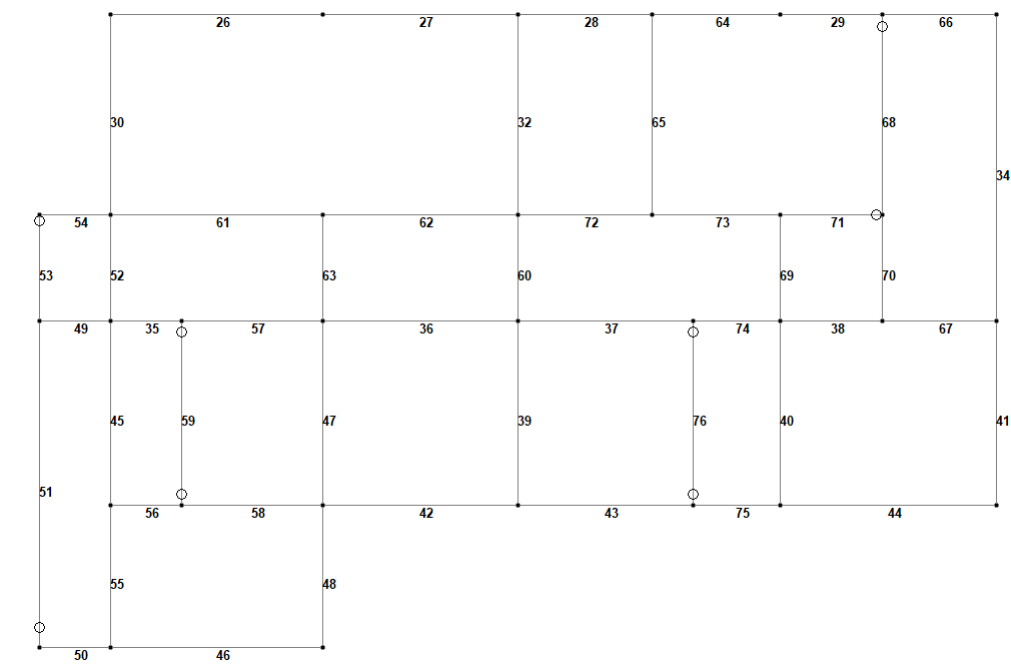
LOAD COMB 231 COMB - 1.164 DEAD - 1 SEISMIC-Z + .3 SEISMIC-X (8)
5 1.164 4 -1.0 3 0.3
LOAD COMB 232 COMB - 0.636 DEAD + 1 SEISMIC-X + .3 SEISMIC-Z (1)
5 0.636 3 1.0 4 0.3
LOAD COMB 233 COMB - 0.636 DEAD + 1 SEISMIC-X - .3 SEISMIC-Z (2)
5 0.636 3 1.0 4 -0.3
LOAD COMB 234 COMB - 0.636 DEAD - 1 SEISMIC-X - .3 SEISMIC-Z (3)
5 0.636 3 -1.0 4 -0.3
LOAD COMB 235 COMB - 0.636 DEAD + 1 SEISMIC-X + .3 SEISMIC-Z (4)
5 0.636 3 -1.0 4 0.3
LOAD COMB 236 COMB - 0.636 DEAD + 1 SEISMIC-Z + .3 SEISMIC-X (5)
5 0.636 4 1.0 3 0.3
LOAD COMB 237 COMB - 0.636 DEAD + 1 SEISMIC-Z - .3 SEISMIC-X (6)
5 0.636 4 1.0 3 -0.3
LOAD COMB 238 COMB - 0.636 DEAD - 1 SEISMIC-Z - .3 SEISMIC-X (7)
5 0.636 4 -1.0 3 -0.3
LOAD COMB 239 COMB - 0.636 DEAD - 1 SEISMIC-Z + .3 SEISMIC-X (8)
5 0.636 4 -1.0 3 0.3
PERFORM ANALYSIS PRINT MODE SHAPES
LOAD LIST 101 TO 128
PRINT STORY DRIFT 0.006500
FINISH

SUPERSTRUCTURE MODEL



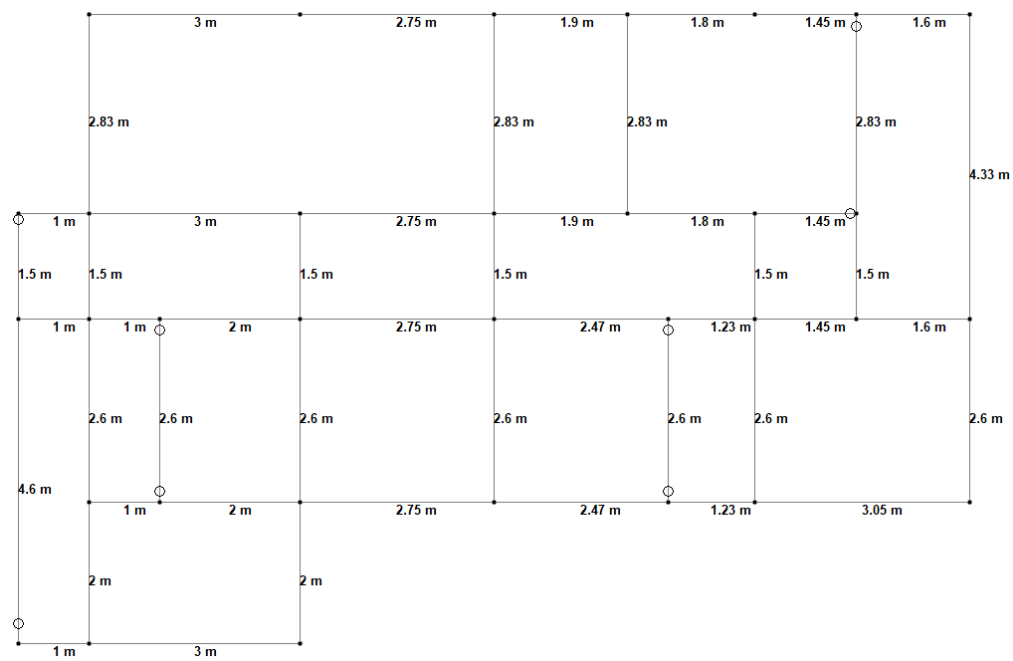
Note: Beams without number in the second image are dummy members. They are used to transmit forces such as walls, floors, and roofing to structural sections.

SUPERSTRUCTURE MODEL



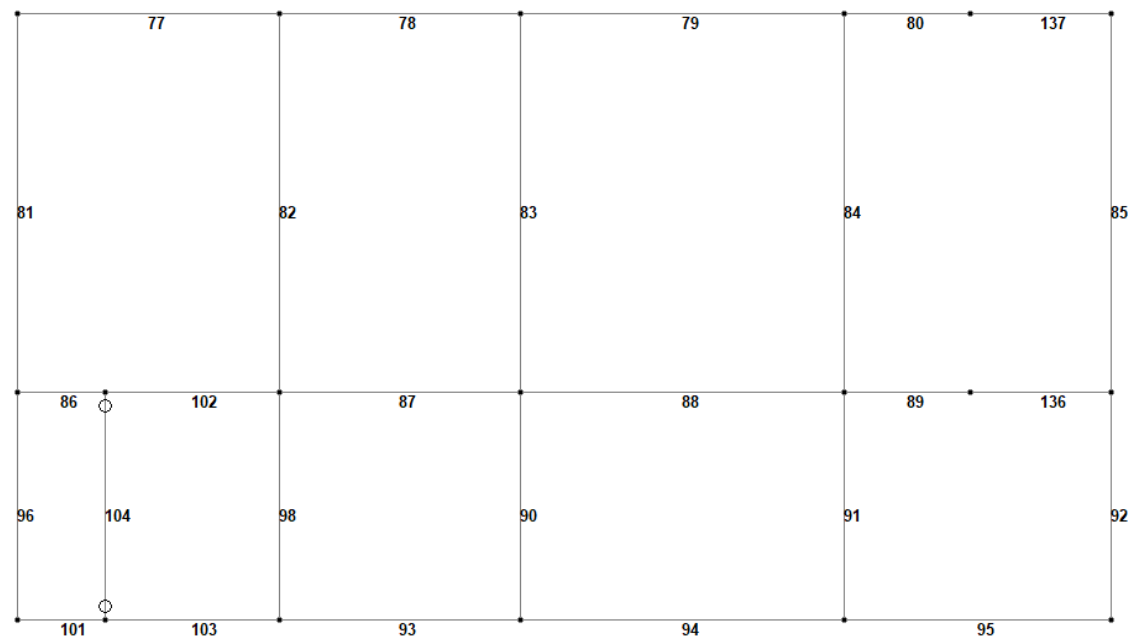
2nd Floor

Dimension

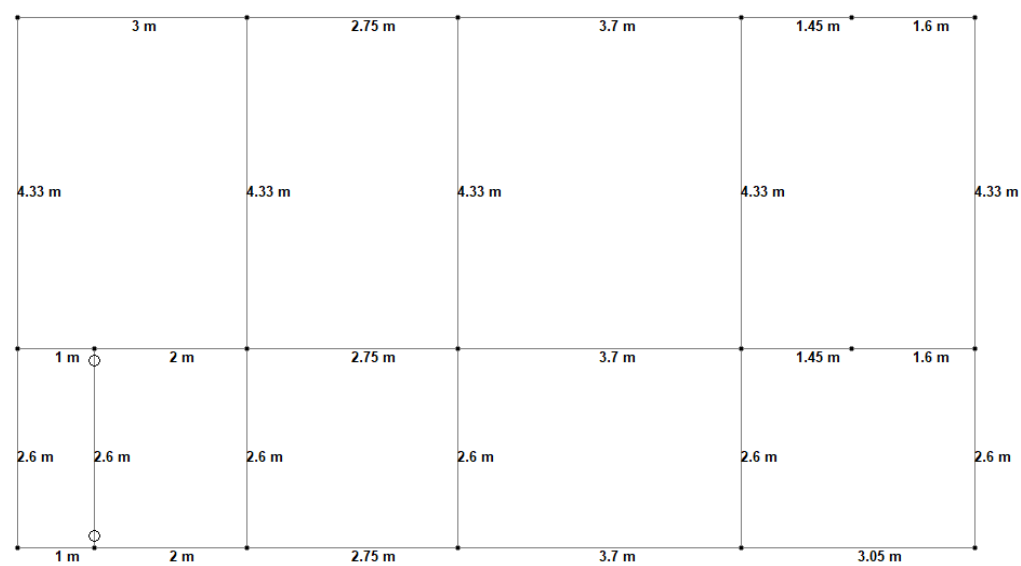


SUPERSTRUCTURE MODEL

Roof

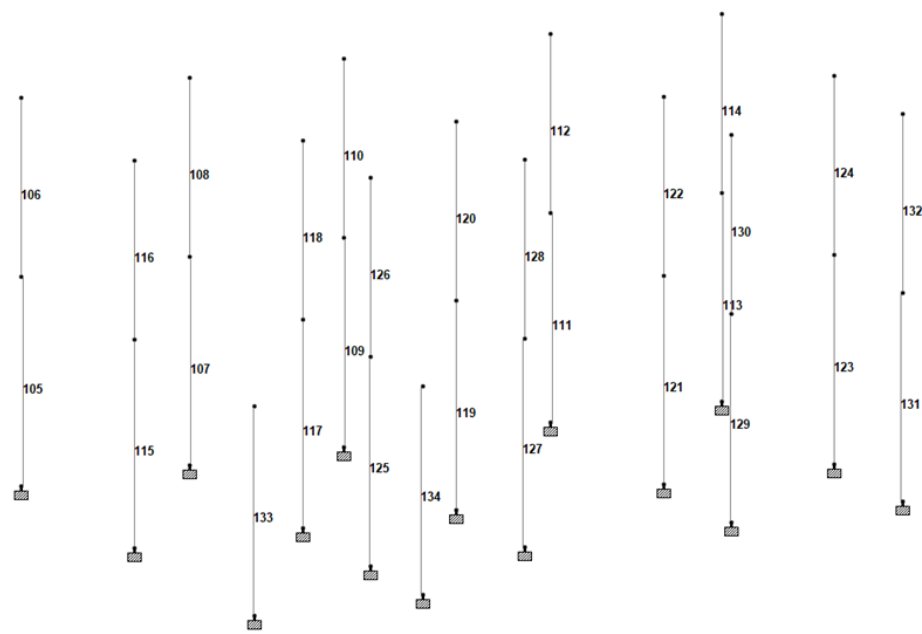


Dimension

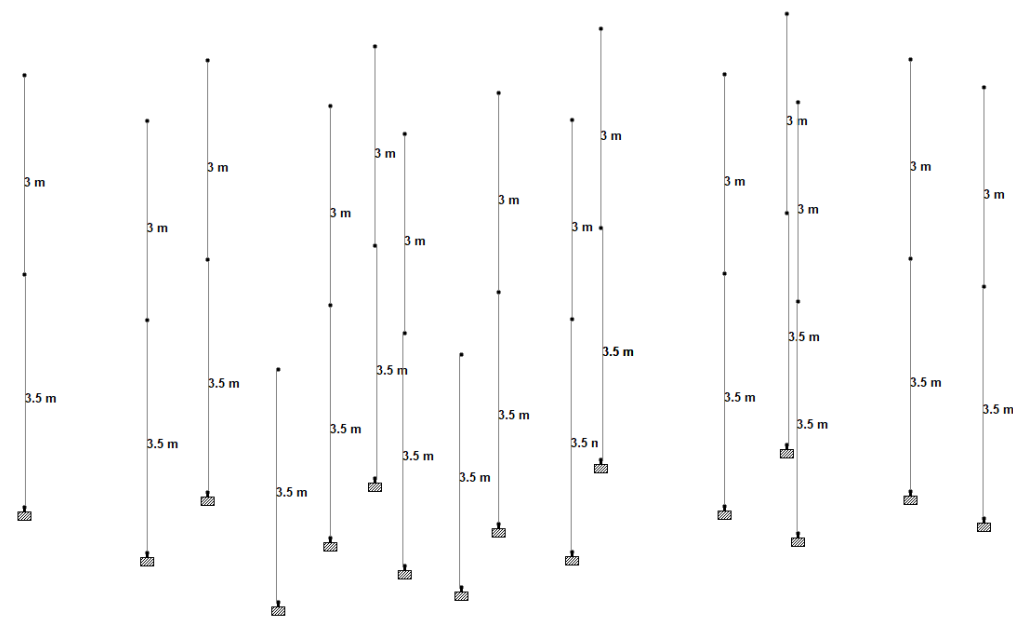


SUPERSTRUCTURE MODEL

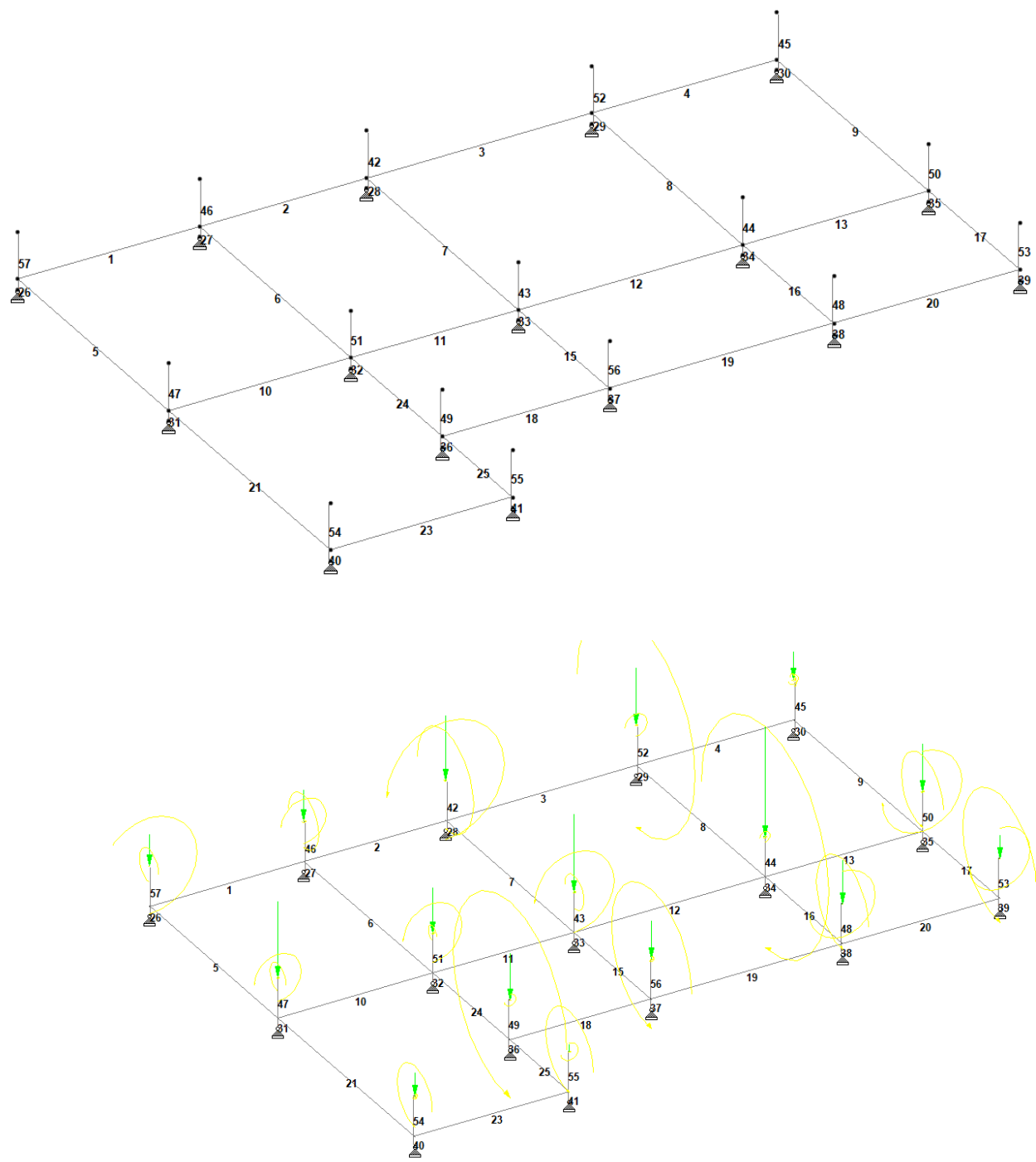
Story Height



Dimension



SUBSTRUCTURE MODEL



SOFT STORY

FLOOR DIAPHRAGM		UNIT - KN		METE			
-----		-----		-----			
NO.	TYPE	FL. LEVEL	FL. WT	CENTRE X	OF Z	MASS	CONTROL JOINT NO.
1	RIGID	3.500	1234.19	6.515	4.219		1017

Rigid Diaphragms

P R O B L E M S T A T I S T I C S			

NUMBER OF JOINTS	69	NUMBER OF MEMBERS	110
NUMBER OF PLATES	0	NUMBER OF SOLIDS	0
NUMBER OF SURFACES	0	NUMBER OF SUPPORTS	16
Using 64-bit analysis engine.			
SOLVER USED IS THE IN-CORE ADVANCED MATH SOLVER			
TOTAL	PRIMARY LOAD CASES =	1,	TOTAL DEGREES OF FREEDOM = 225
TOTAL	LOAD COMBINATION CASES =	0	SO FAR.

SOFT STORY CHECK

VERTICAL STRUCTURAL IRREGULARITIES : SOFT STORY CHECK - ASCE/SEI 7-05			

STORY	FL. LEVEL IN METE	S T A T U S	
----	-----	-----	
		X	Z
1	3.50	OK	OK
NOTE : NO SOFT STOREY IS DETECTED.			

SOFT STORY

```
*****
*
* X DIRECTION : Ta = 0.298 Tb = 0.367 Tuser = 0.000 *
* T = 0.367, LOAD FACTOR = 1.000 *
* UBC TYPE = 97 *
* UBC FACTOR V = 0.2400 x 1722.24 = 413.34 KN *
*
*****
```

Base Shear @ X

LOAD NO.: 1 DIRECTION : X UNIT - METE

STORY	LEVEL	DYN. ECC. (dec)		ACC. ECC. (aec)		DESIGN	ECC.
		X	Z	X	Z		

```
*****
*
* Z DIRECTION : Ta = 0.298 Tb = 0.463 Tuser = 0.000 *
* T = 0.298, LOAD FACTOR = 1.000 *
* UBC TYPE = 97 *
* UBC FACTOR V = 0.2400 x 1722.24 = 413.34 KN *
*
*****
```

Base Shear @ Z

LOAD NO.: 2 DIRECTION : Z UNIT - METE

STORY	LEVEL	DYN. ECC. (dec)		ACC. ECC. (aec)		DESIGN	
		X	Z	X	Z	X	Z

						dec + aec	dec + aec
1	3.50	0.00	0.00	0.67	0.45	0.67	0.00

IRREGULARITY CHECK

--TORSION IRREGULARITY CHECKS

Torsion Irregularity Check

Ref: Fig. C12.3-1 T1- Ratio Limit(s): 1.20, 1.40

Dia.	Extreme Points of Dia in X				Extreme Points of Dia in Z			
	Node	Disp. (mm)	Node	Disp. (mm)	Node	Disp. (mm)	Node	Disp. (mm)
1	78	0.07115	84	0.07143	71	0.12384	36	0.09372

Diaphragm ΔX -max/avg ΔZ -max/avg Status

1 1.0019 1.1385 OK

--GEOMETRY IRREGULARITY CHECKS

Re-Entrant Corner Check.

(Ref: Fig. C12.3-1 T2- Ratio Limit: 0.15)

Node Connectivity	Re-Entrant Node	X-Proj (m)	X-Proj/Lx	Z-Proj (m)	Z-Proj/Lz	Status
72->	75	9.5000	0.7037	0.0000	0.0000	Re-Entrant
78		0.0000	0.0000	2.0000	0.2240	
36->	41	6.7500	0.5000	0.0000	0.0000	Re-Entrant
84		0.0000	0.0000	2.8300	0.3169	

Diaphragm: Lx: Lz:
(m) (m)

1 13.5000 8.9300

--MASS IRREGULARITY CHECKS

Mass Irregularity Check

Ref: Fig. C12.3-2 T2- Ratio Limit: 1.50

Dia.	Level (m)	Mass (kN)	Above (kN)	Below (kN)	Ratio Above	Ratio Below	Status
1	3.500	1234.189	0.000	Base	0.000	N/A	OK

RESPONSE SPECTRA

@X

MASS PARTICIPATION FACTORS IN PERCENT							BASE SHEAR IN KN		
MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	0.09	0.03	84.43	0.095	0.033	84.430	0.46	0.00	0.00
2	17.91	0.00	0.83	18.007	0.036	85.259	86.99	0.00	0.00
3	72.33	0.00	0.00	90.335	0.037	85.263	351.26	0.00	0.00
4	0.86	0.03	5.71	91.200	0.068	90.976	4.20	0.00	0.00
5	0.32	0.00	8.62	91.523	0.068	99.591	1.57	0.00	0.00
6	0.10	0.00	0.00	91.619	0.070	99.592	0.47	0.00	0.00
TOTAL SRSS SHEAR							361.89	0.00	0.00
TOTAL 10PCT SHEAR							361.92	0.00	0.00
TOTAL ABS SHEAR							444.94	0.00	0.00
TOTAL CQC SHEAR							395.42	0.00	0.00

@Z

PARTICIPATION FACTORS

MASS PARTICIPATION FACTORS IN PERCENT							BASE SHEAR IN KN		
MODE	X	Y	Z	SUMM-X	SUMM-Y	SUMM-Z	X	Y	Z
1	0.09	0.03	84.43	0.095	0.033	84.430	0.00	0.00	369.57
2	17.91	0.00	0.83	18.007	0.036	85.259	0.00	0.00	3.63
3	72.33	0.00	0.00	90.335	0.037	85.263	0.00	0.00	0.01
4	0.86	0.03	5.71	91.200	0.068	90.976	0.00	0.00	25.01
5	0.32	0.00	8.62	91.523	0.068	99.591	0.00	0.00	37.71
6	0.10	0.00	0.00	91.619	0.070	99.592	0.00	0.00	0.00
TOTAL SRSS SHEAR							0.00	0.00	372.35
TOTAL 10PCT SHEAR							0.00	0.00	374.88
TOTAL ABS SHEAR							0.00	0.00	435.94
TOTAL CQC SHEAR							0.00	0.00	376.77

RESPONSE SPECTRA

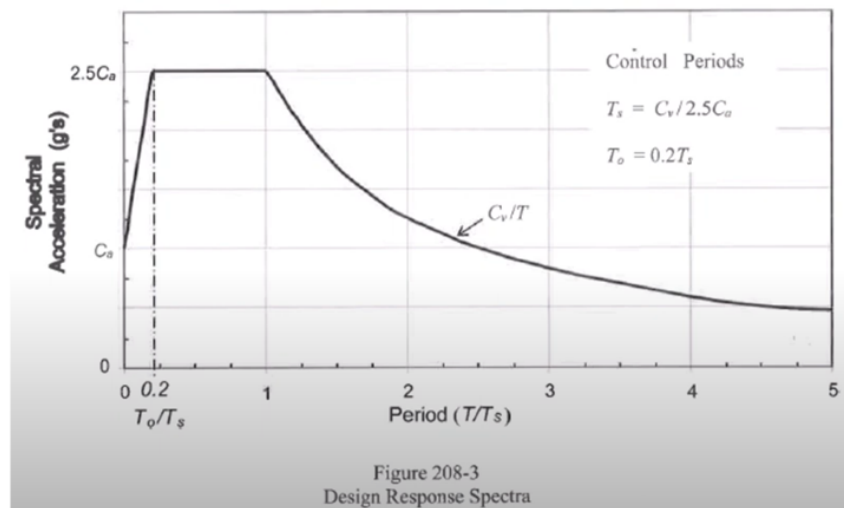
Design Response Spectrum Analysis Table

$C_a =$	0.528	$g =$	9.81
$C_v =$	1.024	$T_s =$	0.7758
$I =$	1	$T_o (-2 \cdot T_s) =$	0.1552

Period (Tn)	Acceleration
0.000	5.180
0.029	6.632
0.058	8.084
0.087	9.536
0.116	11.009
0.175	12.949
0.233	12.949
0.291	12.949
0.582	12.949
0.640	12.949
0.727	12.949
0.873	11.507
1.164	8.630
1.455	6.904
1.745	5.757
2.036	4.934
2.327	4.317
2.618	3.837
2.909	3.453
3.200	3.139
3.491	2.878
3.782	2.656
4.073	2.466
4.364	2.302
4.655	2.158
4.945	2.031
5.236	1.919
5.522	1.819
5.818	1.727
6.109	1.644
6.400	1.570
6.691	1.501
6.982	1.439
7.273	1.381
7.564	1.328
7.855	1.279
8.145	1.233
8.436	1.191
8.727	1.151
9.018	1.114
9.309	1.079
9.600	1.046
9.891	1.016
10.182	0.987
10.473	0.959

Conditions:

$T_n < T_o$	$S_a = (18.75 \cdot C_a^2 \cdot T_n / C_v + C_a) \cdot g$
$T_o \leq T_n < T_s$	$S_a = 2.5 \cdot C_a$
$T_s < T_n$	$S_a = C_v / T_n$



Datas for STAAD Editor:

0.000	5.180	0.029	6.632	0.058	8.084	0.087	9.536	0.116	11.009	0.175	12.949
0.233	12.949	0.291	12.949	0.582	12.949	0.640	12.949	0.727	12.949	0.873	11.507
1.164	8.630	1.455	6.904	1.745	5.757	2.036	4.934	2.327	4.317	2.618	3.837
2.909	3.453	3.200	3.139	3.491	2.878	3.782	2.656	4.073	2.466	4.364	2.302
4.655	2.158	4.945	2.031	5.236	1.919	5.522	1.819	5.818	1.727	6.109	1.644
7.564	1.328	6.691	1.501	6.982	1.439	7.273	1.381	7.564	1.328	7.855	1.279
8.145	1.233	8.436	1.191	8.727	1.151	9.018	1.114	9.309	1.079	9.600	1.046
9.891	1.016	10.182	0.987	10.473	0.959						

$I =$	1	Base Shear Ratio Modifier (NSCP 2015 Sec. 208.5.3.5.4) =	0.9
$R =$	5.5	$I/R =$	0.182

Base Shear Ratio: RSA using CQC

@X

Static Base Shear	=	413.34	RSA Base Shear	=	322.72
Static/RSA =	1.281				
Modified Static / RSA (NSCP 2015 Sec. 208.5.3.5.4) =	0.9 x Static/RSA =	1.153			
Modified I/R =	1.153 * 0.182	=	0.21		

@Z

Static Base Shear	=	413.34	RSA Base Shear	=	341.75
Static/RSA =	1.209				
Modified Static / RSA (NSCP 2015 Sec. 208.5.3.5.4) =	0.9 x Static/RSA =	1.089			
Modified I/R =	1.089 * 0.182	=	0.199		

STORY DRIFT

513. LOAD LIST 101 TO 128
514. PRINT STORY DRIFT 0.006500
STORY DRIFT 0.006500

STAAD SPACE

-- PAGE NO. 29

STORY	HEIGHT	LOAD	AVG. DISP(CM)		DRIFT(CM)		RATIO	STATUS
(METER)			X	Z	X	Z		
BASE=	0.00						ALLOW. DRIFT = L / 154	
1	0.00	101	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		102	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		103	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		104	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		105	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		106	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		107	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		108	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		109	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		110	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		111	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		112	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		113	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		114	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		115	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		116	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		117	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS

STAAD SPACE

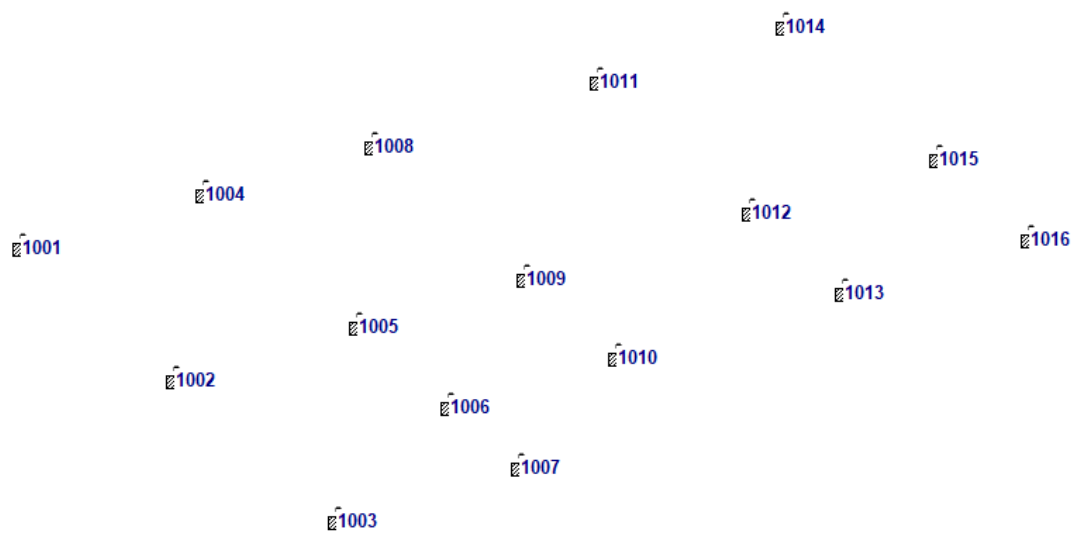
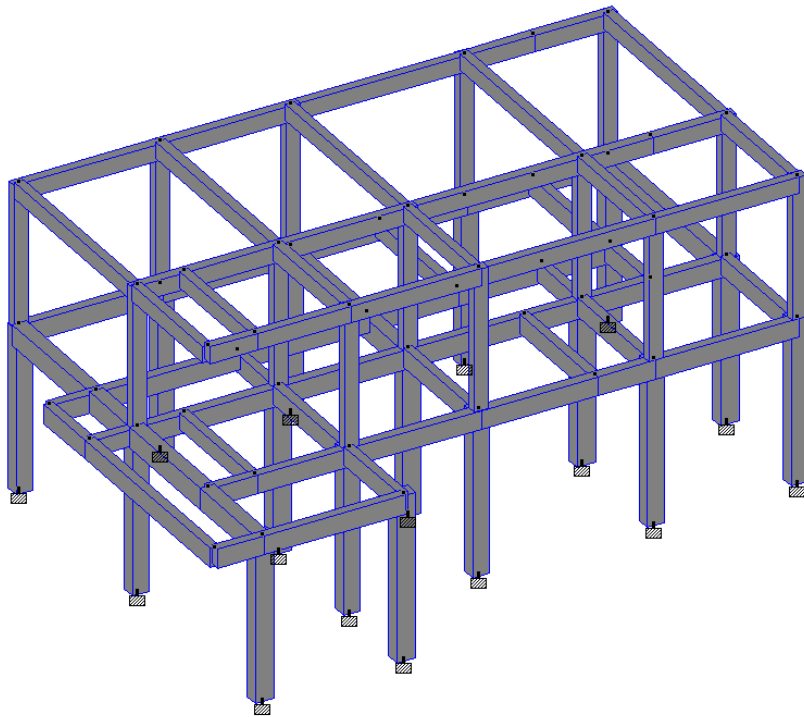
-- PAGE NO. 30

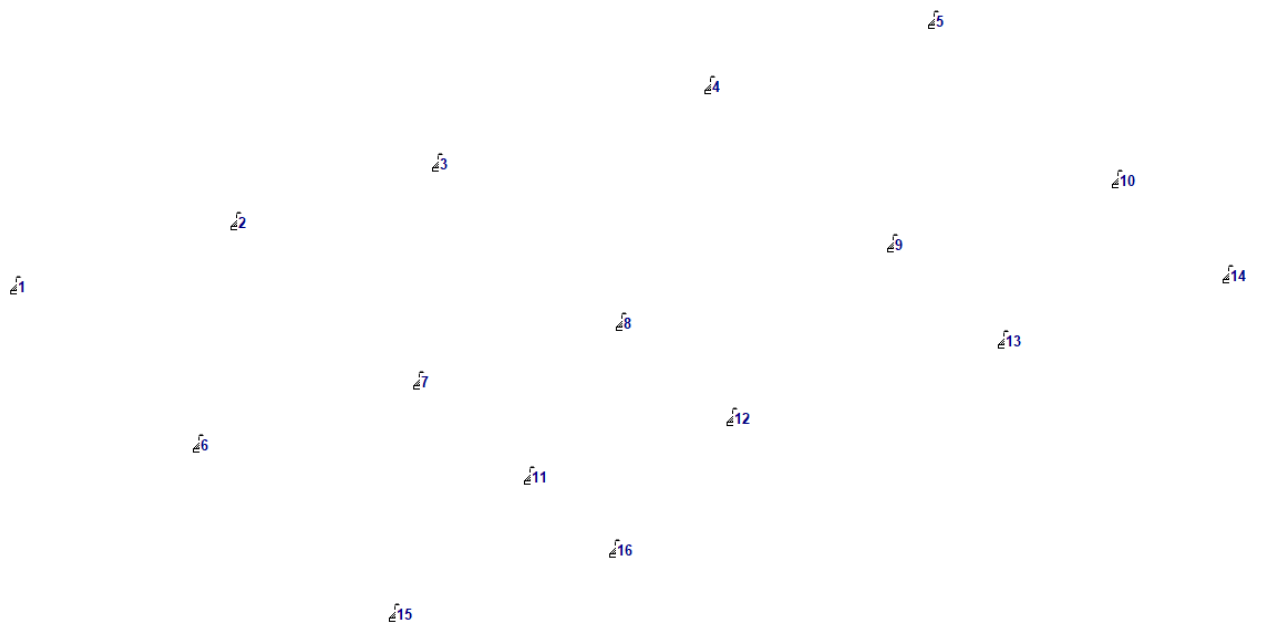
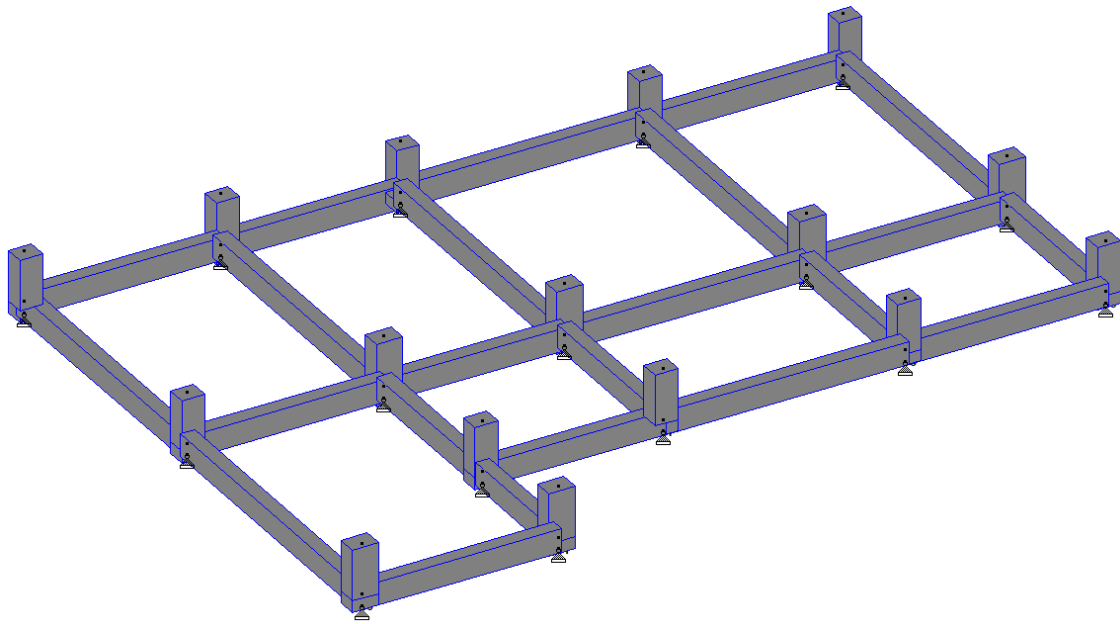
		118	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		119	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		120	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		121	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		122	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		123	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		124	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		125	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		126	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		127	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
		128	0.0000	0.0000	0.0000	0.0000	L / 999999	PASS
2	3.50	101	0.0565	-0.0705	0.0565	0.0705	L / 4961	PASS
		102	-0.0965	-0.0724	0.0965	0.0724	L / 3628	PASS
		103	-0.0200	0.1263	0.0200	0.1263	L / 2772	PASS
		104	-0.0200	-0.2682	0.0200	0.2682	L / 1305	PASS
		105	0.1316	-0.0682	0.1316	0.0682	L / 2660	PASS
		106	-0.1744	-0.0718	0.1744	0.0718	L / 2007	PASS
		107	-0.0215	0.3255	0.0215	0.3255	L / 1075	PASS
		108	-0.0214	-0.4634	0.0214	0.4634	L / 755	PASS
		109	0.6662	0.2791	0.6662	0.2791	L / 525	PASS
		110	0.6476	-0.3239	0.6476	0.3239	L / 540	PASS
		111	-0.7090	-0.4190	0.7090	0.4190	L / 493	PASS
		112	-0.6904	0.1840	0.6904	0.1840	L / 507	PASS
		113	0.2130	0.9493	0.2130	0.9493	L / 369	PASS
		114	0.0002	0.6335	0.0002	0.6335	L / 552	PASS
		115	-0.0616	-1.3764	0.0616	1.3764	L / 254	PASS
		116	-0.0431	-0.7734	0.0431	0.7734	L / 452	PASS
		117	0.1380	-0.0518	0.1380	0.0518	L / 2536	PASS

STORY DRIFT

STORY	HEIGHT	LOAD	AVG. DISP(CM)		DRIFT(CM)		RATIO	STATUS
	(METE)		X	Z	X	Z		
BASE=	0.00						ALLOW. DRIFT = L / 154	
		118	-0.1680	-0.0554	0.1680	0.0554	L / 2084	PASS
		119	-0.0150	0.3418	0.0150	0.3418	L / 1024	PASS
		120	-0.0150	-0.4470	0.0150	0.4470	L / 783	PASS
		121	0.6726	0.2955	0.6726	0.2955	L / 520	PASS
		122	0.6540	-0.3075	0.6540	0.3075	L / 535	PASS
		123	-0.7026	-0.4026	0.7026	0.4026	L / 498	PASS
		124	-0.6840	0.2003	0.6840	0.2003	L / 511	PASS
		125	0.2194	0.9656	0.2194	0.9656	L / 362	PASS
		126	-0.1875	0.9371	0.1875	0.9371	L / 373	PASS
		127	-0.2494	-1.0728	0.2494	1.0728	L / 326	PASS
		128	0.1576	-1.0443	0.1576	1.0443	L / 335	PASS

SUPPORT REACTIONS





REACTIONS AT SUPPORT NODES (SUBSTRUCTURE)

		Horizontal	Vertical	Horizontal	Moment		
Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
1	210 COME	-5.104	80.367	20.247	0	0	0
	218 COME	46.558	156.627	-19.601	0	0	0
	220 COME	-36.309	83.282	48.234	0	0	0
	222 COME	17.841	168.408	-34.536	0	0	0
2	210 COME	10.544	92.564	88.165	0	0	0
	218 COME	5.573	131.414	-6.703	0	0	0
	220 COME	24.378	113.109	84.254	0	0	0
	222 COME	13.19	135.465	-29.961	0	0	0
3	210 COME	-12.07	173.201	77.204	0	0	0
	218 COME	0.406	262.495	6.588	0	0	0
	220 COME	-20.083	189.454	95.648	0	0	0
	222 COME	-5.702	291.507	-32.596	0	0	0
4	210 COME	1.777	162.233	62.445	0	0	0
	218 COME	9.183	228.108	8.4	0	0	0
	220 COME	3.893	189.664	88.5	0	0	0
	222 COME	7.948	236.293	-22.044	0	0	0
5	210 COME	6.761	75.474	69.267	0	0	0
	218 COME	64.029	173.06	-12.135	0	0	0
	220 COME	-21.142	62.909	107.672	0	0	0
	222 COME	33.364	161.989	-46.272	0	0	0
6	210 COME	1.416	241.672	-69.725	0	0	0
	218 COME	47.312	320.321	33.181	0	0	0
	220 COME	-16.018	269.15	-10.377	0	0	0
	222 COME	18.518	305.196	41.569	0	0	0
7	210 COME	-0.454	140.174	-55.449	0	0	0
	218 COME	7.517	205.319	-1.76	0	0	0
	220 COME	-0.988	159.076	9.651	0	0	0
	222 COME	1.493	211.676	-10.419	0	0	0
8	210 COME	-7.574	235.725	-84.197	0	0	0
	218 COME	10.476	308.586	10.951	0	0	0
	220 COME	-15.313	284.495	-4.33	0	0	0
	222 COME	-3.261	311.262	14.849	0	0	0
9	210 COME	-7.7	314.781	-73.745	0	0	0
	218 COME	-3.737	421.979	16.836	0	0	0
	220 COME	-10.53	368.536	-8.948	0	0	0
	222 COME	-8.281	439.681	25.471	0	0	0
10	210 COME	15.496	139.868	-86.692	0	0	0
	218 COME	92.601	253.778	2.919	0	0	0

REACTIONS AT SUPPORT NODES (CONT.) (SUBSTRUCTURE)

	220 COME	-6.494	147.876	-24.702	0	0	0
	222 COME	44.314	229.506	11.561	0	0	0
11	210 COME	-2.244	139.467	-104.858	0	0	0
	218 COME	60.515	175.994	3.062	0	0	0
	220 COME	-23.762	170.956	-58.24	0	0	0
	222 COME	25.404	191.951	16.714	0	0	0
12	210 COME	-5.103	155.329	-38.371	0	0	0
	218 COME	-24.164	162.124	-45.98	0	0	0
	220 COME	-5.293	132.297	-13.425	0	0	0
	222 COME	-16.591	165.763	-62.041	0	0	0
13	210 COME	1.48	176.899	-44.997	0	0	0
	218 COME	-6.493	177.875	-74.029	0	0	0
	220 COME	0.471	148.975	-32.297	0	0	0
	222 COME	-2.977	192.359	-90.385	0	0	0
14	210 COME	1.831	109.517	-18.156	0	0	0
	218 COME	54.908	120.853	-41.106	0	0	0
	220 COME	-17.255	66.913	14.082	0	0	0
	222 COME	23.026	117.364	-55.003	0	0	0
15	210 COME	3.86	99.844	16.426	0	0	0
	218 COME	41.948	102.869	-59.676	0	0	0
	220 COME	-13.744	86.485	43.515	0	0	0
	222 COME	21.558	107.778	-81.67	0	0	0
16	210 COME	-2.918	64.83	22.856	0	0	0
	218 COME	18.53	79.248	-35.052	0	0	0
	220 COME	-16.984	8.52	53.326	0	0	0
	222 COME	5.325	59.204	-61.595	0	0	0

NOTE:

LOAD COMBINATIONS:

- 210 (1.2 DL + .5 LL + 1 WL -X)
- 218 (1.464 DEAD + 0.5 LIVE - 1 SEISMIC-X - .3 SEISMIC-Z)
- 220 (1.464 DEAD + 0.5 LIVE + 1 SEISMIC-Z + .3 SEISMIC-X)
- 222 (1.464 DEAD + 0.5 LIVE - 1 SEISMIC-Z - .3 SEISMIC-X)

produces the most crucial loading to the columns and to the support nodes.

Note: Reactions from the structural analysis were gathered using dynamic analysis, considering Response Spectrum (+ and – directions).

COLUMNS

PROPOSED TWO STOREY RESIDENTIAL BUILDING

REINFORCED CONCRETE COLUMN

C - 1A / Column No. 121

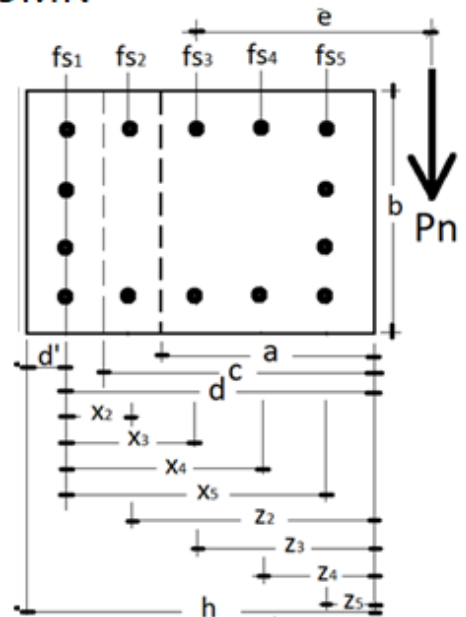
Design Parameters:

h = 400 mm	d' = 60 mm
b = 300 mm	Main bars = 16 mm ϕ
fc' = 21 Mpa	Mux = 22.163359 KNm
fy = 275 Mpa	Pu = 412.15729 KN
b ₁ = 0.85	Escon = 600 Mpa
Es = 200 Gpa	

Main Bars	Loc-Z	Ast
fs1 = 3	-	340.00
fs2 = 2	-	246.67
fs3 = 0	-	246.67
fs4 = 2	-	153.33
fs5 = 3	-	603.19

Shear parameters

Nvh = 3	, lateral ties leg
Nvb = 2	, lateral ties leg
fy _t = 230 Mpa	, lateral ties
Ties, Td = 12 mm ϕ	



Defining Condition;

$\phi = 0.65$, $\epsilon_t \leq \epsilon_{ty}$	if $f_s > f_y$, use f_y
$\phi = Val$, $\epsilon_{ty} < \epsilon_t < 0.005$	
$\phi = 0.90$, $\epsilon_t \geq 0.005$	

Val = Use 0.65 in transition Region

MAXIMUM AXIAL CAPACITY Ag = 120000 NSCP 422.4.2.2

$$P_{cn} = 0.8 [0.85 f'_c (A_g - A_s) + f_y A_s] = 2,127.22 \text{ kN}$$

$$\phi = 0.65, P_{cu} = \phi P_{cn} = 1,382.70 \text{ kN}$$

BALANCE CONDITION CAPACITY, $\phi = 0.65$

$$\epsilon_y = f_y / E_s = 0.00138$$

$$C_b = \epsilon_c d / \epsilon_c + \epsilon_y = 233.14 \text{ mm}$$

$$a_b = \beta C = 198.17 \text{ mm}$$

from strain diagram

As[f_y or f_s]

fs1 = 600(d-C)/C = 275.00	T1 = 165.88 KN, Tension
fs2 = 600(C-Z2)/C = -34.80	C2 = -14.00 KN, Tension
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 205.39	C4 = 82.59 KN, Compression
fs5 = 600(C-Z5)/C = 445.59	C5 = 165.88 KN, Compression

$$C_c = .85 f'_c a_b = 1061.208 \text{ KN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 1129.8 \text{ KN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 140.00 \text{ mm}$$

$$P_{bn} X = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$e_b = 139.89 \text{ mm} \quad \phi P_b = 734.4 \text{ KN}$$

$$M_b = 158.04 \text{ KNm} \quad \phi M_b = 102.73 \text{ KNm}$$

ECCENTRICALLY LOADED SECTION CAPACITY, $\phi = .65$

due to applied load, $e_x = 53.77$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T$$

$$[\sum M_T = 0], P_{bn} X = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$C = 350.36 \text{ mm} \quad a = 297.81 \text{ mm}$$

fs1 = 600(d-C)/C = -17.74	T1 = 10.70 KN, Tension
fs2 = 600(C-Z2)/C = 177.58	C2 = 71.41 KN, Compression
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 337.41	C4 = 110.58 KN, Compression
fs5 = 600(C-Z5)/C = 497.25	C5 = 165.88 KN, Compression

$$C_c = .85 f'_c a_b = 1594.75$$

Pnx = 1953.32	$\phi P_n = 1269.66 \text{ KN}$	>	412.16	Pass!
Mnx = 105.04	$\phi M_n = 68.27 \text{ KNm}$	>	22.16	Pass!

COMPRESSION CONTROLLED CAPACITY, $\phi = .65$

$$\epsilon_t = -0.002$$

$$C_t = \epsilon_{scon} d / (\epsilon_{scon} - \epsilon_s \epsilon_t) = 204.00 \text{ mm}$$

$$a_t = \beta C = 173.40 \text{ mm}$$

from strain diagram

As[f_y or f_s]

fs1 = 600(d-C)/C = 400.00	T1 = 165.88 KN, T
fs2 = 600(C-Z2)/C = -125.49	C2 = -50.46 KN, T
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 149.02	C4 = 59.92 KN, C
fs5 = 600(C-Z5)/C = 423.53	C5 = 165.88 KN, C

$$C_c = .85 f'_c a_b = 928.557 \text{ KN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 938.0 \text{ KN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 140 \text{ mm}$$

$$P_{bn} X = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$e_t = 110.74 \text{ mm} \quad \phi P_t = 609.71 \text{ KN}$$

$$M_t = 67.52 \text{ KNm} \quad \phi M_t = 43.89 \text{ KNm}$$

CHECK SHEAR, $\phi_v = 0.75$

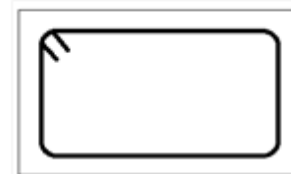
$V_c = 0.17 [1 + (P_u / 14 A_g)] \sqrt{f'_c} b d t$	= 98.96	93.14	KN
$A_v = \pi T d^2 N_v / 4$	= 339.3	226.2	mm ²

Smax, min (16db, 48dties and least col dimension)

$$16 \text{ db} = 256 \text{ mm}$$

$$48 \text{ dties} = 576 \text{ mm}$$

$$\text{Least Column dimension} = 300 \text{ mm}$$



Therefore use, 400x300mm 10-16mm ϕ longitudinal bars (GRADE 40) with 12mm ϕ lateral ties space at, 1@50, 5@150mm, and Rest 200mm O.C, BOTH ENDS.

REINFORCED CONCRETE COLUMN

C - 1B / Column No. 122

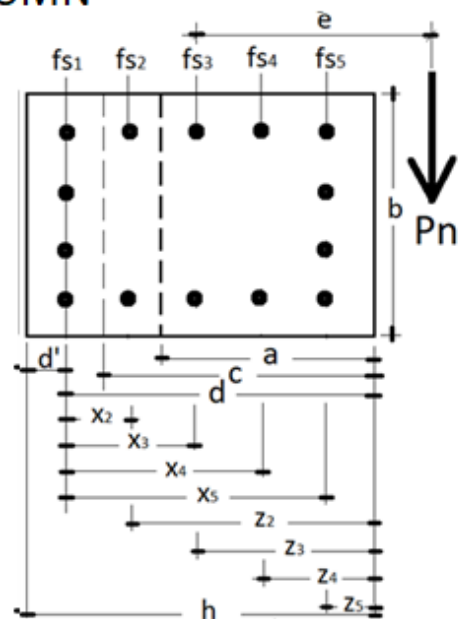
Design Parameters:

h = 300 mm	d' = 60 mm
b = 200 mm	Main bars = 16 mm ϕ
fc' = 21 Mpa	Mux = 6.0932956 KNm
fy = 275 Mpa	Pu = 57.782845 KN
b ₁ = 0.85	Escon = 600 Mpa
Es = 200 Gpa	

Main Bars	Loc-Z	Ast
fs1 = 3	-	240.00
fs2 = 1	-	180.00
fs3 = 0	-	180.00
fs4 = 1	-	120.00
fs5 = 3	-	60.00

Shear parameters

Nvh = 2	, lateral ties leg
Nvb = 2	, lateral ties leg
fy _t = 230	Mpa, lateral ties
Ties, Td = 12	mm ϕ



Defining Condition:

$\phi = 0.65$, $\epsilon_t \leq \epsilon_{ty}$	if $f_s > f_y$, use f_y
$\phi = \text{Val}$, $\epsilon_{ty} < \epsilon_t < 0.005$	
$\phi = 0.90$, $\epsilon_t \geq 0.005$	

Val = Use 0.65 in transition Region

MAXIMUM AXIAL CAPACITY Ag = 60000 NSCP 422.4.2.2

$$P_{cn} = 0.8 [0.85 f_c' (A_g - A_s) + f_y A_s] = 1,151.51 \text{ kN}$$

$$\phi = 0.65, P_{cu} = \phi P_{cn} = 748.48 \text{ kN}$$

BALANCE CONDITION CAPACITY, $\phi = 0.65$

$$\epsilon_y = f_y / E_s = 0.00138$$

$$C_b = \epsilon_c d / \epsilon_c + \epsilon_y = 164.57 \text{ mm}$$

$$a_b = \beta C = 139.89 \text{ mm}$$

from strain diagram

As[f_y or f_s]

fs1 = 600(d-C)/C = 275.00	T1 = 165.88 KN, Tension
fs2 = 600(C-Z2)/C = -56.25	C2 = -6.36 KN, Tension
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 162.50	C4 = 18.38 KN, Compression
fs5 = 600(C-Z5)/C = 381.25	C5 = 165.88 KN, Compression
Cc = .85 f'c ab = 499.392 KN	

$$[\sum F_v = 0], P_{bn} = C2 + C3 + C4 + C5 + Cc - T = 511.4 \text{ KN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 90.00 \text{ mm}$$

$$P_{bn} X = C2 X2 + C3 X3 + C4 X4 + C5 X5 + Cc Xc$$

$$e_b = 138.01 \text{ mm}, \phi P_b = 332.4 \text{ KN}$$

$$M_b = 70.58 \text{ KNm}, \phi M_b = 45.88 \text{ KNm}$$

ECENTRICALLY LOADED SECTION CAPACITY, $\phi = .65$

due to applied load, $e_x = 105.45$

$$[\sum F_v = 0], P_{bn} = C2 + C3 + C4 + C5 + Cc - T$$

$$[\sum M_T = 0], P_{bn} X = C2 X2 + C3 X3 + C4 X4 + C5 X5 + Cc Xc$$

$$C = 182.04 \text{ mm}, a = 154.73 \text{ mm}$$

fs1 = 600(d-C)/C = 191.03	T1 = 115.23 KN, Tension
fs2 = 600(C-Z2)/C = 6.72	C2 = 0.76 KN, Compression
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 204.48	C4 = 23.13 KN, Compression
fs5 = 600(C-Z5)/C = 402.24	C5 = 165.88 KN, Compression
Cc = .85 f'c ab = 552.40	

Pnx = 626.93	$\phi P_n = 407.51 \text{ KN}$	>	57.78	Pass!
Mnx = 66.11	$\phi M_n = 42.97 \text{ KNm}$	>	6.09	Pass!

COMPRESSION CONTROLLED CAPACITY, $\phi = .65$

$$\epsilon_t = -0.002$$

$$C_t = \text{Escon } d / (E_s \text{con} - E_s \epsilon_t) = 144.00 \text{ mm}$$

$$a_t = \beta C = 122.40 \text{ mm}$$

from strain diagram

As[f_y or f_s]

fs1 = 600(d-C)/C = 400.00	T1 = 165.88 KN, T
fs2 = 600(C-Z2)/C = -150.00	C2 = -16.96 KN, T
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00 KN,
fs4 = 600(C-Z4)/C = 100.00	C4 = 11.31 KN, C
fs5 = 600(C-Z5)/C = 350.00	C5 = 165.88 KN, C
Cc = .85 f'c ab = 436.968 KN	

$$[\sum F_v = 0], P_{bn} = C2 + C3 + C4 + C5 + Cc - T = 431.3 \text{ KN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 90 \text{ mm}$$

$$P_{bn} X = C2 X2 + C3 X3 + C4 X4 + C5 X5 + Cc Xc$$

$$e_t = 91.14 \text{ mm}, \phi P_t = 280.35 \text{ KN}$$

$$M_t = 25.55 \text{ KNm}, \phi M_t = 16.61 \text{ KNm}$$

CHECK SHEAR, $\phi_v = 0.75$

$$V_c = 0.17 [1 + (P_u / 14 A_g)] \sqrt{f_c'} b d t = 39.97 \text{ KN}$$

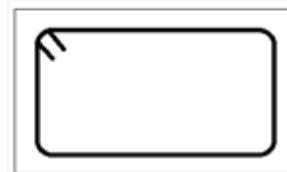
$$A_v = \pi T d^2 N_v / 4 = 226.2 \text{ mm}^2$$

Smax, min (16db, 48dties and least col dimension)

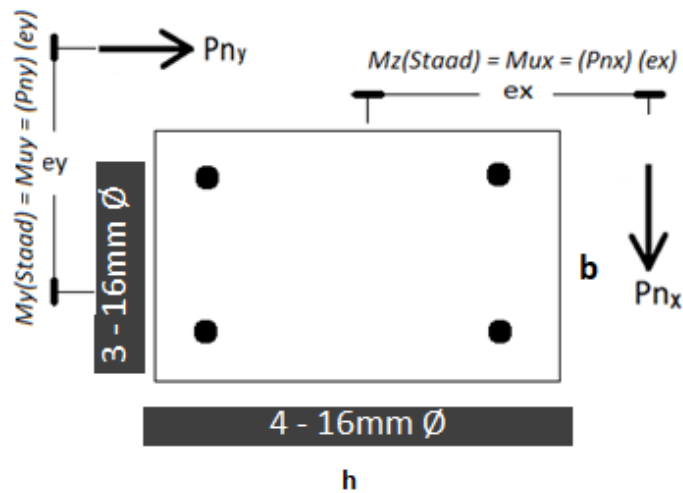
$$16 \text{ db} = 256 \text{ mm}$$

$$48 \text{ dties} = 576 \text{ mm}$$

$$\text{Least Column dimension} = 200 \text{ mm}$$



Therefore use, 300x200mm 6-16mm & 2-12mm ϕ longitudinal bars (GRADE 40) with 12mm ϕ lateral ties space at, 1@50, 5@150mm, and Rest 200mm O.C, BOTH ENDS.



FORCE TRANSFER GUIDE FROM STAAD RESULT OR EQUIVALENT SOFTWARE

$M_z (Staad) = M_{ux} = 6.0933 < 42.97$ **Pass!**, $e_x = 105.45 \text{ mm}$
 $M_y (Staad) = M_{uy} = 29.6344 < 30.63$ **Pass!**, $e_y = 512.86 \text{ mm}$
 $\phi P_{nx} = 407.51 > 57.782844543457$ **Pass!**
 $\phi P_{ny} = 59.73 > 57.782844543457$ **Pass!**

Col Height, $H = 3$ Floor to Beam Bottom
 Length factor, $K = 0.5$ Refer (Sheet 2)

Column Slenderness (Unbraced Column, $KL/r \leq 22$), 406.2.5

$KL/r_x = 16.67 < 22$ **Ok!**
 $KL/r_y = 25 > 22$ **Slender**

Dimension Limits, 418.7.2.1

$250 \text{ mm} \nabla 200$ **Thin Section**

Main reinforcement Ratio

$0.01A_g < A_{st} > 0.06A_g$

$A_{st} = 1432.57$

Ok!

Traverse Reinforcements, 418.7.5.4

No of Leg Req, $h = 2$

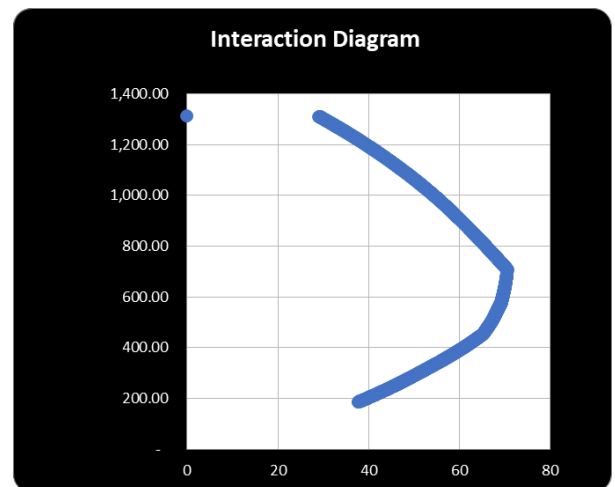
Ok!

Apply on Lo and Joints only

No of Leg Req, $b = 1$

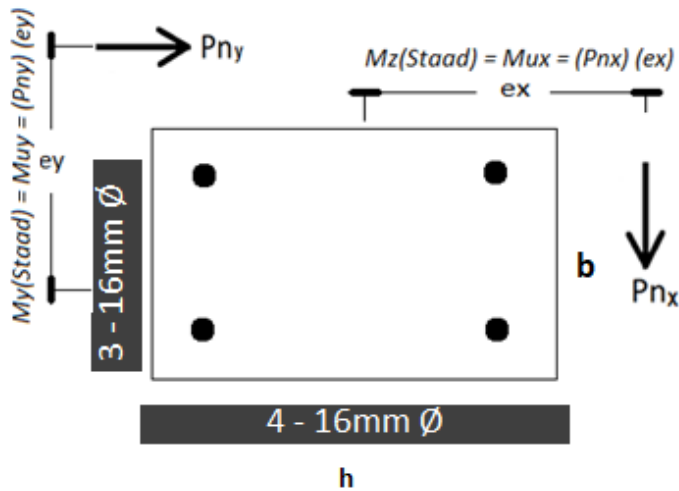
Ok!

Apply on Lo and Joints only



1

Side	h	m	With Seismic Provision, NSCP 2015 Sec 418.7.5					
H	Col mark	Vu	Vs	Smax	Seismic req	QTY	DIST	
Lo	0 - 0.05m	4.09423	(34.51)	200.00	50	1	50	Pass!
	0.05 - 0.5m	4.09423	(34.51)	200.00	50	5	150	Pass!
Mid	> 0.5m	4.09423	(34.51)	200.00	100	Rest	200	Ok!
			$V_s = (V_u / \phi) - V_c$					
			$S = A_v f_y t d / V_s$					
			First lat ties Min of 50mm from Face of Support					



FORCE TRANSFER GUIDE FROM STAAD RESULT OR EQUIVALENT SOFTWARE

$M_z(\text{Staad}) = M_{ux} = 41.5331 < 109.83$ **Pass!**, $e_x = 132.83 \text{ mm}$
 $M_y(\text{Staad}) = M_{uy} = 32.3935 < 68.77$ **Pass!**, $e_y = 103.6 \text{ mm}$
 $\phi P_{nx} = 826.89 > 312.689361572265$ **Pass!**
 $\phi P_{ny} = 663.83 > 312.689361572265$ **Pass!**

Col Height, $H = 3.5$ Floor to Beam Bottom
 Length factor, $K = 0.5$ Refer (Sheet 2)

Column Slenderness (Unbraced Column, $KL/r \leq 22$), 406.2.5

$KL/r_x = 16.67 < 22$ **Ok!**
 $KL/r_y = 19.44 < 22$ **Ok!**

Dimension Limits, 418.7.2.1

250 mm ∇ 300 **Ok!**

Main reinforcement Ratio

$0.01A_g < A_{st} > 0.06A_g$

$A_{st} = 1658.76$

Ok!

Traverse Reinforcements, 418.7.5.4

No of Leg Req, $h = 2$

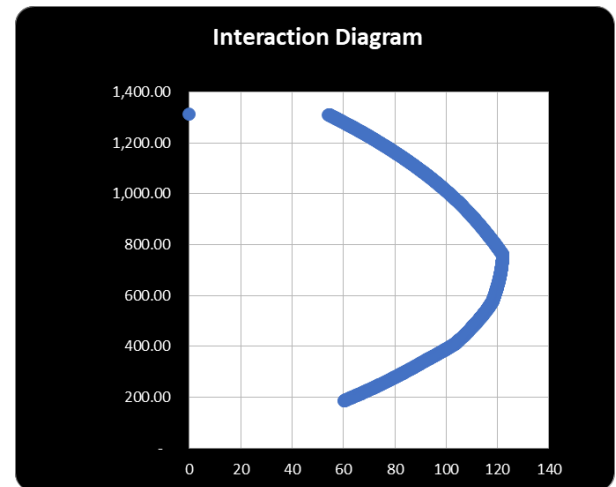
Ok!

Apply on Lo and Joints only

No of Leg Req, $b = 2$

Ok!

Apply on Lo and Joints only



Side	h	m	With Seismic Provision, NSCP 2015 Sec 418.7.5				
H	Col mark	Vu	Vs	Smax	Seismic req	QTY	DIST
Lo	0-0.05m	20.8326	(54.42)	256.00	50	1	50
	833333333	20.8326	(54.42)	256.00	70	5	150
Mid	333333333	20.8326	(54.42)	256.00	100	Rest	200
		$V_s = (V_u / \phi) - V_c$		First lat ties Min of 50mm from Face of Support			
		$S = A_v f_y t d / V_s$					

REINFORCED CONCRETE COLUMN

C - 2B / Column No. 116

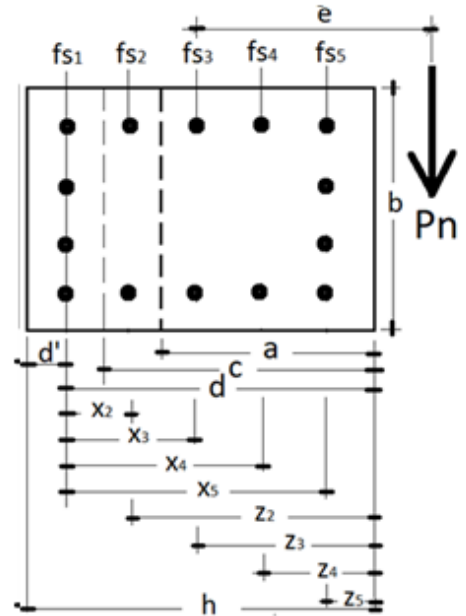
Design Parameters:

h = 300 mm	d' = 60 mm
b = 200 mm	Main bars = 16 mm ϕ
fc' = 21 Mpa	Mux = 15.089848 kNm
fy = 275 Mpa	Pu = 63.738579 kN
bi = 0.85	Escon = 600 Mpa
Es = 200 Gpa	

Main Bars	Loc-Z	Ast
fs1 = 3	- 240.00	603.19
fs2 = 1	- 180.00	113.1
fs3 = 0	- 180.00	0
fs4 = 1	- 120.00	113.1
fs5 = 3	- 60.00	603.19

Shear parameters

Nvh = 2	, lateral ties leg
Nvb = 2	, lateral ties leg
fyf = 230	Mpa, lateral ties
Ties, Td = 12	mm ϕ



Defining Condition:

$\phi = 0.65$, $\epsilon_t \leq \epsilon_{ty}$	if $f_s > f_y$, use f_y
$\phi = 0.90$, $\epsilon_t < \epsilon_t < 0.005$	
$\phi = 0.90$, $\epsilon_t \geq 0.005$	

Val = Use 0.65 in transition Region

MAXIMUM AXIAL CAPACITY Ag = 60000 NSCP 422.4.2.2

$$P_{cn} = 0.8 [0.85 f_c' (A_g - A_s) + f_y A_s] = 1,151.51 \text{ kN}$$

$$\phi = 0.65, P_{cu} = \phi P_{cn} = 748.48 \text{ kN}$$

BALANCE CONDITION CAPACITY, $\phi = 0.65$

$$\epsilon_y = f_y / E_s = 0.00138$$

$$C_b = \epsilon_c d / \epsilon_c + \epsilon_y = 164.57 \text{ mm}$$

$$a_b = \beta C = 139.89 \text{ mm}$$

from strain diagram

As[fy or fs]

fs1 = 600(d-C)/C = 275.00	T1 = 165.88	kN, Tension
fs2 = 600(C-Z2)/C = -56.25	C2 = -6.36	kN, Tension
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00	kN,
fs4 = 600(C-Z4)/C = 162.50	C4 = 18.38	kN, Compression
fs5 = 600(C-Z5)/C = 381.25	C5 = 165.88	kN, Compression

$$C_c = .85 f_c' a_b = 499.392 \text{ kN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 511.4 \text{ kN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 90.00 \text{ mm}$$

$$P_{bnX} = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$e_b = 138.01 \text{ mm} \quad \phi P_b = 332.4 \text{ kN}$$

$$M_b = 70.58 \text{ kNm} \quad \phi M_b = 45.88 \text{ kNm}$$

ECCENTRICALLY LOADED SECTION CAPACITY, $\phi = .90$

due to applied load, $e_x = 236.75$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T$$

$$[\sum M_T = 0], P_{bnX} = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$C = 104.88 \text{ mm} \quad a = 89.15 \text{ mm}$$

fs1 = 600(d-C)/C = 773.00	T1 = 165.88	kN, Tension
fs2 = 600(C-Z2)/C = -429.75	C2 = 31.10	kN, Tension
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00	kN,
fs4 = 600(C-Z4)/C = -86.50	C4 = 9.78	kN, Tension
fs5 = 600(C-Z5)/C = 256.75	C5 = 154.87	kN, Compression

$$C_c = .85 f_c' a_b = 318.26$$

Pnx = 266.37	$\phi P_n = 239.73$	kN	>	63.74	Pass!
Mnx = 63.06	$\phi M_n = 56.75$	kNm	>	15.09	Pass!

TENSION CONTROLLED CAPACITY,

$$\phi = .90$$

$$\epsilon_t = -0.005$$

$$C_t = \epsilon_{scon} d / (\epsilon_{scon} - \epsilon_s \epsilon_t) = 90.00 \text{ mm}$$

$$a_t = \beta C = 76.50 \text{ mm}$$

from strain diagram

As[fy or fs]

fs1 = 600(d-C)/C = 1000.00	T1 = 165.88	kN, T
fs2 = 600(C-Z2)/C = -600.00	C2 = -31.10	kN, T
fs3 = 600(C-Z3)/C = 0.00	C3 = 0.00	kN,
fs4 = 600(C-Z4)/C = -200.00	C4 = -22.62	kN, T
fs5 = 600(C-Z5)/C = 200.00	C5 = 120.64	kN, C

$$C_c = .85 f_c' a_b = 273.105 \text{ kN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 174.1 \text{ kN}$$

$$[\sum M_T = 0], \text{ find } e = x - z, z = 90 \text{ mm}$$

$$P_{bnX} = C_2 X_2 + C_3 X_3 + C_4 X_4 + C_5 X_5 + C_c X_c$$

$$e_t = 226.40 \text{ mm} \quad \phi P_t = 156.73 \text{ kN}$$

$$M_t = 35.48 \text{ kNm} \quad \phi M_t = 31.93 \text{ kNm}$$

CHECK SHEAR, $\phi_v = 0.75$

$$V_c = 0.17 [1 + (P_u / 14 A_g)] \sqrt{f_c'} b d t = 40.23 \text{ kN}$$

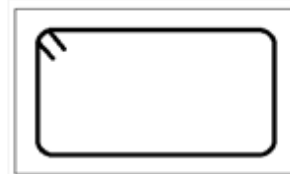
$$A_v = \pi T d^2 N_v / 4 = 226.2 \text{ mm}^2$$

Smax, min (16db, 48dties and least col dimension)

$$16 \text{ db} = 256 \text{ mm}$$

$$48 \text{ dties} = 576 \text{ mm}$$

$$\text{Least Column dimension} = 200 \text{ mm}$$



Therefore use, 300x200mm 6-16mm & 2-12mm ϕ longitudinal bars (GRADE 40) with 12mm ϕ lateral ties space at, 1@50, 5@150mm, and Rest 200mm O.C, BOTH ENDS.

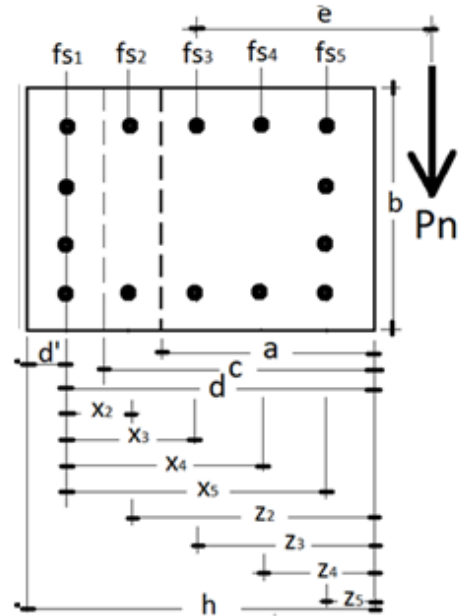
Side	h	m	With Seismic Provision, NSCP 2015 Sec 418.7.5					
H	Col mark	Vu	Vs	Smax	Seismic req	QTY	DIST	
Lo	0-0.05m	6.6548	(31.36)	200.00	50	1	50	Pass!
	0.05-0.5m	6.6548	(31.36)	200.00	50	5	150	Pass!
Mid	>0.5m	6.6548	(31.36)	200.00	100	Rest	200	Ok!

Sx

$$V_s = (V_u / \phi) - V_c$$
$$S = A_v f_y t d / V_s$$

First lat ties Min of 50mm from Face of Support

C - 3A / Column No. 133



Nvh = 3, lateral ties leg
Nvb = 2, lateral ties leg
fyt = 230 Mpa, lateral ties
Ties, Td = 12 mm Ø

MAXIMUM AXIAL CAPACITY $A_g = 120000$ NSCP 422.4.2.2

$$P_{cn} = 0.8 [0.85 f_c' (A_g - A_s) + f_y A_s] = 2,127.22 \text{ kN}$$

$$\phi = 0.65, P_{cu} = \phi P_{cn} = 1,382.70 \text{ kN}$$

BALANCE CONDITION CAPACITY, $\phi = 0.65$

$$\epsilon_y = f_y / E_s = 0.00138$$

$$C_b = \epsilon_c d / \epsilon_c + \epsilon_y = 233.14 \text{ mm}$$

$$ab = \beta C = 198.17 \text{ mm}$$

from strain diagram

As[fy or fs]

$f_{s1} = 600(d-C)/C$	=	275.00	T1 =	165.88	KN, Tension
$f_{s2} = 600(C-Z_2)/C$	=	-34.80	C2 =	-14.00	KN, Tension
$f_{s3} = 600(C-Z_3)/C$	=	0.00	C3 =	0.00	KN,
$f_{s4} = 600(C-Z_4)/C$	=	205.39	C4 =	82.59	KN, Compression
$f_{s5} = 600(C-Z_5)/C$	=	445.59	C5 =	165.88	KN, Compression

$$C_c = .85 f'_c a b = 1061.208 \text{ KN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 1129.8 \text{ KN}$$

$[\Sigma M_T = 0]$, find $e = x - z$, $z = 140.00 \text{ mm}$

$$P_{bn}X = C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_cX_c$$

$$e_b = 139.89 \quad \text{mm} \quad \varnothing P_b = 734.4$$

$$M_b = 158.04 \quad \text{KNm} \quad \phi M_b = 102.73 \quad \text{KNm}$$

ECCENTRICALLY LOADED SECTION CAPACITY, $\phi = .90$

due to applied load, $e_x = 567.47$

$$[\sum F_v = 0], \quad P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T$$

$$[\sum MT = 0], \quad PbnX = C2X2 + C3X3 + C4X4 + C5X5 + CcXc$$

$C = 98.08 \text{ mm}$ $a = 83.37 \text{ mm}$

$fs_1 = 600(d-C)/C$	=	1479.93	$T_1 =$	165.88	KN, Tension
$fs_2 = 600(C-Z_2)/C$	=	-908.97	$C_2 =$	110.58	KN, Tension
$fs_3 = 600(C-Z_3)/C$	=	0.00	$C_3 =$	0.00	KN,
$fs_4 = 600(C-Z_4)/C$	=	-338.01	$C_4 =$	110.58	KN, Tension
$fs_5 = 600(C-Z_5)/C$	=	232.95	$C_5 =$	140.51	KN, Compres

$$C_c = .85 f'_c a b = 446.44$$

$P_{nx} =$	199.91	$\phi P_n =$	179.91	KN	>	118.62	Pass!
$M_{nx} =$	113.44	$\phi M_n =$	102.10	KNm	>	67.31	Pass!

TENSION CONTROLLED CAPACITY,

$\epsilon_t = -0.005$

$$C_t = \frac{f_s \text{con } d}{(E_s \text{con} - E_s \text{ Et})} = 127.50 \text{ mm}$$

$$a_t = \beta C = 108.38 \text{ mm}$$

from strain diagram

As[fy or fs]

$fs_1 = 600(d-C)/C =$	1000.00	$T_1 =$	165.88	KN, T
$fs_2 = 600(C-Z_2)/C =$	-560.78	$C_2 =$	-110.58	KN, T
$fs_3 = 600(C-Z_3)/C =$	0.00	$C_3 =$	0.00	KN,
$fs_4 = 600(C-Z_4)/C =$	-121.57	$C_4 =$	-48.89	KN, T
$fs_5 = 600(C-Z_5)/C =$	317.65	$C_5 =$	165.88	KN, C

$$C_c = .85 f'_c ab = 580.348 \text{ KN}$$

$$[\sum F_v = 0], P_{bn} = C_2 + C_3 + C_4 + C_5 + C_c - T = 420.9 \text{ KN}$$

$[\sum M_T = 0]$, find $e = x - z$, $z = 140 \text{ mm}$

$$P_{bn}X = C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_cX_c$$

$$e_t = 254.11 \text{ mm} \quad \phi P_t = 378.79 \text{ KN}$$

$$M_t = 96.25 \text{ KNm} \quad \emptyset M_t = 86.63 \text{ KNm}$$

CHECK SHEAR, $\phi_v = 0.75$

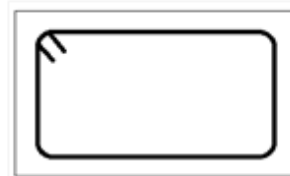
$$\begin{array}{lcl} V_c = 0.17[1+(P_u/14A_g)] v f'_c b dt & = & \begin{array}{|c|c|} \hline 85.07 & 80.07 \\ \hline \end{array} \text{ KN} \\ A_v = \pi T d^2 N_v / 4 & = & \begin{array}{|c|c|} \hline 339.3 & 226.2 \\ \hline \end{array} \text{ mm}^2 \end{array}$$

Smax, min (16db, 48dties and least col dimension)

16 db = 256 mm

$$48 \text{ dtjes} = 576 \text{ mm}$$

Least Column dimension = 300 mm



Therefore use, 400x300mm 10-16mm \varnothing longitudinal bars (GRADE 40) with 12mm \varnothing lateral ties space at, 1@50, 5@150mm , and Rest 200mm O.C, BOTH ENDS.

BEAMS

PROPOSED TWO STOREY RESIDENTIAL BUILDING

REINFORCED CONCRETE BEAM

B - 1 / Beam No. 32

Input Parameters :

Standard Specs	Momen	Sup Top	Mid Bot
$f_c' = 21$	ion Bar, Dt =	4	4
$f_y = 275$	Bar 2-L, Nb =	3	3
$b_1 = .85$	ion Bar, Dc =	4	4
$E_s = 200$ Gpa	Main Bar dia, D =	16	
	Moment, Mu =	111.6	12.4

Shear Capacity			
$b_w = 300$ mm	$f_y t = 230$		
$h = 450$ mm	$A_v = 2$		
$S_b = 10$ mm	Stirrups Bar \emptyset		
$C_c = 40$ mm	Clear Covering		

CONDITION : $V_{al} = 0.65 + 0.25 (\epsilon_t - \epsilon_{ty} / 0.005 - \epsilon_{ty})$

$$\emptyset = 0.65, \epsilon_t \leq \epsilon_{ty}$$

$$V_{al}, \epsilon_{ty} < \epsilon_t < 0.005$$

$$0.90, \epsilon_t \geq 0.005$$

Location of d' & dt ;

	Support	Midspan
$As1 = \pi D^2 Db / 4 =$	804.25	804.25
$2L, As2 = \pi D^2 Nb / 4 =$	603.19	603.19
$y = (As1 y1 + As2 y2) / As =$	25.71	25.71
$d' = C_c + S_b + (D/2) + y =$	83.71	83.71
$dt = h - d' =$	366.29	366.29

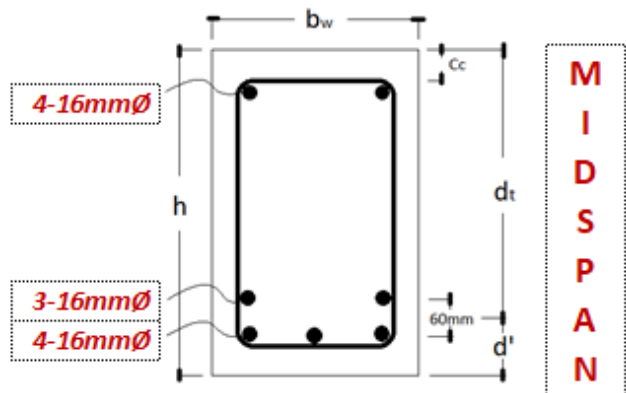
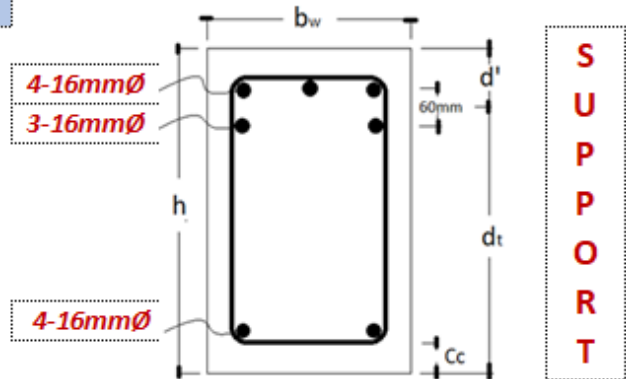
CHECKING : $\epsilon_t \geq 0.004$,

	Support	Midspan
$C_{max} = 600 dt / f_{smin} + 600 =$	157.0	156.98
$a_{max} = \beta_1 C_{max} =$	133.4	133.43
$As_{max} = 0.85 f_c' a_{max} b_w / f_y =$	2598.30	2598.30
$a = (As fy - As' fy) / 0.85 f_c' b =$	72.28	72.28
$C = a / \beta_1 =$	85.03	85.03
$fs' = 600 (C - d') / C =$	9.30	9.30
$fs' = \text{Compression Bars} =$	Not Yield	Not Yield
$fs = 600 (dt - C) / C =$	1984.57	1984.57
$fs = \text{Tension Bars} =$	Yield	Yield

BEAM MOMENT CAPACITY $\emptyset = 0.9$

$$As fy = 1.85 f_c' \beta_1 C b_w + As' fs' \text{ Where, } fs' = (600 C - d') / C$$

	Support	Midspan
$C = \text{by quadratic} =$	84.33	84.33
$a = \beta_1 C =$	71.68	71.68
$fs' = 600 (C - d') / C =$	4.38	4.38
$fs = 600 (dt - C) / C =$	2006.09	2006.09
$M_n = c [d t - (a/2)] + C_s (d t - d') =$	127.84	127.84
SUPPORT, $\emptyset M_n =$	115.05	> 111.61
MIDSPAN, $\emptyset M_n =$	115.05	> 12.35

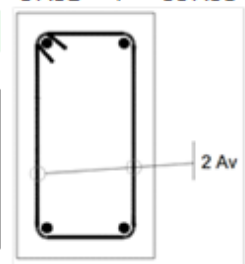


CHECK SHEAR; $\emptyset = 0.75$

$V_c = 0.17 v f_c' b_w dt =$	86	< 107.35
$V_{smax} = 0.67 v f_c' b_w dt =$	337	KN
$V_s = (V_u / \emptyset) - V_c =$	57.52	< 337.38

Section is Adequate

$A_v = 2 (\pi S_b^2 / 4) =$	157.1
Max S, w/c ever is lesser, mm	$V_s \leq 0.33 v f_c' b_w d, d/2$ or 600mm otherwise $V_s > 0.33 v f_c' b_w d,$ or 300mm



Therefore use 300x450 with 11-16mm \emptyset @ support and 11-16mm \emptyset @ midspan Main Bars (Grade 40);

10mm \emptyset 2 leg-stirrups: Sp. at 1@50, 4@150 and rest 200 O.C

Main Bar Spacing Calculator

Sup Main Bar, S = 52 > 25mm

Mid Main Bar, S = 52 > 25mm

Dimensional Limits, 418.6.2.1

$b_w \geq \max[.3h, 200\text{mm}]$ Ok!

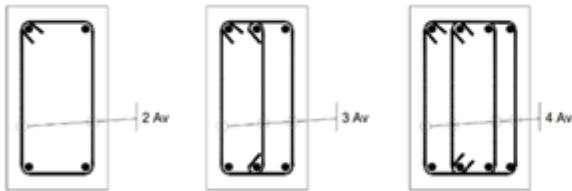
Main Reinforcements Ratio Limits, 418.6.3.1

$A_{smin} < A_s < A_{smax}$, Ok!

$A_{smin} < A_s < A_{smax}$, Ok!

Main Reinforcements, 418.6.3.2

$M_{umin} \geq 0.25 M_{umax}$ Increased Mumin!



Add extra Stirrups to increase area of Shear resisting steel, A_v

NSCP 2015 418.6.4

Beam mark on critical	Beam Length, m	V_u	V_s	S_{max}	Req per Seismic	Stirrups Spacing		
						Qty	mm	
	0 - 0.05m	107.35	57.52	257.5	50.00	1.00	50.00	Pass!
2h	0.05 - 0.9m	106.06	55.81	265.4	91.57	4.00	150.00	Pass!
> 2h	> 0.9m	81.90	23.60	627.7	183.14	Rest	200.00	Pass!

REINFORCED CONCRETE BEAM

B - 2 / Beam No. 40

Input Parameters :

Standard Specs	Moment	Sup Top	Mid Bot	Shear Capacity
$f_c' = 21$	ion Bar, Dt =	4	4	$b_w = 200$ mm $f_{yt} = 230$
$f_y = 275$	Bar 2-L, Nb =	3	3	$h = 400$ mm $A_v = 2$
$b_1 = .85$	ion Bar, Dc =	3	3	$S_b = 10$ mm Stirrups Bar \emptyset
$E_s = 200$ Gpa	Main Bar dia, D =	16		$C_c = 40$ mm, Clear Covering
	Moment, Mu =	90.4	3.1	

CONDITION : $\text{Val} = 0.65 + 0.25 (\epsilon_t - \epsilon_{ty} / 0.005 - \epsilon_{ty})$

$$\emptyset = 0.65, \epsilon_t \leq \epsilon_{ty}$$

$$\text{Val}, \epsilon_{ty} < \epsilon_t < 0.005$$

$$0.90, \epsilon_t \geq 0.005$$

Location of d' & dt ;

	Support	Midspan
$As1 = \pi D^2 Db / 4 =$	804.25	804.25
$2L, As2 = \pi D^2 Nb / 4 =$	603.19	603.19
$y = (As1 y1 + As2 y2) / As =$	25.71	25.71
$d' = C_c + S_b + (D/2) + y =$	83.71	83.71
$dt = h - d' =$	316.29	316.29

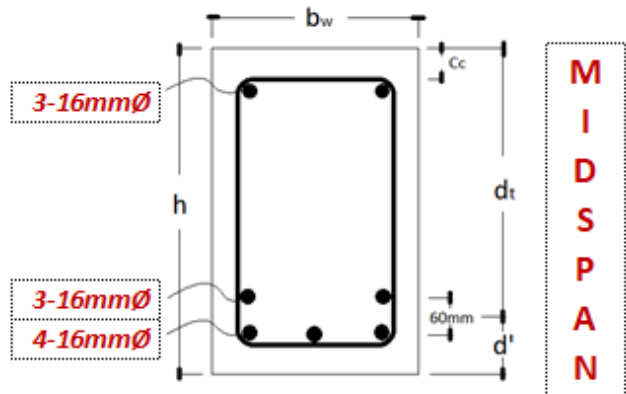
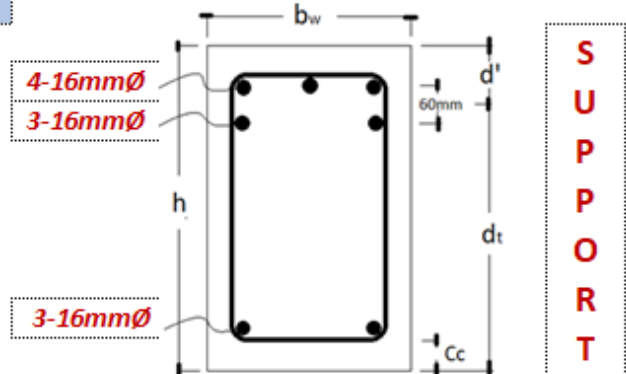
CHECKING : $\epsilon_t \geq 0.004$,

	Support	Midspan
$C_{max} = 600 dt / f_{smin} + 600 =$	135.6	135.55
$a_{max} = \beta_1 C_{max} =$	115.2	115.22
$AS_{max} = 0.85 f_c' a_{max} b_w / f_y =$	1495.74	1495.74
$a = (As f_y - As' f_y) / 0.85 f_c' b =$	108.42	108.42
$C = a / \beta_1 =$	127.55	127.55
$f_s' = 600 (C - d') / C =$	206.20	206.20
$f_s' = \text{Compression Bars} =$	Not Yield	Not Yield
$f_s = 600 (dt - C) / C =$	887.84	887.84
$f_s = \text{Tension Bars} =$	Yield	Yield

BEAM MOMENT CAPACITY $\emptyset = 0.9$

$$As f_y = 1.85 f_c' \beta_1 C b_w + As' f_s' \text{ Where, } f_s' = (600 C - d') / C$$

	Support	Midspan
$C = \text{by quadratic} =$	104.11	104.11
$a = \beta_1 C =$	88.49	88.49
$f_s' = 600 (C - d') / C =$	117.54	117.54
$f_s = 600 (dt - C) / C =$	1222.81	1222.81
$M_n = \phi [d t - (a/2)] + C_s (d t - d' =$	102.43	102.43
SUPPORT, $\emptyset M_n =$	92.19	> 90.35
MIDSPAN, $\emptyset M_n =$	92.19	> 3.07

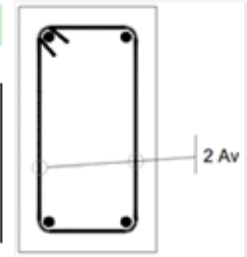


CHECK SHEAR; $\emptyset = 0.75$

$V_c = 0.17 \sqrt{f_c'} b_w dt =$	49	< 87.80
$V_{smax} = 0.67 \sqrt{f_c'} b_w dt =$	194	KN
$V_s = (V_u / \emptyset) - V_c =$	67.79	< 194.22

Section is Adequate

$A_v = 2 (\pi S_b^2 / 4) =$	157.1
$V_s \leq 0.33 \sqrt{f_c'} b_w d, d/2$	
or 600mm otherwise	
$V_s > 0.33 \sqrt{f_c'} b_w d,$	
or 300mm	



Therefore use 200x400 with 10-16mm \emptyset @ support and 10-16mm \emptyset @ midspan Main Bars (Grade 40);

10mm \emptyset 2 leg-stirrups: Sp. at 1@50, 4@150 and rest 200 O.C

Main Bar Spacing Calculator

Sup Main Bar, $S = 18.666667 < 25\text{mm}$

Mid Main Bar, $S = 18.666667 < 25\text{mm}$

Dimensional Limits, 418.6.2.1

$b_w \geq \max[.3h, 200\text{mm}]$ **Ok!**

Main Reinforcements Ratio Limits, 418.6.3.1

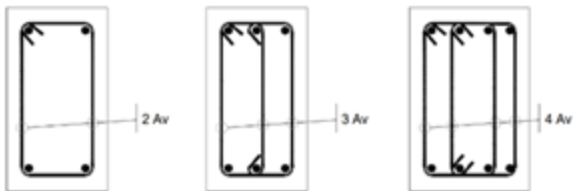
$A_{smin} < A_s < A_{smax}$, **Ok!**

$A_{smin} < A_s < A_{smax}$, **Ok!**

Main Reinforcements, 418.6.3.2

$M_{umin} \geq 0.25 M_{umax}$ **Increased Mumin!**

By Code, D_c shall atleast half of A_{st} at Support



Add extra Stirrups to increase area of Shear resisting steel, A_v

NSCP 2015 418.6.4

Beam mark on critical	Beam Length, m	V_u	V_s	S_{max}	Req per Seismic	Stirrups Spacing		
						Qty	mm	
	0 - 0.05m	87.80	67.79	191.9	50.00	1.00	50.00	Pass!
2h	0.05 - 0.8m	86.91	66.60	195.3	79.07	4.00	150.00	Pass!
> 2h	> 0.8m	70.18	44.29	293.7	158.14	Rest	200.00	Pass!

REINFORCED CONCRETE BEAM

B - 3 / Beam No. 65

Input Parameters :

Standard Specs

$$f_c' = 21$$

$$f_y = 275$$

$$b_1 = .85$$

$$E_s = 200 \text{ Gpa}$$

Momen

$$\text{ion Bar, Dt} =$$

$$\text{Bar 2-L, Nb} =$$

$$\text{ion Bar, Dc} =$$

$$\text{Main Bar dia, D} =$$

$$\text{Moment, Mu} =$$

Sup	Mid
Top	Bot
2	2
2	2
2	2
16	
42.8	12.1

Shear Capacity

$$b_w = 200 \text{ mm } f_{yt} = 230$$

$$h = 350 \text{ mm } A_v = 2$$

$$S_b = 10 \text{ mm } \text{Stirrups Bar } \emptyset$$

$$C_c = 40 \text{ mm, Clear Covering}$$

CONDITION : $\text{Val} = 0.65 + 0.25 (\epsilon_t - \epsilon_{ty} / 0.005 - \epsilon_{ty})$

$$\emptyset = 0.65, \epsilon_t \leq \epsilon_{ty}$$

$$\text{Val}, \epsilon_{ty} < \epsilon_t < 0.005$$

$$0.90, \epsilon_t \geq 0.005$$

Location of d' & dt ;

$$A_{s1} = \pi D^2 D_b / 4$$

$$2L, A_{s2} = \pi D^2 N_b / 4$$

$$y = (A_{s1} y_1 + A_{s2} y_2) / A_s$$

$$d' = C_c + S_b + (D/2) + y$$

$$dt = h - d'$$

Support Midspan

$$= 402.12 \quad 402.12$$

$$= 402.12 \quad 402.12$$

$$= 30.00 \quad 30.00$$

$$= 88.00 \quad 88.00$$

$$= 262.00 \quad 262.00$$

CHECKING : $\epsilon_t \geq 0.004$,

$$C_{max} = 600 dt / f_{smin} + 600$$

$$a_{max} = \beta_1 C_{max}$$

$$A_{smax} = 0.85 f_c' a_{max} b_w / f_y$$

$$a = (A_s f_y - A_s' f_y) / 0.85 f_c' b$$

$$C = a / \beta_1$$

$$f_s' = 600 (C - d') / C$$

$$f_s' = \text{Compression Bars}$$

$$f_s = 600 (dt - C) / C$$

$$f_s = \text{Tension Bars}$$

Support Midspan

$$= 112.3 \quad 112.29$$

$$= 95.4 \quad 95.44$$

$$= 1239.02 \quad 1239.02$$

$$= 61.95 \quad 61.95$$

$$= 72.88 \quad 72.88$$

$$= -124.43 \quad -124.43$$

$$= \text{Not Yield} \quad \text{Not Yield}$$

$$= 1556.84 \quad 1556.84$$

$$= \text{Yield} \quad \text{Yield}$$

BEAM MOMENT CAPACITY $\emptyset = 0.9$

$$A_s f_y = 0.85 f_c' \beta_1 C b_w + A_s' f_s' \text{ Where, } f_s' = (600 C - d') / C$$

Support Midspan

$$C = \text{by quadratic}$$

$$a = \beta_1 C$$

$$f_s' = 600 (C - d') / C$$

$$f_s = 600 (dt - C) / C$$

$$M_n = [C dt - (a/2)] + C_s (dt - d')$$

$$= 80.39 \quad 80.39$$

$$= 68.33 \quad 68.33$$

$$= -56.83 \quad -56.83$$

$$= 1355.56 \quad 1355.56$$

$$= 51.60 \quad 51.60$$

$$\text{SUPPORT, } \emptyset M_n = 46.44$$

$$>$$

$$42.81$$

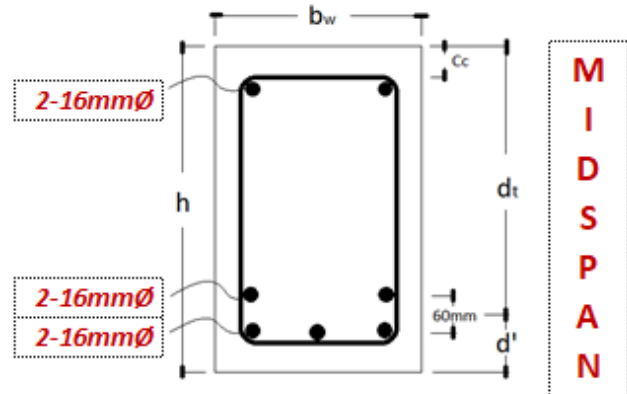
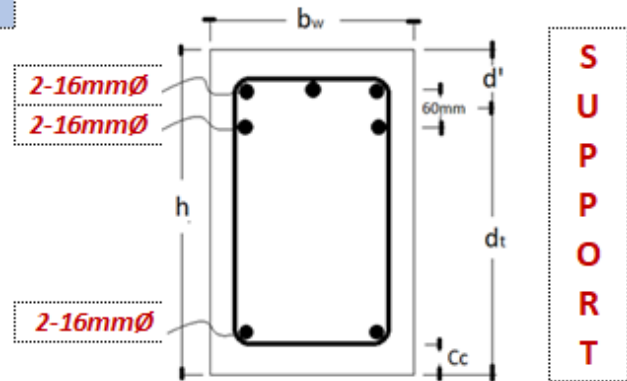
Pass!

$$\text{MIDSPAN, } \emptyset M_n = 46.44$$

$$>$$

$$12.07$$

Pass!



CHECK SHEAR; $\emptyset = 0.75$

$$V_c = 0.17 v_{fc}' b_w dt = 41 < 55.10$$

$$V_{smax} = 0.67 v_{fc}' b_w dt = 161 \text{ KN}$$

$$V_s = (V_u / \emptyset) - V_c = 32.65 < 160.89$$

Section is Adequate

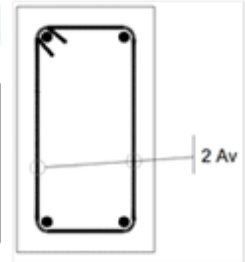
$$A_v = 2 (\pi S_b^2 / 4) = 157.1$$

Max S, w/c
ever is
lesser, mm

$$V_s \leq 0.33 v_{fc}' b_w d, d/2$$

$$V_s > 0.33 v_{fc}' b_w d,$$

$$\text{or } 300 \text{ mm}$$



Therefore use 200x350 with 6-16mmØ @ support and 6-16mmØ @ midspan Main Bars (Grade 40);

10mmØ 2 leg-stirrups: Sp. at 1@50, 5@150 and rest 200 O.C

Main Bar Spacing Calculator

Sup Main Bar, $S = 88 > 25\text{mm}$

Mid Main Bar, $S = 88 > 25\text{mm}$

Dimensional Limits, 418.6.2.1

$b_w \geq \max[.3h, 200\text{mm}]$ Ok!

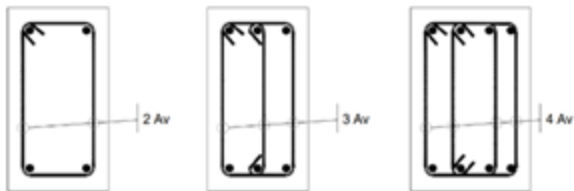
Main Reinforcements Ratio Limits, 418.6.3.1

$A_{smin} < A_s < A_{smax}$, Ok!

$A_{smin} < A_s < A_{smax}$, Ok!

Main Reinforcements, 418.6.3.2

$M_{umin} \geq 0.25 M_{umax}$ Ok!



Add extra Stirrups to increase area of Shear resisting steel, A_v

NSCP 2015 418.6.4

Beam mark on critical	Beam Length, m	V_u	V_s	S_{max}	Req per Seismic	Stirrups Spacing		
						Qty	mm	
	0 - 0.05m	55.10	32.65	343.1	50.00	1.00	50.00	Pass!
2h	0.05 - 0.7m	54.23	31.48	355.7	65.50	5.00	150.00	Pass!
> 2h	> 0.7m	39.93	12.42	901.4	131.00	Rest	200.00	Pass!

REINFORCED CONCRETE BEAM

RB - 1 / Beam No. 81

Input Parameters :

Standard Specs

$$f_c' = 21$$

$$f_y = 275$$

$$b_1 = .85$$

$$E_s = 200 \text{ Gpa}$$

Momen

$$\text{ion Bar, } D_t =$$

$$\text{Bar 2-L, } N_b =$$

$$\text{ion Bar, } D_c =$$

$$\text{Main Bar dia, } D =$$

$$\text{Moment, } M_u =$$

Sup	Mid
Top	Bot
3	3
0	0
2	2
16	16
31.1	5.7

Shear Capacity

$$b_w = 200 \text{ mm } f_{yt} = 230$$

$$h = 350 \text{ mm } A_v = 2$$

$$S_b = 10 \text{ mm } \text{Stirrups Bar } \phi$$

$$C_c = 40 \text{ mm, Clear Covering}$$

CONDITION : $\text{Val} = 0.65 + 0.25 (\epsilon_t - \epsilon_{ty} / 0.005 - \epsilon_{ty})$

$$\phi = 0.65, \epsilon_t \leq \epsilon_{ty}$$

$$\text{Val}, \epsilon_{ty} < \epsilon_t < 0.005$$

$$0.90, \epsilon_t \geq 0.005$$

Location of d' & d_t ;

Support Midspan

$$A_{s1} = \pi D^2 D_b / 4 = 603.19 \quad 603.19$$

$$2L, A_{s2} = \pi D^2 N_b / 4 = 0.00 \quad 0.00$$

$$y = (A_{s1} y_1 + A_{s2} y_2) / A_s = 0.00 \quad 0.00$$

$$d' = C_c + S_b + (D/2) + y = 58.00 \quad 58.00$$

$$d_t = h - d' = 292.00 \quad 292.00$$

CHECKING : $\epsilon_t \geq 0.004$,

Support Midspan

$$C_{max} = 600 d_t / f_{smin} + 600 = 125.1 \quad 125.14$$

$$a_{max} = \beta_1 C_{max} = 106.4 \quad 106.37$$

$$A_{smax} = 0.85 f_c' a_{max} b_w / f_y = 1380.89 \quad 1380.89$$

$$a = (A_s f_y - A_s' f_y) / (0.85 f_c' b) = 46.46 \quad 46.46$$

$$C = a / \beta_1 = 54.66 \quad 54.66$$

$$f_s' = 600 (C - d') / C = -36.62 \quad -36.62$$

$$f_s' = \text{Compression Bars} = \text{Not Yield} \quad \text{Not Yield}$$

$$f_s = 600 (d_t - C) / C = 2605.07 \quad 2605.07$$

$$f_s = \text{Tension Bars} = \text{Yield} \quad \text{Yield}$$

BEAM MOMENT CAPACITY $\phi = 0.9$

$$A_s f_y = 1.85 f_c' \beta_1 C b_w + A_s' f_s' \text{ Where, } f_s' = (600 C - d') / C$$

Support Midspan

$$C = \text{by quadratic} = 56.63 \quad 56.63$$

$$a = \beta_1 C = 48.13 \quad 48.13$$

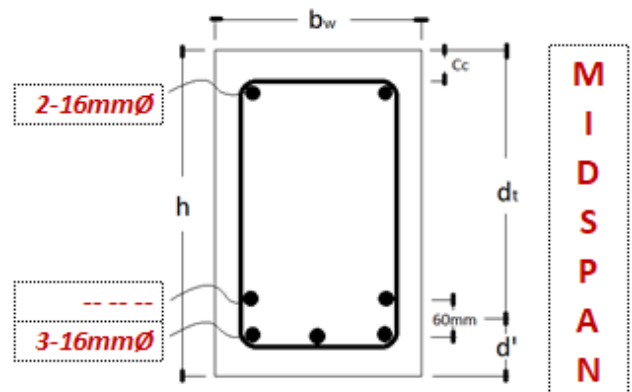
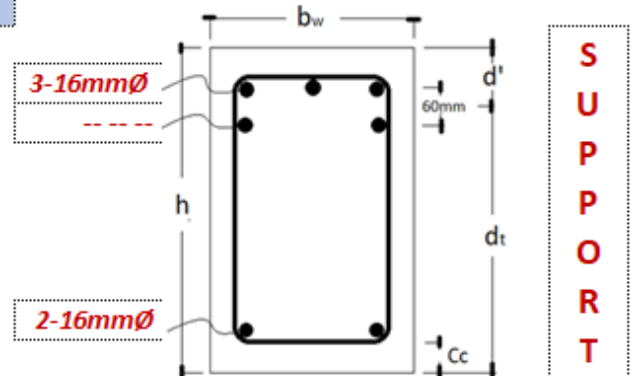
$$f_s' = 600 (C - d') / C = -14.56 \quad -14.56$$

$$f_s = 600 (d_t - C) / C = 2493.99 \quad 2493.99$$

$$M_n = \phi [d_t (a/2)] + C_s (d_t - d') = 44.67 \quad 44.67$$

$$\text{SUPPORT, } \phi M_n = 40.20 > 31.10 \quad \text{Pass!}$$

$$\text{MIDSPAN, } \phi M_n = 40.20 > 5.71 \quad \text{Pass!}$$



CHECK SHEAR; $\phi = 0.75$

$$V_c = 0.17 \sqrt{f_c'} b_w d_t = 45 < 17.72$$

$$V_{smax} = 0.67 \sqrt{f_c'} b_w d_t = 179 \text{ KN}$$

$$V_s = (V_u / \phi) - V_c = (21.87) < 179.31$$

Section is Adequate

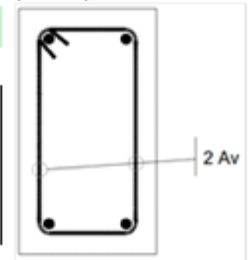
$$A_v = 2 (\pi S_b^2 / 4) = 157.1$$

$$V_s \leq 0.33 \sqrt{f_c'} b_w d, d/2$$

$$\text{or } 600 \text{ mm otherwise}$$

$$V_s > 0.33 \sqrt{f_c'} b_w d,$$

$$\text{or } 300 \text{ mm}$$



Therefore use 200x350 with 5-16mm ϕ @ support and 5-16mm ϕ @ midspan Main Bars (Grade 40);

10mm ϕ 2 leg-stirrups: Sp. at 1@50, 4@150 and rest 200 O.C

Main Bar Spacing Calculator

Sup Main Bar, $S = 36 > 25\text{mm}$

Mid Main Bar, $S = 36 > 25\text{mm}$

Dimensional Limits, 418.6.2.1

$b_w \geq \max[.3h, 200\text{mm}]$ Ok!

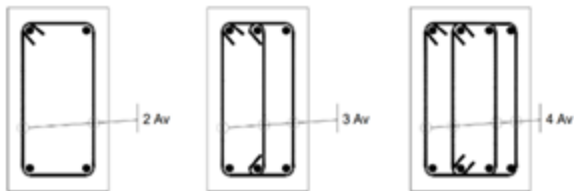
Main Reinforcements Ratio Limits, 418.6.3.1

$A_{smin} < A_s < A_{smax}$, Ok!

$A_{smin} < A_s < A_{smax}$, Ok!

Main Reinforcements, 418.6.3.2

$M_{umin} \geq 0.25 M_{umax}$ Increased Mumin!



Add extra Stirrups to increase area of Shear resisting steel, A_v

NSCP 2015 418.6.4

Beam mark on critical	Beam Length, m	V_u	V_s	S_{max}	Req per Seismic	Stirrups Spacing		
						Qty	mm	
	0 - 0.05m	17.72	(21.87)	512.2	50.00	1.00	50.00	Pass!
2h	0.05 - 0.7m	17.47	(22.20)	504.4	73.00	4.00	150.00	Pass!
> 2h	> 0.7m	13.93	(26.92)	416.1	146.00	Rest	200.00	Pass!

REINFORCED CONCRETE BEAM

FTB - 1 / Beam No. 23

Input Parameters :

Standard Specs	Momen	Sup Top	Mid Bot	Shear Capacity
$f_c' = 21$	ion Bar, Dt =	3	3	$b_w = 220$ mm $f_{yt} = 230$
$f_y = 275$	Bar 2-L, Nb =	0	0	$h = 350$ mm $A_v = 2$
$b_1 = .85$	ion Bar, Dc =	3	3	$S_b = 10$ mm Stirrups Bar \emptyset
$E_s = 200$ Gpa	Main Bar dia, D =	16		$C_c = 40$ mm, Clear Covering
	Moment, Mu =	37.6	1.3	

CONDITION : $\text{Val} = 0.65 + 0.25 (\epsilon_t - \epsilon_{ty} / 0.005 - \epsilon_{ty})$

$$\phi = 0.65, \epsilon_t \leq \epsilon_{ty}$$

$$\text{Val}, \epsilon_{ty} < \epsilon_t < 0.005$$

$$0.90, \epsilon_t \geq 0.005$$

Location of d' & dt ;

	Support	Midspan
$As1 = \pi D^2 Db / 4 =$	603.19	603.19
$2L, As2 = \pi D^2 Nb / 4 =$	0.00	0.00
$y = (As1 y1 + As2 y2) / As =$	0.00	0.00
$d' = Cc + Sb + (D/2) + y =$	58.00	58.00
$dt = h - d' =$	292.00	292.00

CHECKING : $\epsilon_t \geq 0.004$,

	Support	Midspan
$C_{max} = 600 dt / f_{smin} + 600 =$	125.1	125.14
$a_{max} = \beta_1 C_{max} =$	106.4	106.37
$As_{max} = 0.85 f_c' a_{max} b_w / f_y =$	1518.98	1518.98
$a = (As f_y - As' f_y) / 0.85 f_c' b =$	42.24	42.24
$C = a / \beta_1 =$	49.69	49.69
$f_s' = 600 (C - d') / C =$	-100.29	-100.29
$f_s' = \text{Compression Bars} =$	Not Yield	Not Yield
$f_s = 600 (dt - C) / C =$	2925.58	2925.58
$f_s = \text{Tension Bars} =$	Yield	Yield

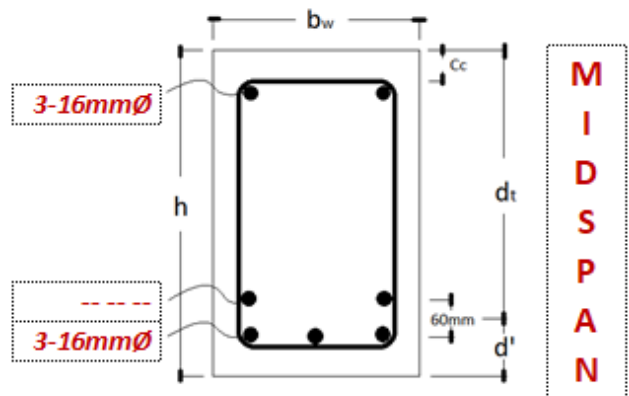
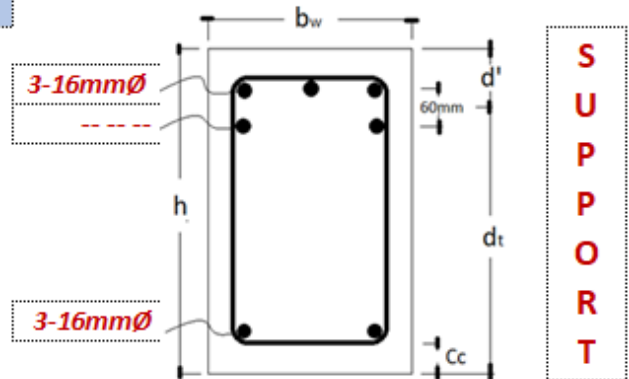
BEAM MOMENT CAPACITY $\phi = 0.9$

$$As f_y = 1.85 f_c' \beta_1 C b_w + As' f_s' \text{ Where, } f_s' = (600 C - d') / C$$

	Support	Midspan
$C = \text{by quadratic} =$	55.17	55.17
$a = \beta_1 C =$	46.89	46.89
$f_s' = 600 (C - d') / C =$	-30.82	-30.82
$f_s = 600 (dt - C) / C =$	2575.87	2575.87
$M_n = c[dt - (a/2)] + C_s (dt - d') =$	45.10	45.10
SUPPORT, $\phi M_n =$	40.59	> 37.61
MIDSPAN, $\phi M_n =$	40.59	> 1.27

SUPPORT, $\phi M_n =$

MIDSPAN, $\phi M_n =$



CHECK SHEAR; $\phi = 0.75$

$$V_c = 0.17 \sqrt{f_c'} b_w dt = 50 < 27.91$$

$$V_{smax} = 0.67 \sqrt{f_c'} b_w dt = 197 \text{ KN}$$

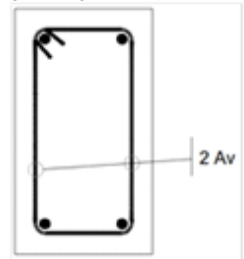
$$V_s = (V_u / \phi) - V_c = (12.83) < 197.24$$

Section is Adequate

$$A_v = 2 (\pi S_b^2 / 4) = 157.1$$

Max S, w/c ever is lesser, mm

$V_s \leq 0.33 \sqrt{f_c'} b_w d, d/2$
or 600mm otherwise
 $V_s > 0.33 \sqrt{f_c'} b_w d,$
or 300mm



Therefore use 220x350 with 6-16mm \emptyset @ support and 6-16mm \emptyset @ midspan Main Bars (Grade 40);

10mm \emptyset 2 leg-stirrups: Sp. at 1@50, 4@150 and rest 200 O.C

Main Bar Spacing Calculator

Sup Main Bar, S = 46 > 25mm

Mid Main Bar, S = 46 > 25mm

Dimensional Limits, 418.6.2.1

$b_w \geq \max[.3h, 200\text{mm}]$ Ok!

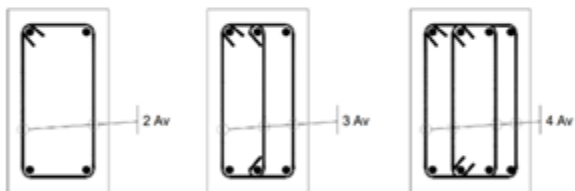
Main Reinforcements Ratio Limits, 418.6.3.1

$A_{smin} < A_s < A_{smax}$, Ok!

$A_{smin} < A_s < A_{smax}$, Ok!

Main Reinforcements, 418.6.3.2

$M_{umin} \geq 0.25 M_{umax}$ Increased Mumin!



Add extra Stirrups to increase area of Shear resisting steel, A_v

NSCP 2015 418.6.4

Beam mark on critical	Beam Length, m	V_u	V_s	S_{max}	Req per Seismic	Stirrups Spacing		
						Qty	mm	
	0 - 0.05m	27.91	(12.83)	872.8	50.00	1.00	50.00	Pass!
2h	0.05 - 0.7m	27.78	(13.01)	860.9	73.00	4.00	150.00	Pass!
> 2h	> 0.7m	26.05	(15.31)	731.5	146.00	Rest	200.00	Pass!

FOOTINGS

PROPOSED TWO STOREY RESIDENTIAL BUILDING

ISOLATED RECTANGULAR FOOTING DESIGN

F - 1 / Node No. 7

Input Parameters:

Concrete Strength,	$f_c' =$	21	Mpa
Rebar yield strength,	$f_y =$	275	Mpa
Net allowable Soil Pressure,	$q_a =$	100	kPa
Footing Embedment Depth,	$D_f =$	0.95	m
Surcharge,	$q_s =$	0	kPa
Soil Weight,	$w_s =$	17	kN/m ³
Footing Thickness,	$t =$	0.3	m
Length,	$L =$	1.4	m
Width,	$B =$	1.4	m
Clear Covering,	$c =$	75	mm

Longitudinal Bar,	Ax =	9	16 mmØ
Traverse Bar,	Ay =	9	16 mmØ
Loc X - dir	dx =	0	m, 0 from center
Loc Y - dir	dy =	0	m, 0 from center
Depth,	Cx =	0.4	m
Width,	Cy =	0.3	m
Load,	Pd =	119.08	KN
Load,	Pl =	22.1	KN
Moment X,	Mx =	0	KNm
Moment Y,	Mv =	0	KNm

Check Soil Bearing Capacity

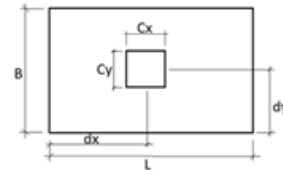
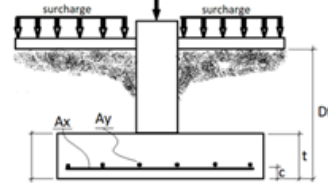
Applied Load,	$P_d + P_l =$	141.18
Surcharge,	$q_s (LB) =$	0.00
Weight Footing,	$(23.5-w_s) tBL =$	3.82
	$P_n =$	145.00 kN

$M_x = 0$	KNm	$M_y = 0$	KNm
$e_x = 0.000$	m	$L/6 = 0.233$	m
$e_y = 0.000$	m	$B/6 = 0.2333$	m

$$q_{nx}(\max) = \frac{P}{BL} + \frac{6M}{L^2B} = 73.98 < 100.00 \quad \text{Pass!}$$

$$q_{ny}(\max) = \frac{P}{BL} + \frac{6M}{B^2L} = 73.98 < 100.00 \quad \text{Pass!}$$

$$q_n(\max) = \frac{P}{BL} + \frac{6M_y}{B^2L} + \frac{6M_x}{L^2B} = 73.98 < 100.00 \quad \text{Pass!}$$



Check Thickness ; Two-way Shear

Applied Load,	$1.2P_d + 1.6P_l =$	178.26
Surcharge,	$1.2 q_s (LB) =$	0.00
Weight Footing,	$1.2(23.5-w_s) tLB =$	4.59
	$P_u =$	182.84

$M_x = 0$	$M_y = 0$
$e_x = 0$	$e_y = 0.00$
$L/6 = 0.23$	$L/6 = 0.233$

$$q_{u\max} = 93.2869 \quad q_{u\max y} = 93.28694 \text{ Kpa}$$

$$d = 0.209 \text{ m}$$

$$V_{ux} = q_u (B - (C_x + d))(C_y + d) = 153.93 \text{ KN}$$

$$V_{uy} = q_u (B - (C_x + d))(C_y + d) = 153.93 \text{ KN}$$

$$b_o = 2(D_1 + d) 2(W_1 + d) = 2.236 \text{ m}$$

$$\phi V_{c1} = \phi 0.33 \sqrt{f_c'} b_o d = 530.033 \text{ KN}$$

$$\beta_c = \text{Long/short side of column} = 1.333$$

$$\phi V_{c2} = \phi \left(1 + \frac{2}{\beta_c} \right) .17 \sqrt{f_c'} b_o d = 682.6 \text{ KN}$$

$$\alpha_s = 40$$

$$\phi V_{c2} = \phi \left(2 + \frac{\alpha_s d}{\beta_c} \right) .083 \sqrt{f_c'} b_o d = 1102.48$$

$$\phi V_c = \min \phi V_{c1}, \phi V_{c2}, \phi V_{c3} \quad 530 > 154$$

Pass!

Check One-way Shear;

must, $V_c > V_u$

$$V_{ux} = q_u B[(B - C)/2 - d] = 38.01 \text{ KN}$$

$$V_{uy} = q_u L[(L - C)/2 - d] = 44.54 \text{ KN}$$

$$\phi V_{cx} = \phi 0.17 \sqrt{f_c'} B d = 170.96 \text{ KN} \quad \text{Pass!}$$

$$\phi V_{cy} = \phi 0.17 \sqrt{f_c'} L d = 170.96 \text{ KN} \quad \text{Pass!}$$

Check Flexural Reinforcement; $A_{smin} = 0.002Bt$

$$M_{ux} = 16.33 \text{ KNm} \quad M_{uy} = 19.75 \text{ KNm}$$

$$A_{sx} = 1809.56 \text{ mm}^2 \quad A_{sy} = 1809.56 \text{ mm}^2$$

$$A_{smin x} = 840.00 \quad A_{smin y} = 840.00 \text{ mm}^2$$

$$S_x = 138.3 \quad S_y = 138.3 \text{ mm} \quad (S_{max} = 450 \text{ mm})$$

$$a_x = \frac{A_{sx} f_y}{.85 f_c' B} = 19.913 \text{ mm}, a_y = 19.91 \text{ mm}$$

Check Tension Contolled Limit $\phi = 0.9$

$$a_b/d = 0.583 > a_x/d \text{ \& } a_y/d$$

$$a_x/d = 0.095 \quad a_y/d = 0.095$$

$$\phi M_{nx} = \phi A_{sx} f_y \left(d - \frac{a_x}{2} \right) \quad \phi M_{ny} = \phi A_{sy} f_y \left(d - \frac{a_y}{2} \right)$$

$$\phi M_{nx} = 89.14 \text{ KNm}, \quad \phi M_{ny} = 89.14 \text{ KNm}$$

> M_u

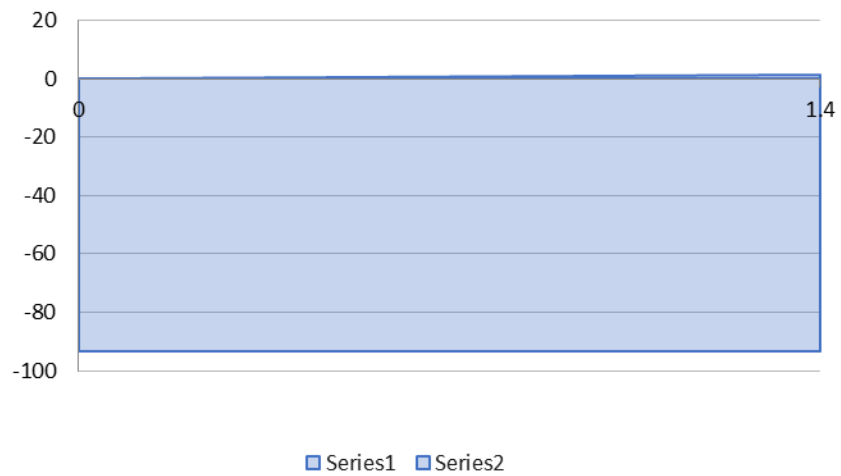
Pass!

> M_u

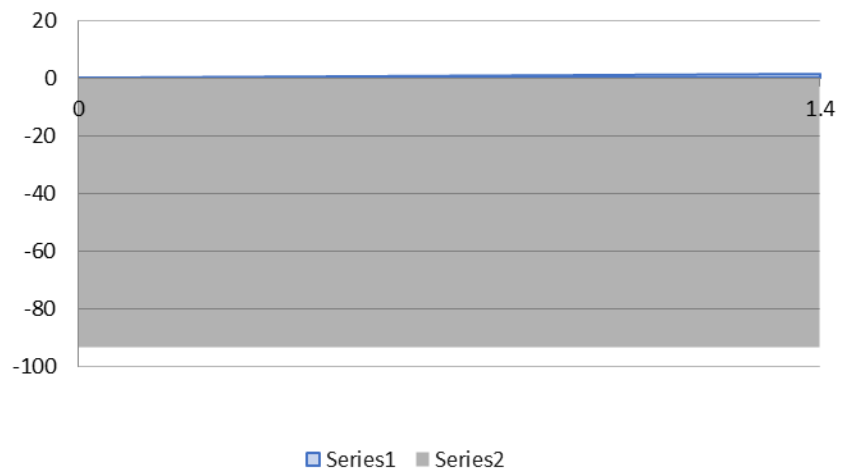
Pass!

Therefore use, 1.4x1.4x0.3m thick Footing with
16mm ϕ Tension Bar Grade (40) sp. @ 138.25mm and 138mm along BL respectively O.C.

SOIL PRESSURE ALONG L @ FACTORED LOAD



SOIL PRESSURE ALONG B @ FACTORED LOAD



ISOLATED RECTANGULAR FOOTING DESIGN

F - 2 / Node No. 11

Input Parameters:

Concrete Strength,	$f_c' =$	21	Mpa
Rebar yield strength,	$f_y =$	275	Mpa
Net allowable Soil Pressure,	$q_a =$	100	kPa
Footing Embedment Depth,	$D_f =$	0.95	m
Surcharge,	$q_s =$	0	kPa
Soil Weight,	$w_s =$	17	kN/m ³
Footing Thickness,	$t =$	0.3	m
Length,	$L =$	1.2	m
Width,	$B =$	2	m
Clear Covering,	$c =$	75	mm

Longitudinal Bar,	$A_x =$	7	16	mm ϕ
Traverse Bar,	$A_y =$	7		
Loc X - dir	$dx =$	0	m	0 from center
Loc Y - dir	$dy =$	0	m	0 from center
Depth,	$C_x =$	0.35	m	
Width,	$C_y =$	0.3	m	
Load,	$P_d =$	118.654	KN	
Load,	$P_l =$	15.49	KN	
Moment X,	$M_x =$	0	KNm	
Moment Y,	$M_y =$	0	KNm	

Check Soil Bearing Capacity

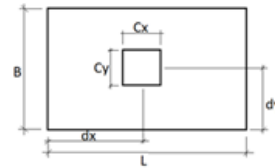
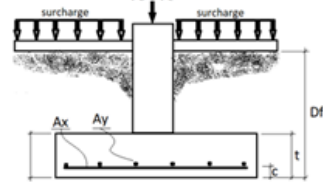
Applied Load, $P_d + P_l = 134.14$
 Surcharge, $q_s \text{ (LB)} = 0.00$
 Weight Footing, $(23.5 - w_s) tBL = 4.68$
 $P_n = 138.82 \text{ kN}$

$M_x = 0 \text{ KNm}$ $M_y = 0 \text{ KNm}$
 $e_x = 0.000 \text{ m}$ $L/6 = 0.200 \text{ m}$
 $e_y = 0.000 \text{ m}$ $B/6 = 0.3333 \text{ m}$

$$q_{nx}(\max) = \frac{P}{BL} + \frac{6M}{L^2 B} = 57.84 < 100.00 \text{ Pass!}$$

$$q_{ny}(\max) = \frac{P}{BL} + \frac{6M}{B^2 L} = 57.84 < 100.00 \text{ Pass!}$$

$$q_n(\max) = \frac{P}{BL} + \frac{6M_y}{B^2 L} + \frac{6M_x}{L^2 B} = 57.84 < 100.00 \text{ Pass!}$$



Check Thickness ; Two-way Shear

Applied Load, $1.2P_d + 1.6P_l = 167.17$
 Surcharge, $1.2 q_s \text{ (LB)} = 0.00$
 Weight Footing, $1.2(23.5 - w_s) tLB = 5.62$
 $P_u = 172.78$

$M_x = 0$ $M_y = 0$
 $e_x = 0$ $e_y = 0.00$
 $L/6 = 0.2$ $L/6 = 0.333$
 $q_{u\max} = 71.9937$ $q_{u\max y} = 71.99367 \text{ Kpa}$

$d = 0.209 \text{ m}$

$V_{ux} = q_u (BL - (C_x + d)(C_y + d)) = 152.30 \text{ KN}$
 $V_{uy} = q_u (BL - (C_x + d)(C_y + d)) = 152.30 \text{ KN}$
 $b_o = 2(D_1 + d) 2(W_1 + d) = 2.136 \text{ m}$
 $\phi V_{c1} = \phi 0.33 \sqrt{f_c'} b_o d = 506.3285 \text{ KN}$
 $\beta_c = \text{Long/short side of column} = 1.167$
 $\phi V_{c2} = \phi (1 + \frac{2}{\beta_c}) .17 \sqrt{f_c'} b_o d = 708 \text{ KN}$
 $\alpha_c = 40$
 $\phi V_{c2} = \phi (2 + \frac{\alpha_c d}{\beta_c}) .083 \sqrt{f_c'} b_o d = 1167.25$

$\phi V_c = \min \phi V_{c1}, \phi V_{c2}, \phi V_{c3} = 506.3 > 152 \text{ Pass!}$

Check One-way Shear;

must, $V_c > V_u$

$V_{ux} = q_u B[(B - C)/2 - d] = 31.10 \text{ KN}$
 $V_{uy} = q_u L[(L - C)/2 - d] = 55.38 \text{ KN}$
 $\phi V_{cx} = \phi 0.17 \sqrt{f_c'} B d = 244.23 \text{ KN Pass!}$
 $\phi V_{cy} = \phi 0.17 \sqrt{f_c'} L d = 146.54 \text{ KN Pass!}$

Check Flexural Reinforcement; $A_{smin} = 0.002Bt$

$M_{ux} = 13.00 \text{ KNm}$ $M_{uy} = 31.21 \text{ KNm}$

$A_{sx} = 1407.43 \text{ mm}^2$ $A_{sy} = 1407.43 \text{ mm}^2$
 $A_{smx} = 1200.00$ $A_{smy} = 720.00 \text{ mm}^2$

$S_x = 289.7$ $S_y = 156.3 \text{ mm}$ ($S_{\max} = 450 \text{ mm}$)

$a_x = \frac{A_{sx} f_y}{.85 f_c B} = 10.842 \text{ mm}$, $a_y = 18.07 \text{ mm}$

Check Tension Contolled Limit $\phi = 0.9$

$a_b/d = 0.583 > a_x/d \text{ \& } a_y/d$
 $a_x/d = 0.052$ $a_y/d = 0.086$

$\phi M_{nx} = \phi A_{sx} f_y (d - \frac{a_x}{2})$ $\phi M_{ny} = \phi A_{sy} f_y (d - \frac{a_y}{2})$

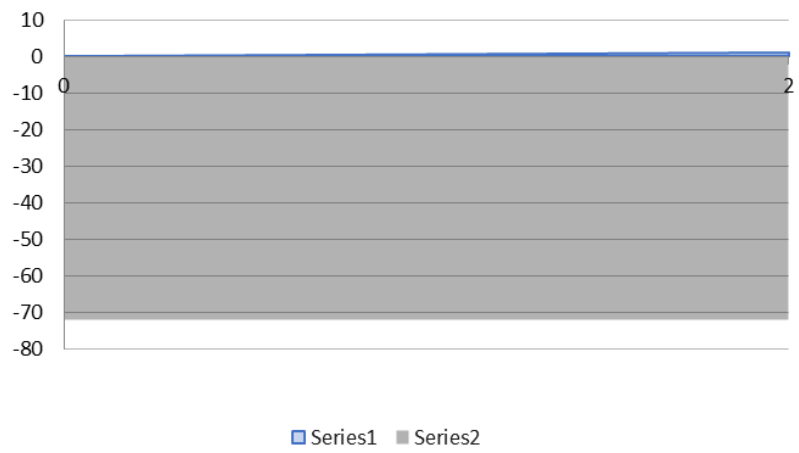
$\phi M_{nx} = 70.91 \text{ KNm}$ $\phi M_{ny} = 69.66 \text{ KNm}$
 $> M_u \text{ Pass!}$ $> M_u \text{ Pass!}$

Therefore use, 1.2x2x0.3m thick Footing with
 16mm ϕ Tension Bar Grade (40) sp. @ 289.67mm and 156mm along BL respectively O.C.

SOIL PRESSURE ALONG L @ FACTORED LOAD



SOIL PRESSURE ALONG B @ FACTORED LOAD



ISOLATED RECTANGULAR FOOTING DESIGN

F - 3 / Node No. 16

Input Parameters:

Concrete Strength,	$f_c' =$	21	Mpa
Rebar yield strength,	$f_y =$	275	Mpa
Net allowable Soil Pressure,	$q_a =$	100	kPa
Footing Embedment Depth,	$D_f =$	0.95	m
Surcharge,	$q_s =$	0	kPa
Soil Weight,	$w_s =$	17	kN/m ³
Footing Thickness,	$t =$	0.25	m
Length,	$L =$	1	m
Width,	$B =$	1	m
Clear Covering,	$c =$	75	mm

Longitudinal Bar,	Ax =	5	16	mmØ
Traverse Bar,	Ay =	5	16	mmØ
Loc X - dir	dx =	0	m, 0 from center	
Loc Y - dir	dy =	0	m, 0 from center	
Depth,	Cx =	0.4	m	
Width,	Cy =	0.3	m	
Load,	Pd =	22.101	KN	
Load,	Pl =	3.012	KN	
Moment X,	Mx =	0	KNm	
Moment Y,	Mv =	0	KNm	

Check Soil Bearing Capacity

Applied Load,	$P_d + P_l =$	25.11
Surcharge,	$q_s (LB) =$	0.00
Weight Footing,	$(23.5 \cdot w_s) tBL =$	1.63
	$P_n =$	26.74 kN

$$M_x = 0 \quad \text{KNm} \quad M_y = 0 \quad \text{KNm}$$

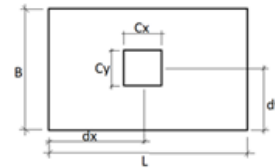
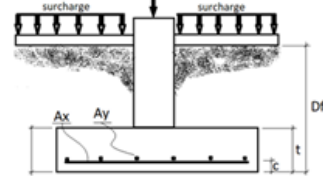
$$e_x = 0.000 \quad \text{m} \quad L/6 = 0.167 \quad \text{m}$$

$$e_y = 0.000 \quad \text{m} \quad B/6 = 0.1667 \quad \text{m}$$

$$q_{nx}(\max) = \frac{P}{BL} + \frac{6M}{L^2 B} = 26.74 < 100.00 \quad \text{Pass!}$$

$$q_{ny}(\max) = \frac{P}{BL} + \frac{6M}{B^2 L} = 26.74 < 100.00 \quad \text{Pass!}$$

$$q_n(\max) = \frac{P}{BL} + \frac{6M_y}{B^2 L} + \frac{6M_x}{L^2 B} = 26.74 < 100.00 \quad \text{Pass!}$$



Check Thickness ; Two-way Shear

Applied Load,	$1.2P_d + 1.6P_l =$	31.34
Surcharge,	$1.2 q_s (LB) =$	0.00
Weight Footing,	$1.2(23.5 \cdot w_s) tLB =$	1.95
	$P_u =$	33.29

$$M_x = 0 \quad M_y = 0$$

$$e_x = 0 \quad e_y = 0.00$$

$$L/6 = 0.17 \quad L/6 = 0.167$$

$$q_{umaxx} = 33.2904 \quad q_{umaxy} = 33.2904 \quad \text{Kpa}$$

$$d = 0.159 \quad \text{m}$$

$$V_{ux} = q_u (BL - (C_x + d)(C_y + d)) = 24.75 \quad \text{KN}$$

$$V_{uy} = q_u (BL - (C_x + d)(C_y + d)) = 24.75 \quad \text{KN}$$

$$b_o = 2(D_1 + d) 2(W_1 + d) = 2.036 \quad \text{m}$$

$$\phi V_{c1} = \phi 0.33 \sqrt{f_c'} b_o d = 367.1637 \quad \text{KN}$$

$$\beta_c = \text{Long/short side of column} = 1.333$$

$$\phi V_{c2} = \phi \left(1 + \frac{2}{\beta_c} \right) .17 \sqrt{f_c'} b_o d = 472.9 \quad \text{KN}$$

$$\alpha_s = 40$$

$$\phi V_{c2} = \phi \left(2 + \frac{\alpha_s d}{\beta_c} \right) .083 \sqrt{f_c'} b_o d = 625.19$$

$$\phi V_c = \min \quad \phi V_{c1}, \phi V_{c2}, \phi V_{c3} \quad 367.2 > 25$$

Pass!

Check One-way Shear;

must, $V_c > V_u$

$$V_{ux} = q_u B[(B - C)/2 - d] = 4.69 \quad \text{KN}$$

$$V_{uy} = q_u L[(L - C)/2 - d] = 6.36 \quad \text{KN}$$

$$\phi V_{cx} = \phi 0.17 \sqrt{f_c'} B d = 92.90 \quad \text{KN} \quad \text{Pass!}$$

$$\phi V_{cy} = \phi 0.17 \sqrt{f_c'} L d = 92.90 \quad \text{KN} \quad \text{Pass!}$$

Check Flexural Reinforcement; $A_{smin} = 0.002Bt$

$$M_{ux} = 1.50 \quad \text{KNm} \quad M_{uy} = 2.04 \quad \text{KNm}$$

$$A_{sx} = 1005.31 \quad \text{mm}^2 \quad A_{sy} = 1005.31 \quad \text{mm}^2$$

$$A_{smx} = 500.00 \quad A_{smy} = 500.00 \quad \text{mm}^2$$

$$S_x = 192.5 \quad S_y = 192.5 \quad \text{mm} \quad (S_{max} = 450 \text{mm})$$

$$a_x = \frac{A_{sx} f_y}{.85 f_c B} = 15.488 \quad \text{mm}, a_y = 15.49 \quad \text{mm}$$

Check Tension Contolled Limit $\phi = 0.9$

$$a_b/d = 0.583 > a_x/d \text{ \& } a_y/d$$

$$a_x/d = 0.097 \quad a_y/d = 0.097$$

$$\phi M_{nx} = \phi A_{sx} f_y \left(d - \frac{a_x}{2} \right) \quad \phi M_{ny} = \phi A_{sy} f_y \left(d - \frac{a_y}{2} \right)$$

$$\phi M_{nx} = 37.63 \quad \text{KNm}, \quad \phi M_{ny} = 37.63 \quad \text{KNm}$$

> M_u

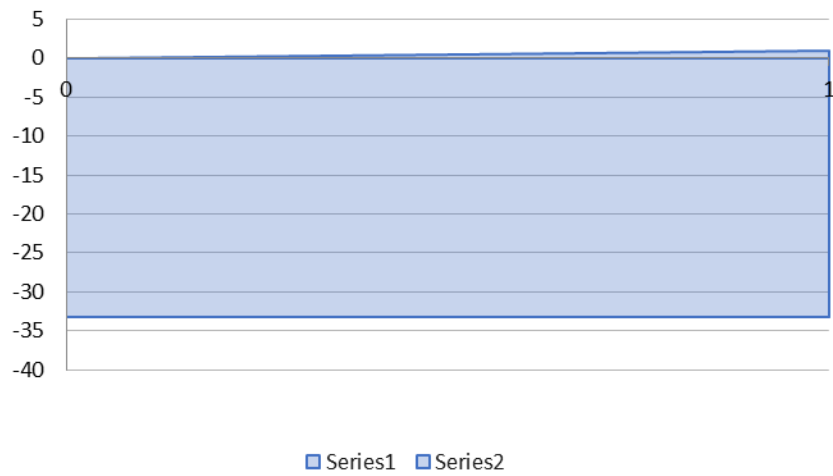
Pass!

> M_u

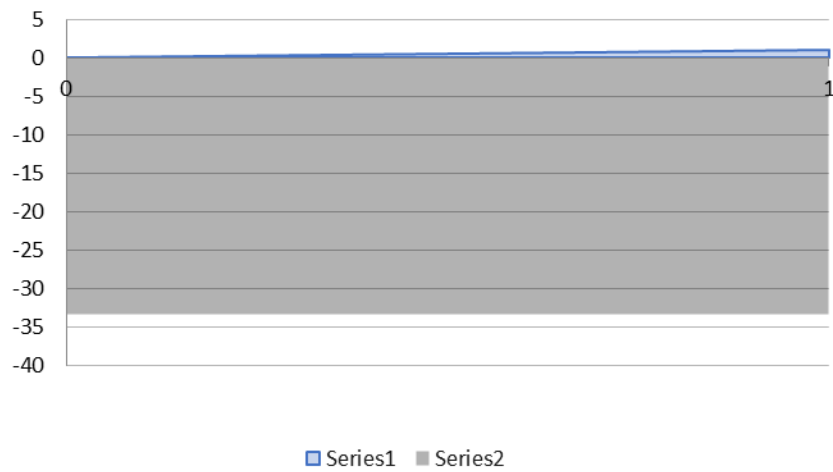
Pass!

Therefore use, 1x1x0.25m thick Footing with
16mm ϕ Tension Bar Grade (40) sp. @ 192.5mm and 192mm along BL respectively O.C.

SOIL PRESSURE ALONG L @ FACTORED LOAD



SOIL PRESSURE ALONG B @ FACTORED LOAD



SLAB

PROPOSED TWO STOREY RESIDENTIAL BUILDING

REINFORCED CONCRETE DESIGN FOR SLAB

S-2 GRID 1-1' D'-C

Two-way Slab

Input Parameters :

$f'_c = 21$ Mpa
 $f_y = 275$ Mpa
 $b_1 = .85$
 $E_s = 200$ Gpa
 $\mu_c = 23.6$ KN/m²

$d^b = 10$ mm², Bar ϕ
 $t = 100$ mm
 $LA = 1.9$ m, Short
 $LB = 3$ m, Long

	LONG SPAN		SHORT SPAN	
Bar ϕ	Sup	Mid	Sup	Mid
Top, (-)	200		200	
Bot, (+)		200		200

Deadload, $D = 4.5$ KN/m
 Liveload, $L = 2$ KN/m

ANALYSIS;

Case 9

$1.2 D = Du = 5.4$ KN/m
 $1.6 L = Lu = 3.2$ KN/m
 $W_u = 1.2 D + 1.6 L = 8.6$ KN/m
 $m = LA/LB = 0.65$

Moment Coefficients: ACI 318-63 Code

$Ca, neg = 0.083$; $b, neg = 0.008$
 $CaL = 0.054$; $CbL = 0.01$
 $CaD = 0.034$; $CbD = 0.01$

Moment along Long span

Sup, $Ma = Ca Wu LB = 0.62$ KNm
 Mid, $Ma = Ca Wu LB = 0.50$ KNm

Moment along Short span

Sup, $Mb = Cb Wu LB = 2.58$ KNm
 Mid, $Mb = Cb Wu LB = 1.29$ KNm

CHECK MOMENT CAPACITY;

$A^b = \pi d^b / 4 = 78.54$ mm² ; $b = 1$ m Strip

LONG SPAN	
Sup, $As = A^b b / S^b =$	392.70 mm ²
Mid, $As = A^b b / S^b =$	392.70 mm ²
SHORT SPAN	
Sup, $As = A^b b / S^b =$	392.70 mm ²
Mid, $As = A^b b / S^b =$	392.7 mm ²
$d = t - (20 + d^b/2) =$	75.00 mm

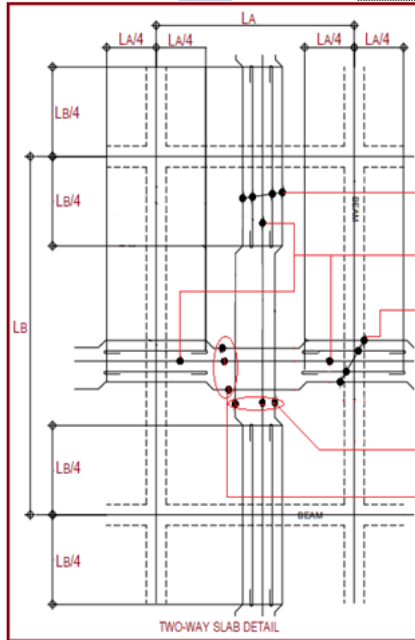
	LONG SPAN	SHORT SPAN
Top, $a = As f_y / 0.85 f'_c b =$	6.05	6.05
Bot, $a = As f_y / 0.85 f'_c b =$	6.05	6.05
Top, $C = \alpha / \beta_1 =$	7.12	7.12
Bot, $C = \alpha / \beta_1 =$	7.12	7.12
$\epsilon_y = f_y / E_s =$	0.00138	
$\epsilon_s = 0.003[(d-c)/c] =$	0.029	> 0.005 Tension Control

Thus, Use = 0.90

	LONG SPAN			SHORT SPAN		
Sup, $M_n = 0.85 f'_c a b (d - (a/2)) =$	7.77	>	0.62	7.77	>	2.58
Mid, $M_n = 0.85 f'_c a b (d - (a/2)) =$	7.77	>	0.50	7.77	>	1.29

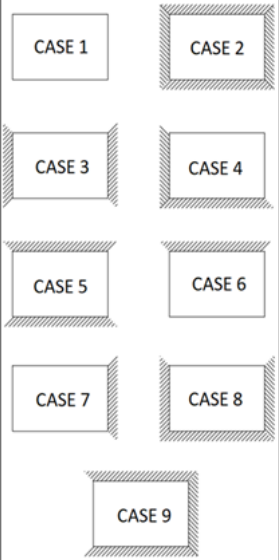
Minimum Thickness, $t = LB / 33 > 100$ Pass!

Therefore use, 100mm thick slab with 10mm ϕ rebar (Grade 40)
 spaced; along short span top/bot - 200/200: long span 200/200 o.c.



LONG, SUP TOP BARS - 200mm
 BOT, SUP TEMP BARS - 300mm
 SHORT, SUP TOP BARS - 200mm
 LONG, MID BOT BARS - 200mm
 SHORT, MID BOT BARS - 200mm

MOMENT COEFFICIENT METHOD
 ACI 318-63 Code, Method 3



REINFORCED CONCRETE DESIGN FOR SLAB

S-2 GRID 2-3 C-B

Two-way Slab

Input Parameters :

$f'_c = 21$ Mpa
 $f_y = 275$ Mpa
 $b_1 = .85$
 $E_s = 200$ Gpa
 $\mu'_c = 23.6$ KN/m³

$d^b = 10$ mm², Bar \emptyset
 $t = 100$ mm
 $LA = 2.7$ m, Short
 $LB = 2.75$ m, Long

	LONG SPAN		SHORT SPAN	
Bar \emptyset	Sup	Mid	Sup	Mid
Top, (-)	200		200	
Bot, (+)		200		200

Deadload, $D = 7.9$ KN/m
 Liveload, $L = 2$ KN/m

ANALYSIS;

Case 8

$1.2 D + Du = 9.48$ KN/m
 $1.6 L + Lu = 3.2$ KN/m
 $W_u = 1.2 D + 1.6 L = 12.68$ KN/m
 $m = LA/LB = 1.00$

Moment Coefficients: ACI 318-63 Code

$Ca, \text{neg} = 0.033$ $Cb, \text{neg} = 0.061$
 $CaL = 0.028$ $CbL = 0.03$
 $CaD = 0.020$ $CbD = 0.02$

Moment along Long span

Sup, $Ma = Ca Wu LB = 5.85$ KNm
 Mid, $Ma = Ca Wu LB = 2.37$ KNm

Moment along Short span

Sup, $Mb = Cb Wu LB = 3.05$ KNm
 Mid, $Mb = Cb Wu LB = 2.04$ KNm

CHECK MOMENT CAPACITY;

$A^b = \pi d^b / 4 = 78.54$ mm² $b = 1$ m Strip

	LONG SPAN	
Sup, $As = A^b b / S^b =$	392.70	mm ²
Mid, $As = A^b b / S^b =$	392.70	mm ²
	SHORT SPAN	
Sup, $As = A^b b / S^b =$	392.70	mm ²
Mid, $As = A^b b / S^b =$	392.7	mm ²
$d = t - (20 + d^b / 2) =$	75.00	mm

	LONG SPAN	SHORT SPAN	
Top, $a = As f_y / 0.85 f'_c b =$	6.05	6.05	mm
Bot, $a = As f_y / 0.85 f'_c b =$	6.05	6.05	mm
Top, $C = a / b_1 =$	7.12	7.12	mm
Bot, $C = a / b_1 =$	7.12	7.12	mm

$\epsilon_y = f_y / E_s = 0.00138$

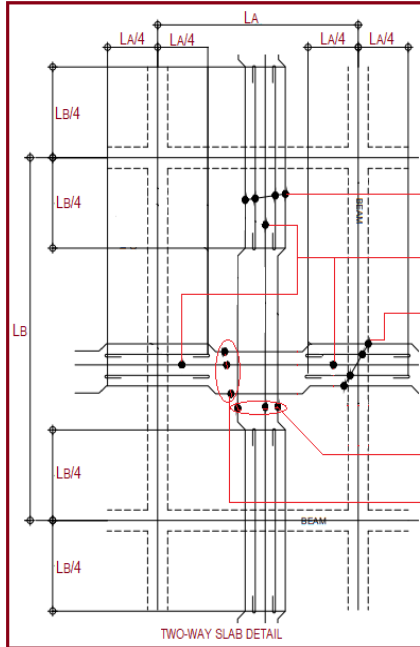
$\epsilon_s = 0.003[(d-c)/c] = 0.029 > 0.005$ Tension Control

Thus, Use = 0.90

	LONG SPAN			SHORT SPAN			
Sup, $M_n = 0.85 f'_c a b (d - (a/2)) =$	7.77	>	5.85	7.77	>	3.05	Pass! KNm
Mid, $M_n = 0.85 f'_c a b (d - (a/2)) =$	7.77	>	2.37	7.77	>	2.04	Pass! KNm

Minimum Thickness, $t = LB / 33 > 100$ Pass!

Therefore use, 100mm thick slab with 10mm \emptyset rebar (Grade 40)
 spaced; along short span top/bot - 200/200; long span 200/200 o.c.



MOMENT COEFFICIENT METHOD
 ACI 318-63 Code, Method 3

CASE 1

CASE 2

CASE 3

CASE 4

CASE 5

CASE 6

CASE 7

CASE 8

CASE 9