University of Asia Pacific
Department of Civil Engineering
Final Examination Spring – 2012
Program: B. Sc. Engineering (Civil)

Course Title: Geotechnical Engineering II — Course Code: CE 441
Time: 3 hours — Full Marks: 120 (20 X 6 = 120)

Answer any 6 (six) of the following 8 (eight) questions

1. **(a)** What is subsurface exploration in terms of geotechnical engineering? Give two reasons as to why subsurface exploration is required in geotechnical engineering. 4

   (b) Write down the preliminary information that would be important to execute geotechnical subsurface exploration for a building and for a bridge project. 4

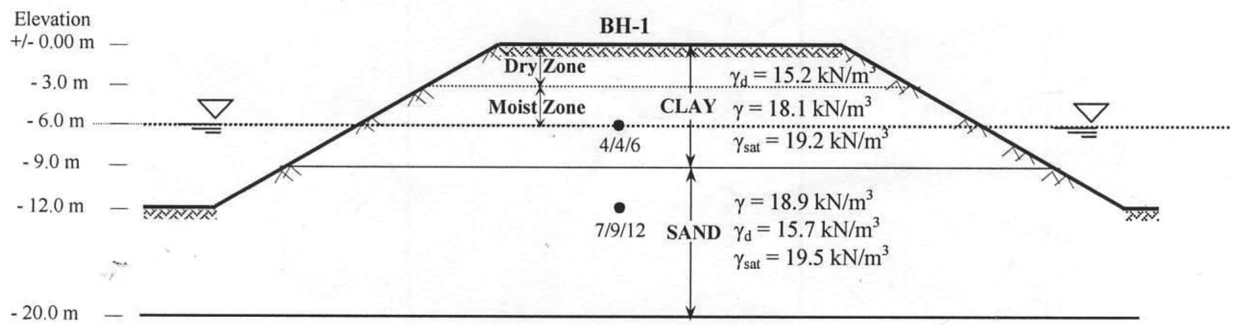
   (c) Write down any two general guidelines used for the selection of depth and location of boreholes for typical civil engineering projects. 4

   (d) Write short notes on (any two): **4 x 2=8**

   (i) Standard Penetration Test (ii) Drilling & logging (iii) Disturbed and undisturbed sampling

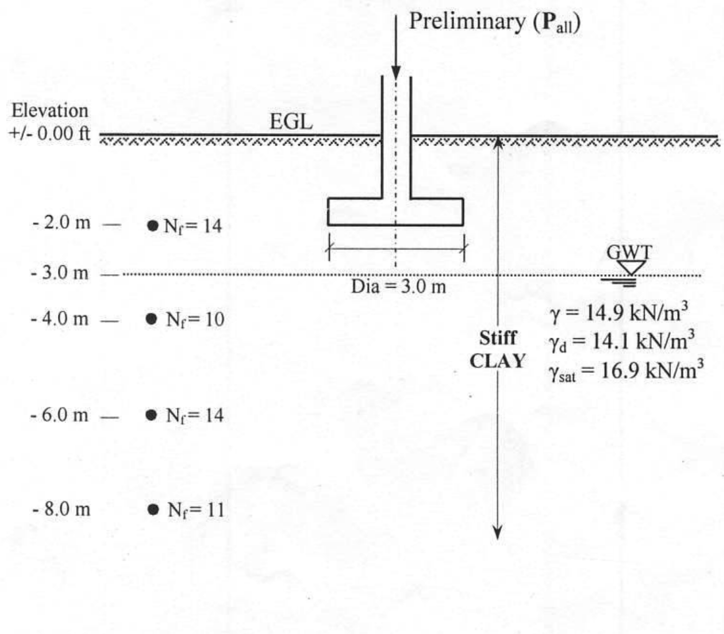
2. **(a)** Is it possible to collect absolutely undisturbed sample? Write a short note on the expression to quantify degree of disturbances during sampling procedure. 4

   (b) A borehole was advanced as a part of a preliminary geotechnical investigation for a site in Bangladesh as shown below. Determine cohesion and angle of internal friction at corresponding depths of the clay and sand deposits, respectively, based on the available data (Use empirical correlations as provided in **Appendix**). Use hammer efficiency as 58%. 9

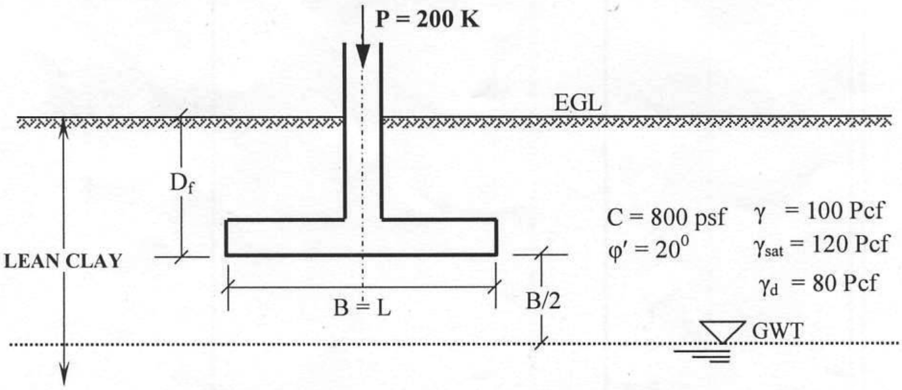


Subsurface Soil Stratigraphy

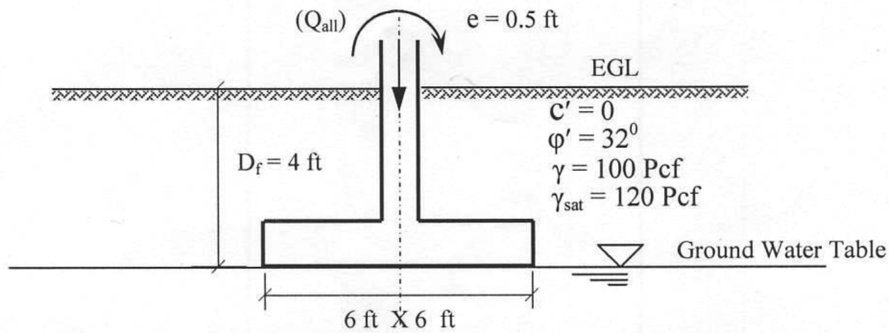
   (c) Using Terzaghi's bearing capacity equation (as appropriate), calculated the preliminary allowable column load for the for the conditions as shown below. Use FS = 3. Note that no laboratory tests were conducted to obtain the shear strength of the clay formation. So, use empirical correlation to estimated design shear strength. Assume CF60 = 1.0. 7



3. (a) Using General Bearing Capacity Equation (GBCE), design the size of the square footing for the conditions as shown below. Use a factor of safety of 2.5 and $B = 2\ D_f$. 11

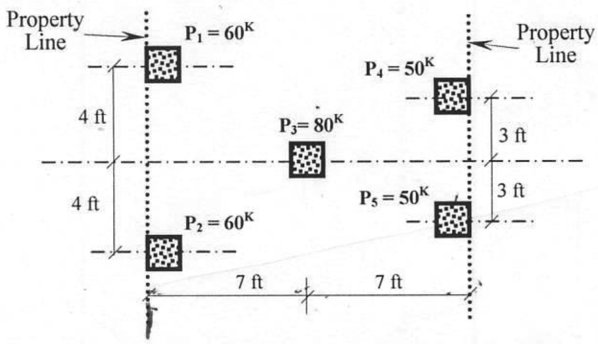


(b) An eccentrically loaded foundation is shown below. Determine the allowable load the foundation can carry. Use Meyerhof's effective area method and FS = 2.5. 9

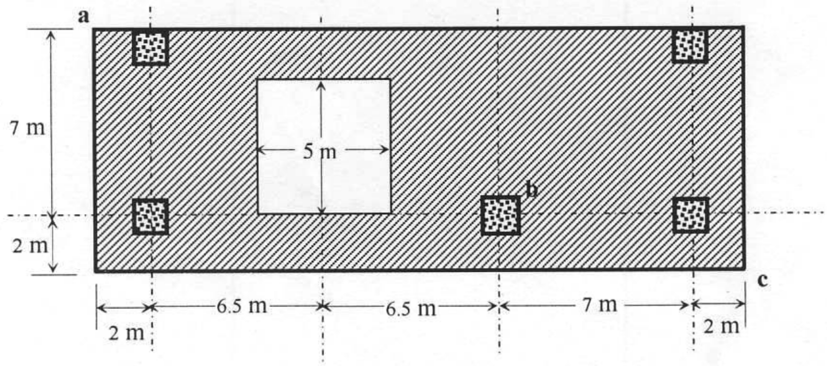


4. (a) Write down the factors considered in general bearing capacity equation which were not considered in Terzaghi's bearing capacity equation. 3

(b) Design the size of a combined trapezoidal footing for the following conditions. All columns have x-sectional dimension of 12 in by 12 in. Use q_a =3.0 ksf. 7

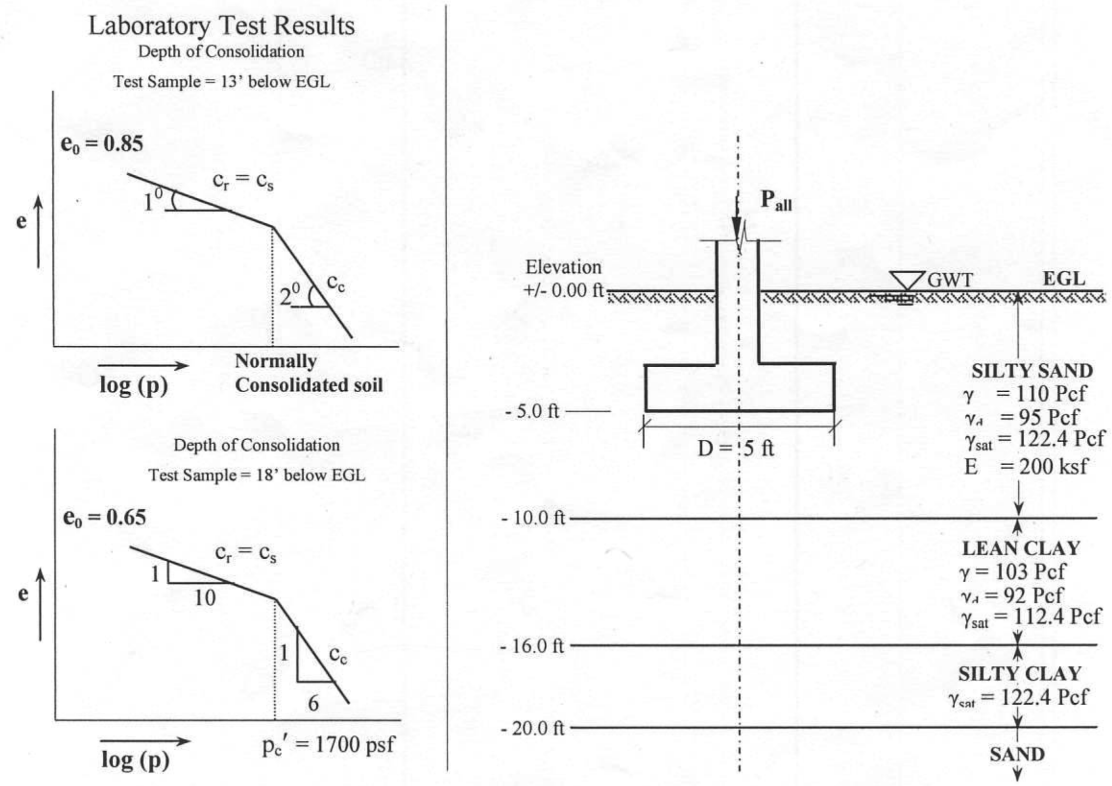


(c) The plan of a mat foundation is shown below. Column load for all conrner columns is 200 kN each and other column is 800 kN. All columns are having sizes of 400 mm by 400 mm. Calculate soil pressures at points a, b, c and at the geometric centroid of the mat foundation. 10

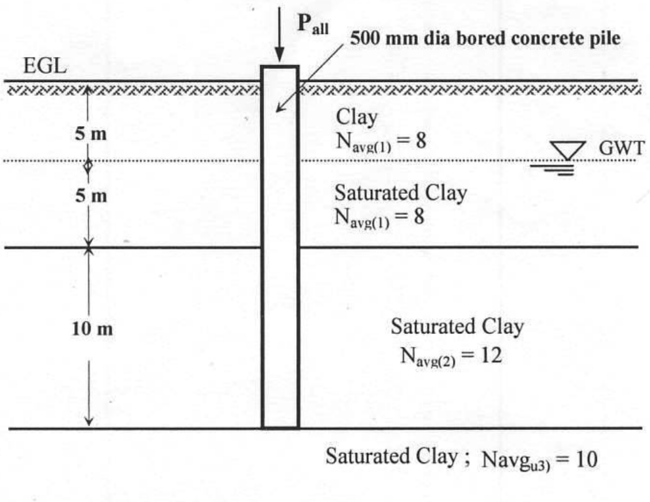


5. (a) Depict and write short notes on general and local shear failure patterns for shallow foundation. **6**

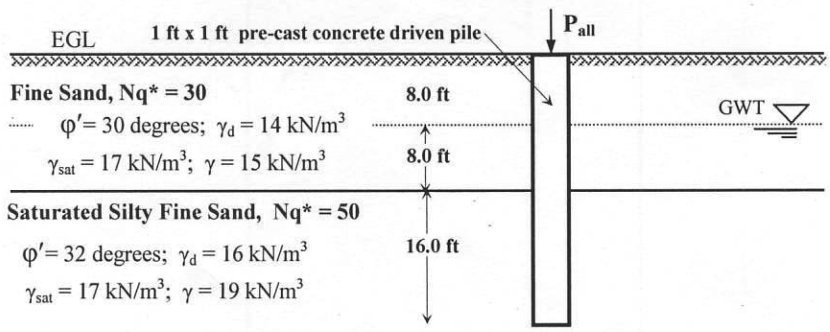
(b) A footing designed as per allowable bearing capacity based on shearing failure is shown in the following figure. Estimate settlements for both sand and clay layers. Use $q_a = p = 2.4$ ksf. **14**



6. (a) For the following condition, calculate the allowable capacity of a single pile. **10**



(b) For the following condition, calculate the allowable capacity of a single pile. **10**



7. (a) What do you understand by shallow and deep foundations? Categorize shallow foundations. Draw sketches of different combined footings. Also categorize pile foundations. No description is required. 10

(b) Draw arrangement of group piles for the following sets of piles. 6

(i) Triple row for a wall (ii) 11 piles

(c) With sketches write short notes on cantilever retaining wall. 4

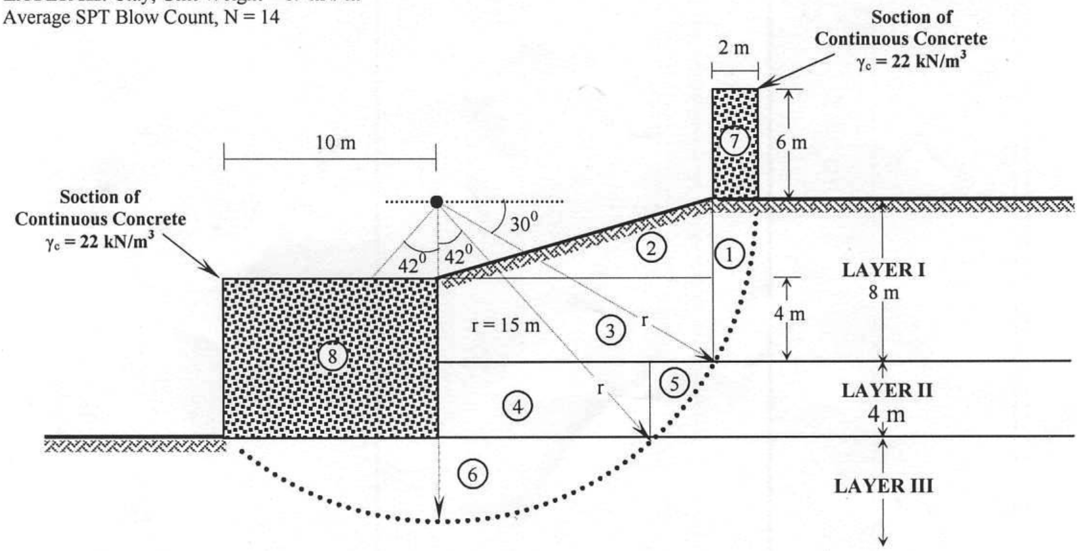
8. (a) What are the criteria for checking the stability of a retaining wall? Show with sketches the proportioning geometries for cantilever and gravity retaining walls. 7

(b) Determine the factor of safety (slope stability) against the failure arc through the slope as shown below. 13

LAYER I: Sandy Clay; Unit Weight = 17 kN/m^3
Average SPT Blow Count, N = 7

LAYER II: Clay; Unit Weight = 18.0 kN/ m^3
Average SPT Blow Count, N = 10

LAYER III: Clay; Unit Weight = 19 kN/ m^3
Average SPT Blow Count, N = 14



The University of Asia Pacific
Department of Civil Engineering

APPENDIX

Parameter for 60% Energy Correction For Field SPT

E_m = Hammer Efficiency (Donut + Cathed) = 0.55 to 0.60

C_B = Correction for Borehole Diameter
= 1.0 (For Dia 2.5" – 4.5")
= 1.05 (For Dia of 6")
= 1.15 (For Dia 8")

C_S = Correction for Sampler
= 1.0 Standard Sampler
= 1.2 Sampler Without Liner

C_R = Correction for Rod Length
= 0.75 for L = (3-4) m
= 0.85 for L = (4-6) m
= 0.95 for L = (6-10) m
= 1.0 for L > 10 m

Relevant Empirical Correlations

$CF_1 = \sqrt{\frac{2000}{\sigma_{v0}'}}$ (σ_{v0}' is in psf) $CF_1 = \sqrt{\frac{100}{\sigma_{v0}'}}$ (σ_{v0}' is in kPa)

$C_u = (q_{unc}/2)$

$q_{unc} = 300\ N_f$ (q_{unc} in psf)

$\phi' = 17 + \sqrt{20(N_1)_{60}}$ (ϕ' is in degree)

BEARING CAPACITY OF SOIL

(A) TERZAGHI'S ULTIMATE BEARING CAPACITY EQUATIONS

Applicable For Dense/Stiff Soil Considering General Shear Failure

c-part, q-part, γ-part

$$q_u = 1.3\,cN_c + q_f N_q + 0.4\,\gamma_{bf} B N_\gamma$$ **(For Square Foundation)**

$$q_u = 1.3\,cN_c + q_f N_q + 0.3\,\gamma_{bf} B N_\gamma$$ **(For Circular Foundation)**

$$q_u = cN_c + q_f N_q + 0.5\,\gamma_{bf} B N_\gamma$$ **(For Strip Foundation)**

Table: Terzaghi's Bearing Capacity Factors (General Shear Failure)

φ′ (degree)	N_c	N_q	N_γ
0	5.7	1.0	0.0
10	9.61	2.69	0.56
20	17.69	7.44	3.64
30	37.16	22.46	19.13
35	57.75	41.44	45.41

B) TERZAGHI'S MODIFIED ULTIMATE BEARING CAPACITY EQUATIONS

Applicable For Medium Dense/Stiff Soil Considering Local Shear Failure

$q_u = 0.867\, c N_c' + q_f N_q' + 0.4\, \gamma_{bf} B N_\gamma'$ **(For Square Foundation)**

$q_u = 0.867\, c N_c' + q_f N_q' + 0.3\, \gamma_{bf} B N_\gamma'$ **(For Circular Foundation)**

$q_u = 0.67\, c N_c' + q_f N_q' + 0.5\, \gamma_{bf} B N_\gamma'$ **(For Strip Foundation)**

N_c', N_q', N_γ' = Terzaghi's Modified Bearing capacity factors (for local shear failure) that are functions only of the soil friction angle φ'

Table: Terzaghi's Bearing Capacity Factors (Local Shear Failure)

φ' (degree)	N_c'	N_q'	N_γ'
0	5.7	1.0	0.0
10	8.02	1.94	0.24
20	11.85	3.88	1.12
30	18.99	8.31	4.39
35	25.18	12.75	8.35

(C) THE GENERAL BEARING CAPACITY EQUATION

$$q_u = c N_c F_{cs} F_{cd} F_{ci} + q_f N_q F_{qs} F_{qd} F_{qi} + 0.5\, \gamma_{bf} B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i}$$

$F_{cs}, F_{qs}, F_{\gamma s}$ = Shape Factors
$F_{cd}, F_{qd}, F_{\gamma d}$ = Depth Factors
$F_{ci}, F_{qi}, F_{\gamma i}$ = Inclination Factors

Table: General Bearing Capacity Factors

ϕ'	N_c	N_q	N_γ
0	5.14	1.00	0.00
10	8.35	2.47	1.22
20	14.83	6.40	5.39
26	22.25	11.85	12.54
28	25.80	14.72	16.72
30	30.14	18.40	22.40
32	35.49	23.18	30.22
34	42.16	29.44	41.06

Shape Factors

$F_{cs} = 1 + (B/L)(N_q/N_c)$
$F_{qs} = 1 + (B/L)\tan\phi'$
$F_{\gamma s} = 1 - 0.4\,(B/L)$
Where L = Length of the foundation (L>B)

Depth Factors

For D_f/B < or = 1

$F_{cd} = 1 + 0.4\,(D_f/B)$
$F_{qd} = 1 + 2\tan\phi'(1 - \sin\phi')^2 (D_f/B)$
$F_{\gamma d} = 1$

For $D_f/B > 1$

$F_{cd} = 1 + 0.4\tan^{-1}(D_f/B)$
$F_{qd} = 1 + 2\tan\phi'(1 - \sin\phi')^2 \tan^{-1}(D_f/B)$
$F_{\gamma d} = 1$
The factor $\tan^{-1}(D_f/B)$ is in radians.

Inclination Factors

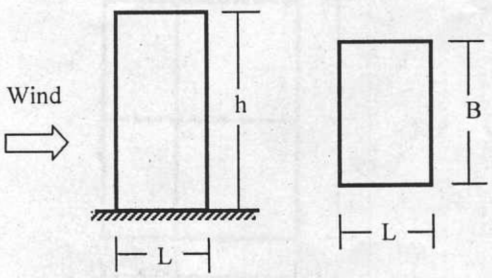
$F_{ci} = F_{qi} = (1 - \beta^0/90^0)^2$
$F_{\gamma i} = (1 - \beta/\phi')^2$
β = Inclination of the applied load on the foundation with respect to the vertical

Height z (ft)	C_G (for non-slender structures)		
	Exp A	Exp B	Exp C
0~15	1.654	1.321	1.154
50	1.418	1.215	1.097
100	1.309	1.162	1.067
150	1.252	1.133	1.051
200	1.215	1.114	1.039
300	1.166	1.087	1.024
400	1.134	1.070	1.013
500	1.111	1.057	1.005
650	1.082	1.040	1.000
1000	1.045	1.018	1.000

Height z (ft)	C_z		
	Exp A	Exp B	Exp C
0~15	0.368	0.801	1.196
50	0.624	1.125	1.517
100	0.849	1.371	1.743
150	1.017	1.539	1.890
200	1.155	1.671	2.002
300	1.383	1.876	2.171
400	1.572	2.037	2.299
500	1.736	2.171	2.404
650	1.973	2.357	2.547
1000	2.362	2.595	2.724

Category	C_I
Essential facilities	1.25
Hazardous facilities	1.25
Special occupancy	1.00
Standard occupancy	1.00
Low-risk structure	0.80

Location	V_b (mph)
Dhaka	130
Chittagong	160
Rajshahi	95
Khulna	150



h/B	L/B					
	0.1	0.5	0.65	1.0	2.0	≥ 3.0
≤ 0.5	1.40	1.45	1.55	1.40	1.15	1.10
1.0	1.55	1.85	2.00	1.70	1.30	1.15
2.0	1.80	2.25	2.55	2.00	1.40	1.20
≥ 4.0	1.95	2.50	2.80	2.20	1.60	1.25

Response Modification Coefficient, R for Structural Systems

Basic Structural System	Description Of Lateral Force Resisting System	R
(a) Bearing Wall System	Light framed walls with shear panels Shear walls Light steel framed bearing walls with tension only bracing Braced frames where bracing carries gravity loads	6~8 6 4 4~6
(b) Building Frame System	Steel eccentric braced frame (EBF) Light framed walls with shear panels Shear walls Concentric braced frames (CBF)	10 7~9 8 8
(c) Moment Resisting Frame System	Special moment resisting frames (SMRF) (i) Steel (ii) Concrete Intermediate moment resisting frames (IMRF), concrete Ordinary moment resisting frames (OMRF) (i) Steel (ii) Concrete	 12 12 8 6 5
(d) Dual System	Shear walls Steel EBF Concentric braced frame (CBF)	7~12 6~12 6~10
(e) Special Structural Systems	According to Sec 1.3.2, 1.3.3, 1.3.5 of BNBC	

Site Coefficient, S for Seismic Lateral Forces

Type	Site Soil Characteristics Description	Coefficient, S
S_1	A soil profile with either: A rock–like material characterized by a shear–wave velocity greater than 762 m/s or by other suitable means of classification, or Stiff or dense soil condition where the soil depth exceeds 61 meters	1.0
S_2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 meters	1.2
S_3	A soil profile 21 meters or more in depth and containing more than 6 meters of soft to medium stiff clay but not more than 12 meters of soft clay	1.5
S_4	A soil profile containing more than 12 meters of soft clay characterized by a shear wave velocity less than 152 m/s	2.0