

15153 WEST 32ND DRIVE, GOLDEN, COLORADO 80401 (303) 421 - 4165

May 9, 2023

Ms. Kim White
Community Development Director
Town of Grand Lake
1026 Park Avenue
Grand Lake, Colorado 80447

**RE: - ASBUILT Drystack Boulder Gravity Retaining Walls
1204 W. Portal Road Certification / Inspection Letter**

Dear Ms. White:

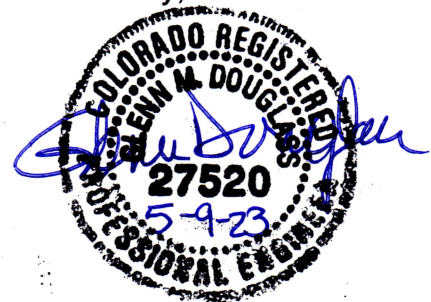
I, Glenn M. Douglass, a Registered Professional Engineer in the State of Colorado, do hereby certify that I have inspected the above referenced drystack boulder retaining walls on May 5, 2023.

Based on our experience with drystack boulder wall and boulder slope construction methodology, the embankment fill slopes and boulder placements were observed to be constructed in accordance to previous boulder slope and wall designs this firm has been involved with. The boulder slopes vary between 0.75:1 to 1.25:1 horizontal to vertical. The vertical heights of the boulder walls and slopes vary between 4 to 11.75 feet in height and are constructed from native and imported boulders ranging in size from 2 to 5 feet in diameter.

Attached are the boulder retaining wall stability calculations and typical construction detail of the as-built walls. We have also prepared an As-Built Retaining Wall Site Plan showing the locations of the recently constructed walls.

It is our professional opinion, based on our experience with drystack boulder wall construction methodology, that the completed walls are satisfactory in terms of structural stability for site conditions and loading.

Sincerely,



Glenn M. Douglass, P.E.

cc: Cindy Biersdorfer & Keith Nichols

**DRystack BOULDER GRAVITY TYPE
RETAINING WALL
DETAILS AND DESIGN CALCULATIONS**

FOR

**1204 W. PORTAL ROAD
SITE RETAINING / LANDSCAPING WALLS**

PREPARED FOR:

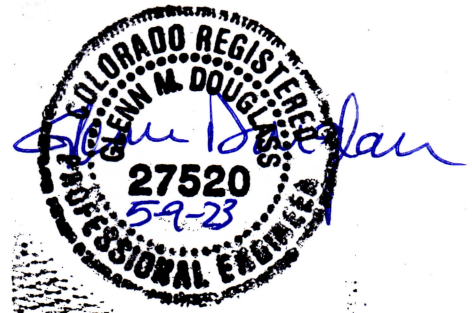
Cindy Biersdorfer & Keith Nichols
1204 W. Portal Road
Grand Lake, Colorado 80447

PREPARED BY:

Douglass Engineering
15153 W. 32nd Drive
Golden, CO 80401

(303) 421-4165

MAY 2023

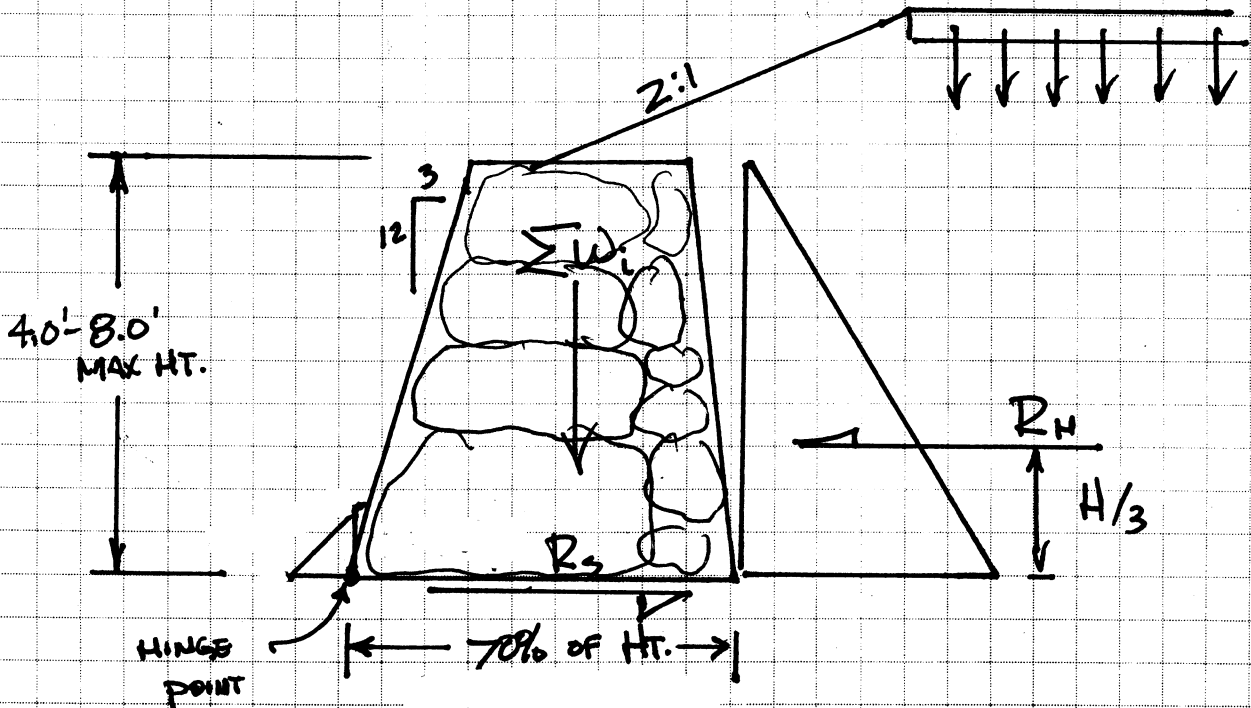


DRYSTACK BOULDER WALL DIAGRAM

DESIGN CRITERIA : VARIES 4' to 8'
 MAX HEIGHT = 8.0'

1. UNIT WEIGHT SOIL : 115 pcf.
2. UNIT WEIGHT ROCK : 125 pcf.
3. ALLOWABLE SOIL BEARING CAP. : 3500 pcf.
4. COEF. OF SLIDING FRICTION : 0.5
5. PASSIVE EARTH PRESSURE : 300 pcf.
6. ACTIVE EARTH PRESSURE : 35 pcf.
7. * INTERNAL FRICTION ϕ : 30°

TYPICAL WALL CONFIGURATION:



RETAINING WALL EQUIVALENT HEIGHT: 4.5'

CALCULATE ACTIVE EARTH PRESSURE:

$$R_H = \frac{1}{2} (0.33) \times 115 \text{ lb/ft}^3 \times (4.5)^2$$
$$= 384.2 \text{ lbs.}$$

RESULTANT ACTS $H/3$ FROM BASE $H/3 = 1.5'$

CALC. MOMENT OVERTURNING $M_o = 384.2 \times 1.5'$
 $= 576.3 \text{ ft-lbs.}$

CALC. MOMENT RESTORING: Wt. OF ROCK:
 $125 \text{ lbs.} \times 3.0 \times 4.5 = 1688\#$

$$M_R = 1688 \times 1.5 = 2531 \text{ ft-lbs.}$$

OVERTURNING RATIO: $M_R / M_o = 2531 / 576.3 = 4.39$
 $= 4.39 > 1.5$ OK ✓

$$M_{\text{NET}} = 2531 \text{ ft-lbs.} - 576.3 \text{ ft-lbs.}$$
$$= 1954.7 \text{ ft-lbs.}$$

$$\bar{x} = 1954.7 / 1688 = 1.158$$

$$e = 3/2 - 1.158 = 0.342$$

CHECK AGAINST SLIDING: $R_s = (\sum W_i + R_v) \tan \delta$

$$\text{RATIO} = R_s / R_H = \frac{1688\# (0.50)}{384.2} = 2.19 > 1.5$$

OK ✓

CALCULATIONS FOR 8.0' HIGH DRY STACK BOULDER WALL.

USE EQUIVALENT HEIGHT: 8.0'

CALC. ACTIVE EARTH PRESSURE: $R_H = \frac{1}{2} (33) (115 \frac{\#}{ft^3}) (8.0)^2$
 $= 1214.40 \text{ LBS.}$

RESULTANT ACTS $H/3$ FROM BASE = $8.0/3 = 2.67'$

MOMENT OVERTURNING $M_O = 1214.4 \# \times 2.67'$
 $= 3238.4 \text{ Ft. lbs.}$

MOMENT RESTORING: W_t OF ROCK: $125 \frac{\text{lb}}{\text{ft}^3} \times 5.5 \times 8.0$
 $= 5500 \text{ lbs.}$

$M_R = 5500 \text{ lbs.} \times 2.5' = 13,750 \text{ Ft. lbs.}$

OVERTURNING RATIO: $M_R / M_O = 13,750 / 3238 = 4.25$

$4.25 > 1.5 \therefore \underline{\text{OK}} \checkmark$

$M_{\text{NET}} = 13,750 - 3238 = 10512 \#$ $\bar{x} = 10512 / 5500 = 1.91$
 $e = \frac{5}{2} - 1.91 = 0.46$

CHECK AGAINST SLIDING $R_s = (\sum W_i + R_v) \tan \delta$

RATIO = $R_s / R_H = \frac{5500 \# (.50)}{1214 \#} =$

$= 2.27 > 1.5 \checkmark$

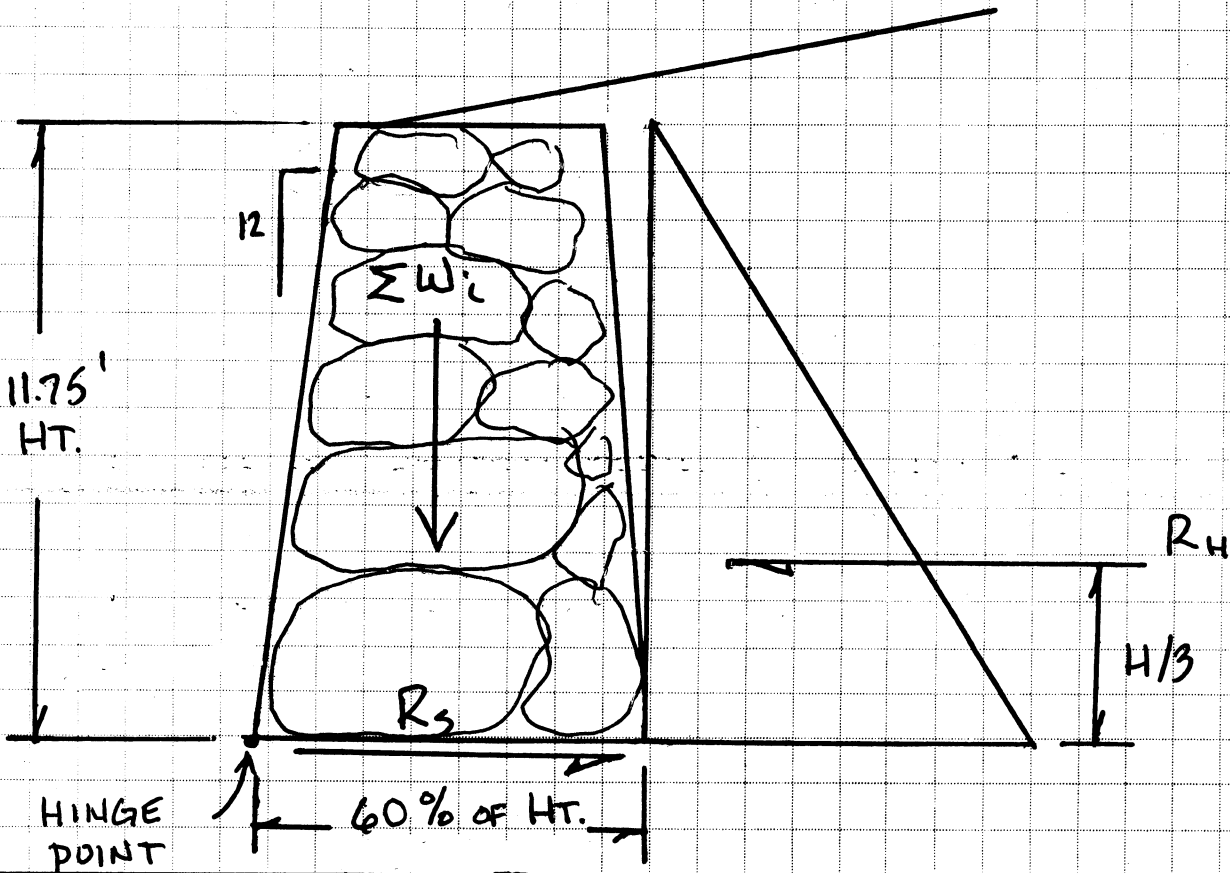
OK

DRY STACK BOULDER WALL DIAGRAM

DESIGN CRITERIA: MAX HEIGHT = 11.75'

1. UNIT WEIGHT SOIL : 115 #/ft³
2. UNIT WEIGHT ROCKS : 125 #/ft³
3. ALLOWABLE SOIL BEARING CAP : 3000 pcf.
4. COEF. OF SLIDING FRICTION : 0.5
5. PASSIVE EARTH PRESSURE: 300 pcf.
6. ACTIVE EARTH PRESSURE: 35 pcf.
7. ANGLE (ϕ) OF INTERNAL FRICTION : 30°

WALL CONFIGURATION



CALCULATIONS FOR 11.75' HIGH DRUSTACK BOULDER WALL

USE EQUIVALENT HEIGHT : 12.0'

CALC ACTIVE EARTH PRESSURE :

$$P_H = \frac{1}{2} (0.33) (115 \# / \text{ft}^3) (12.0)^2 \\ = 2732.40 \text{ lbs.}$$

RESULTANT ACTS $\frac{1}{3}(H)$ FROM BASE = $12.0/3 = 4.0'$

CALC. OVERTURNING MOMENT : $M_O = 2732 \times 4.0$
 $= 10929.6 \text{ ft-lbs.}$

CALC. RESTORING MOMENT : M_R

WEIGHT OF ROCK : $125 \# / \text{ft}^3 \times 7.8' \times 12.0'$
 $= 11700 \text{ lbs.}$

$$M_R = 11700 \text{ lbs} \times 3.9' = 45630 \text{ ft-lbs.}$$

OVERTURNING RATIO : M_R / M_O

$$= 45630 / 10929 = 4.18$$

$$4.18 > 1.5 \therefore \text{OK} \checkmark$$

$$M_{\text{NET}} : 45630 - 10929 = 34701 \text{ ft-lbs}$$

$$\bar{x} = 34701 / 45630 = 0.7285$$

$$e = 3/2 - 0.7285 = 0.7715$$

DOUGLASS ENGINEERING
15153 W. 32ND DRIVE
GOLDEN, COLORADO 80401
(303) 421 - 4165

JOB 1204 W. PORTAL ROAD
SHEET NO. 6 OF 7
CALCULATED BY GMD DATE 5-9-23
CHECKED BY _____ DATE _____
SCALE _____

11.75' HT DRYSTACK WALL (CONT.)

CHECK AGAINST SLIDING

$$R_s = (\sum W_i + R_v) \tan \delta$$

$$\text{RATIO} = R_s / R_H = \frac{11700 \# (0.50)}{2732 \#}$$

$$= 2.14$$

2.14 > 1.5 ∴ OK ✓

BEARING CAPACITY CALCULATIONS:

$$Factor\ Safety = \frac{Q_c \text{ (soil capacity)}}{Q_c \text{ (bearing stress)}} = \frac{Q_{ult}}{Q_a}$$

$$Q_{ult} = c N_c + .5 \gamma (B) N_\gamma$$

c = cohesion
 B = equiv. ftg. width.
 N_c, N_γ = bearing capacity factors from
 Fig. 7 using ϕ of
 foundation soil.

$\phi = 27^\circ$ (silty clay - sandy clay)
 $N_c = 23.94$
 $N_\gamma = 14.47$

Assume cohesion $c = 0$ for extreme case + conservative design.

$$\therefore Q_{ult} = 0.5(125)(4.5)(14.47) =$$

$$Q_{ult} = \dots = 4069 \text{ psf.} \leftarrow \text{seems high, use typical value of 2500 psf this type soil}$$

$$Q_a = \frac{\gamma_r (H L \cdot H)}{B} = \frac{(125)(4.5)(6.5)}{3.09} = 1183 \text{ psf.}$$

$$B = L - 2e \quad e = \frac{P_s \gamma_s}{W_r} = \frac{(928.8)(2.33)}{3062.5} = .71$$

$$B = 4.5 - (2)(.71) = 3.09$$

$$FS_{BC} = \frac{Q_{ult}}{Q_a} = \frac{4069}{1183} = 3.44 \text{ OK, However if more realistic value of 2500 psf is used for } Q_{ult}$$

$$FS_{BC} = 2.11 > 2.0 \text{ } \checkmark \text{ OK} = \frac{2500}{1183} = 2.11 \text{ } \textcircled{OK} \checkmark > \underline{2.0}$$

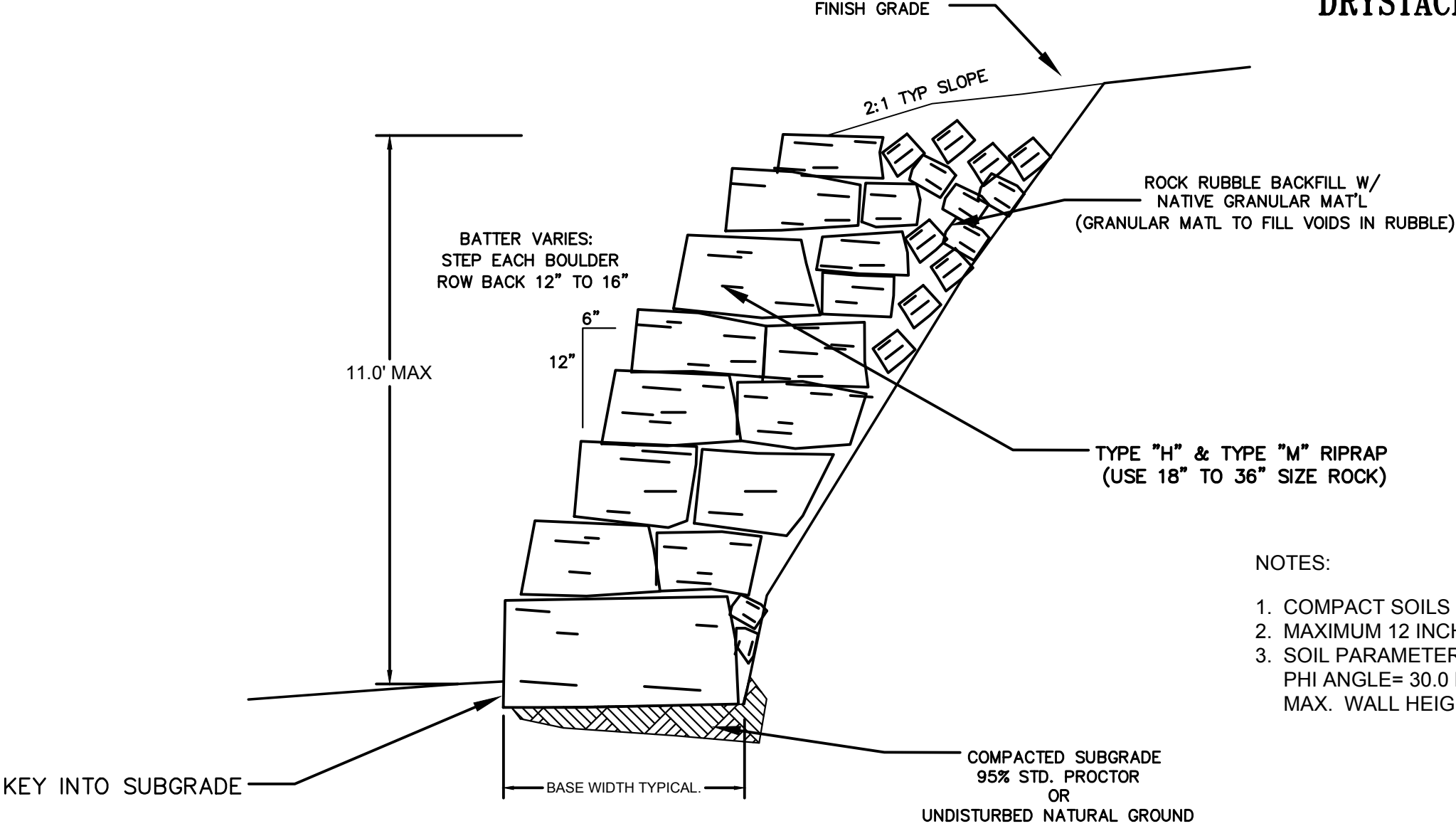
ϕ^+	N_c	N_q^*	N_γ	N_q/N_c	$\tan \phi$
0	5.14	1.00	0.00	0.20	0.00
1	5.38	1.09	0.07	0.20	0.02
2	5.63	1.20	0.15	0.21	0.03
3	5.90	1.31	0.24	0.22	0.05
4	6.19	1.43	0.34	0.23	0.07
5	6.49	1.57	0.45	0.24	0.09
6	6.81	1.72	0.57	0.25	0.11
7	7.16	1.88	0.71	0.26	0.12
8	7.53	2.06	0.86	0.27	0.14
9	7.92	2.25	1.03	0.28	0.16
10	8.35	2.47	1.22	0.30	0.18
11	8.80	2.71	1.44	0.31	0.19
12	9.28	2.97	1.69	0.32	0.21
13	9.81	3.26	1.97	0.33	0.23
14	10.37	3.59	2.29	0.35	0.25
15	10.98	3.94	2.65	0.36	0.27
16	11.63	4.34	3.06	0.37	0.29
17	12.34	4.77	3.53	0.39	0.31
18	13.10	5.26	4.07	0.40	0.32
19	13.93	5.80	4.68	0.42	0.34
20	14.83	6.40	5.39	0.43	0.36
21	15.82	7.07	6.20	0.45	0.38
22	16.88	7.82	7.13	0.46	0.40
23	18.05	8.66	8.20	0.48	0.42
24	19.32	9.60	9.44	0.50	0.45
25	20.72	10.66	10.88	0.51	0.47
26	22.25	11.85	12.54	0.53	0.49
27	23.94	13.20	14.47	0.55	0.51
28	25.80	14.72	16.72	0.57	0.53
29	27.86	16.44	19.34	0.59	0.55
30	30.14	18.40	22.40	0.61	0.58
31	32.67	20.63	25.99	0.63	0.60
32	35.49	23.18	30.22	0.65	0.62
33	38.64	26.09	35.19	0.68	0.65
34	42.16	29.44	41.06	0.70	0.67
35	46.12	33.30	48.03	0.72	0.70
36	50.59	37.75	56.31	0.75	0.73
37	55.63	42.92	66.19	0.77	0.75
38	61.35	48.93	78.03	0.80	0.78
39	67.87	55.96	92.25	0.82	0.81
40	75.31	64.20	109.41	0.85	0.84
41	83.86	73.90	130.22	0.88	0.87
42	93.71	85.38	155.55	0.91	0.90
43	105.11	99.02	186.54	0.94	0.93
44	118.37	115.31	224.64	0.97	0.97
45	133.88	134.88	271.76	1.01	1.00
46	152.10	158.51	330.35	1.04	1.04
47	173.64	187.21	403.67	1.08	1.07
48	199.26	222.31	496.01	1.12	1.11
49	229.93	265.51	613.16	1.15	1.15
50	266.89	319.07	762.89	1.20	1.19

+ Use ϕ , the phi angle for foundation soils

* N_q not used, wall embedment ignored (sect 3.2.1)

Figure 7:
Bearing Capacity Factors
(after Vesic (13))

**BIERSDORFER – NICHOLS RESIDENCE
TYPICAL DETAIL FOR
DRystack BOULDER SLOPE / WALL**



NOTES:

1. COMPACT SOILS TO 95% STD. PROCTOR (ASTM D - 698)
2. MAXIMUM 12 INCH LIFTS WHEN COMPACTING SOIL BACKFILL.
3. SOIL PARAMETERS:
PHI ANGLE= 30.0 DEG. DENSITY= 125 PCF
MAX. WALL HEIGHT: 11 FT

TYPICAL DRystack BOULDER RETAINING WALL
USING MACHINE PLACED TYPE H & VH RIPRAP
FOR WALLS 8 TO 11 FEET IN HEIGHT
TYPICAL DRIVEWAY FILL SECTION

SECTION 

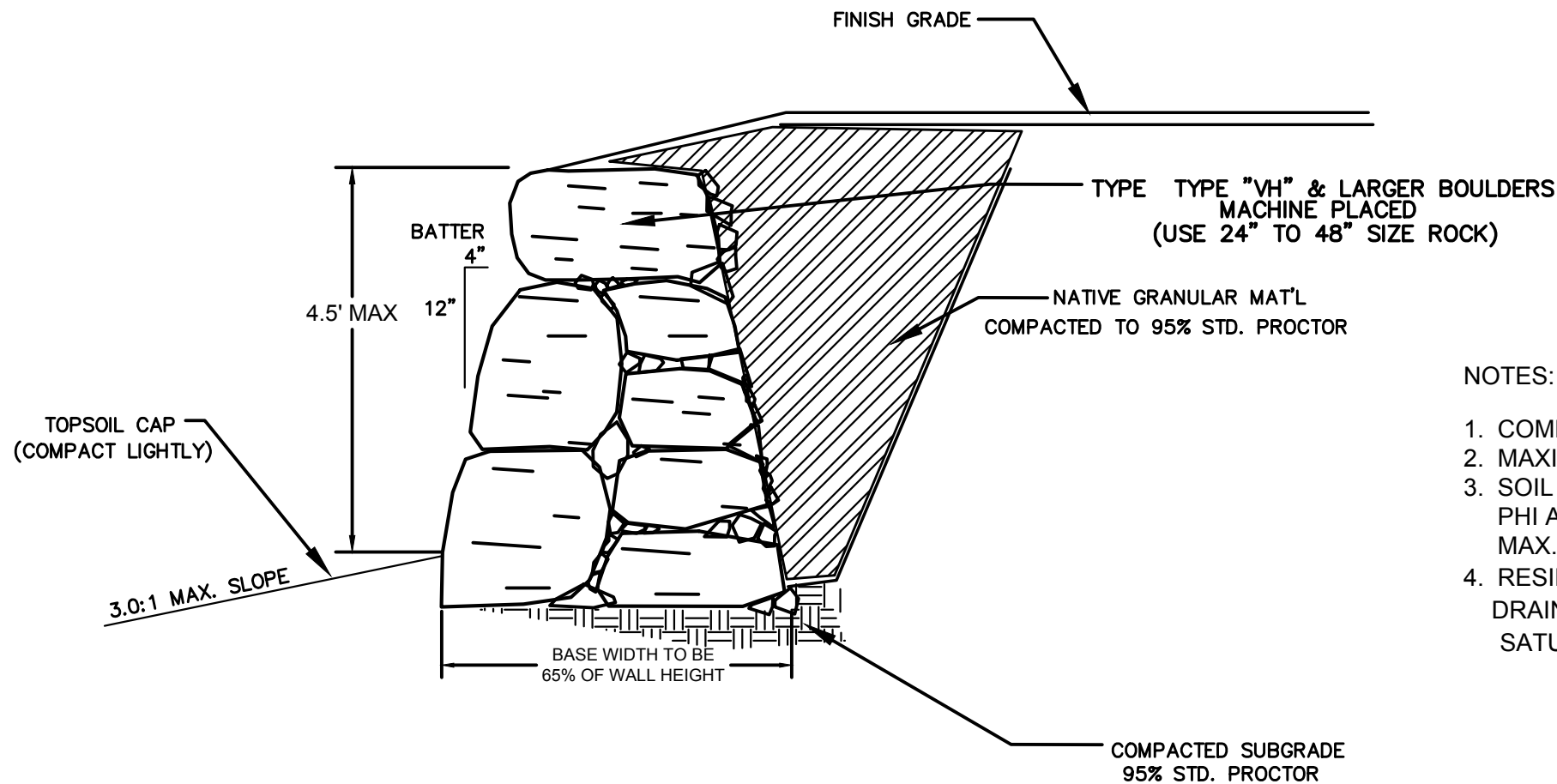


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**1204 WEST PORTAL ROAD
DRystack RETAINING WALLS**

REV. DATE: 5-9-23 SHEET: 1 OF 2

**BIERSDORFER - NICHOLS RESIDENCE
TYPICAL DETAIL FOR
DRystack BOULDER RETAINING WALLS**



NOTES:

1. COMPACT SOILS TO 95% STD. PROCTOR (ASTM D - 698)
2. MAXIMUM 12 INCH LIFTS WHEN COMPACTING SOIL BACKFILL.
3. SOIL PARAMETERS:
PHI ANGLE= 30.0 DEG. DENSITY= 125 PCF
MAX. WALL HEIGHT: 8 FT
4. RESIDENCE DOWNSPOUTS TO BE CONNECTED TO SUBGRADE DRAIN PIPES AND DISCHARGED BEYOND WALL TO PREVENT SATURATION OF BACKFILL SOILS

TYPICAL DRystack BOULDER / GRAVITY TYPE RETAINING WALL
USING MACHINE PLACED TYPE VH / LARGER BOULDERS
FOR WALLS VARYING 4 TO 8 FT. MAX HEIGHT
RETAINED CUT & FILL SLOPES FOR
FOR DRIVEWAY & TURNAROUND & LANDSCAPE WALLS

SECTION **(B)**



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**1204 WEST PORTAL ROAD
DRystack RETAINING WALLS**