**NOTE: Configurations, geometry, units, AND questions can and will be changed on the final exam.**

# ARCH 331. Practice Final Examination

*Note: No aids are allowed for part 1. For part 2, a reference document and any necessary charts will be provided (also posted), and* *two single sides* *of letter sized paper with notes are allowed along with a silent,* ***non-programmable*** *calculator.*

***Part 1)*** *Worth 10%* *(conceptual questions)*

***Part 2)*** Clearly show all your work and record your **final answers in the boxes**.

*Question 1)* *Worth 45%*

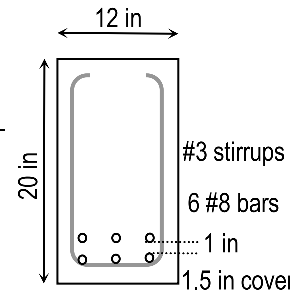


Figure 1a

- Solid slabs 5 in.-thick are integrally supported on three beams in a two-story frame. The center to center beam spacing is 25 ft.
- The floor slab has a dead load of 30 lb/ft$^2$ (not including self weight), and a live load of 50 lb/ft$^2$.
- The roof slab has a dead load of 25 lb/ft$^2$ (not including self weight) and live load of 20 lb/ft$^2$.
- The cross section geometry of the girders which support the beams is shown in Figure 1a. The 12 in. by 20 in. section has 6 #-8 bars (two layers), #3 stirrups, and I = 5200 in$^4$. The self weight is 233 lb/ft.
- The material is light-weight concrete (140 lb/ft$^3$) with E = 3,460 ksi and $f'_c$ = 4,000 psi with grade 60 reinforcement.
- Figure 1b shows the *factored* total loading on a girder in the frame from live, dead, and wind loading.

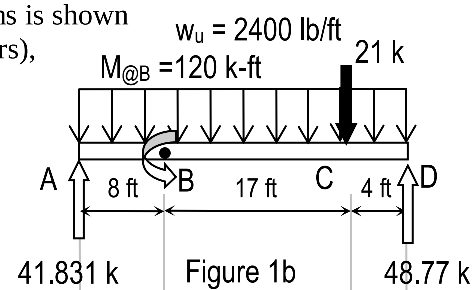


Figure 1b

FIND:

a) If the *first* floor slab is adequate for shear assuming $d$=4 in. and the clear span, $l_n$,= 24 ft.

b) The completed bending moment diagram and maximum factored moment for the girder (Figure 1b & c).

c) If the girder is adequate for bending and reinforcing when $M_u$ = 275 k-ft, knowing $d$ = 16.625 in..

d) The recommended reinforcement ratio, ρ, for the girder when the design moment, $M_u$ = 180 k-ft.

e) The most economical W section of A992 ($F_y$ = 50 ksi) steel that could be used for a 29 ft simply supported beam using the provided Beam Design Moment diagrams if the unbraced length is 12.5 ft and $M_u$ = 150 k-ft *at midspan* when no self weight has been included (yet).

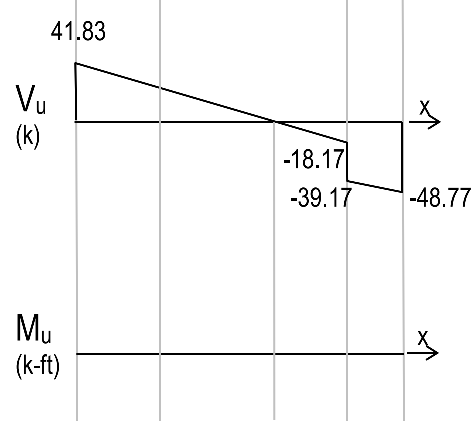


Figure 1c

f) The maximum deflection of the beam shown in Figure 1b for a W 12 x 53 when end A is considered pinned and end D is considered fixed when there is an unfactored distributed load of 1600 lb/ft over the entire length. E = 29 x 10$^3$ ksi, $I_x$ = 425 in$^4$, and $I_y$ = 95.8 in$^4$.

g) The minimum dimension required for a square footing 18 in. deep when the dead load is 105.7 kips and the live load is 36.5 kips for a soil with $q_{allowed}$ = 1800 lb/ft$^2$ and a density of 80 lb/ft$^3$. Assume normal weight concrete (150 lb/ft$^3$).

h) The maximum two-way design shear in a 10 ft. square footing having the loads in part g) when the column is 18 in. square and $d$ = 13.5 in..

**Disclaimer: Answers have NOT been painstakingly researched.**

| | | |
|---|---|---|
| a) yes (2567 lb/unit < $\phi V_c$) | b) | |
| c) no (ρ > $\rho_{.005}$, $\phi M_n$ = 280.3 k-ft) | d) 0.013 | e) |
| f) 0.86 in | g) 9.16 ft | h) 172.5 k |

*Question 2) Worth 45%*

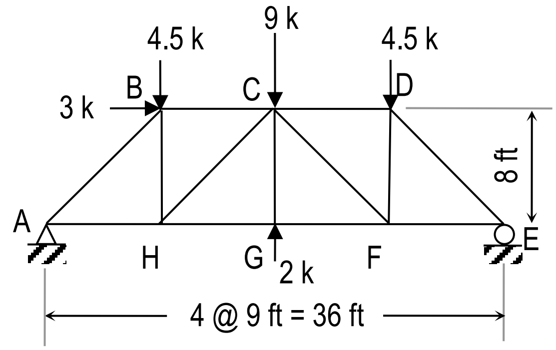


Figure 2a

- A parallel chord truss is shown in the Figure 2a supports dead load and 7 day roof live load. It also has a lateral live load at B of 3 kips. The reactions at the pin and roller supports have been determined to be: $A_x$ = -3 k, $A_y$ = 7.33 k and E = 8.67 k.
- The truss is constructed with 5 1/8 in. x 12 in. glu-lam lumber for the top and bottom chords having E =1.85 x $10^6$ psi, $\alpha$ = 3.8 x $10^{-6}$ /°F, $F_c$ = 1700 psi (no adjustment factors); $F'_p$ = 750 psi (<u>with</u> adjustment factors).
- The top chord is connected to a vertical web member as shown in Figure 2b with 2 – ¾" A 325-SC bolts (class A), standard bolt holes and 3 in. spacing.
- The truss is constructed with a L 4 x 3.5 x ½ in. steel angle welded flush to a 0.75 in. x 3 in. plate for the vertical web members as shown in Figures 2b and c.
- The truss is constructed with C 3 x 5 steel channel sections for the diagonal members as shown in Figures 2 b and c. There is a lap splice as shown.
- All steel is A36 ($F_y$ = 36 ksi, $F_u$ = 58 ksi). The weld material is EXX60.

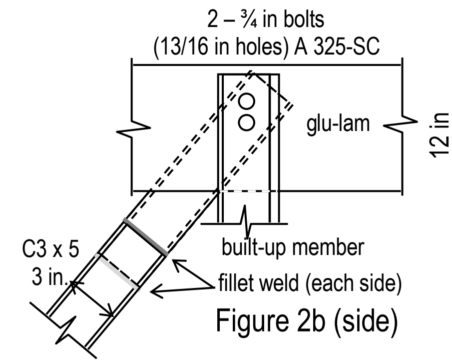


Figure 2b (side)

<u>FIND:</u>

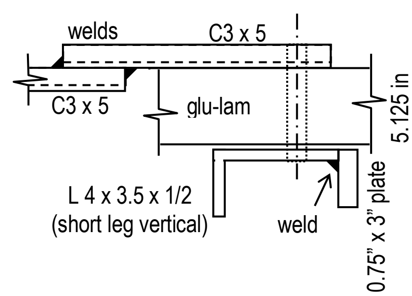


Figure 2c (top)

i) The member forces in BC and HC using the method of sections.
j) The moment of inertia about the *x* axis for the vertical steel web members by completing the chart of Table 2 when $\hat{y}$ = 1.196" from the top of the section.
k) The maximum (factored) compressive load for the vertical steel web members when $r_x$ = 1.01 in. and $r_y$ = 1.80 in..
l) If the top glu-lam chord from C to D is adequate with a member force of 75 kips in compression and a maximum unbraced length of 9 ft. laterally. The ends are pinned in the plane of the truss.
m) The size of the weld required for the lap splice with a factored member force of 40.5 kips in tension.
n) The maximum (factored) shear in the bolts of the connection shown considering the vertical member only.
o) The *design capacity* of the bolted connection shown with respect to bearing in the diagonal member ($t_w$ = 0.258 in.) **and** the top chord.
p) The *design capacity* of the bolted connection shown with respect to tension for the vertical steel member assuming a shear lag factor, *U* = 0.80.

Table 2

| | A ($in^2$) | $I_x$ ($in^4$) | $d_y$ (in) | $Ad_y^2$ ($in^3$) |
|---|---|---|---|---|
| angle | 3.5 | | | |
| plate | 2.25 | | | |

**Disclaimer: Answers have NOT been painstakingly researched.**

| | | | | | |
|---|---|---|---|---|---|
| i) | BC = 11.25 k (C) | | | j) | 5.80 $in^4$ |
| k) | 115.6 k | l) | | m) | 3/8 in. |
| n) | 19.0 k | o) | 5.8 k (78.3 k) | p) | 184.9 k (186.3 k) |

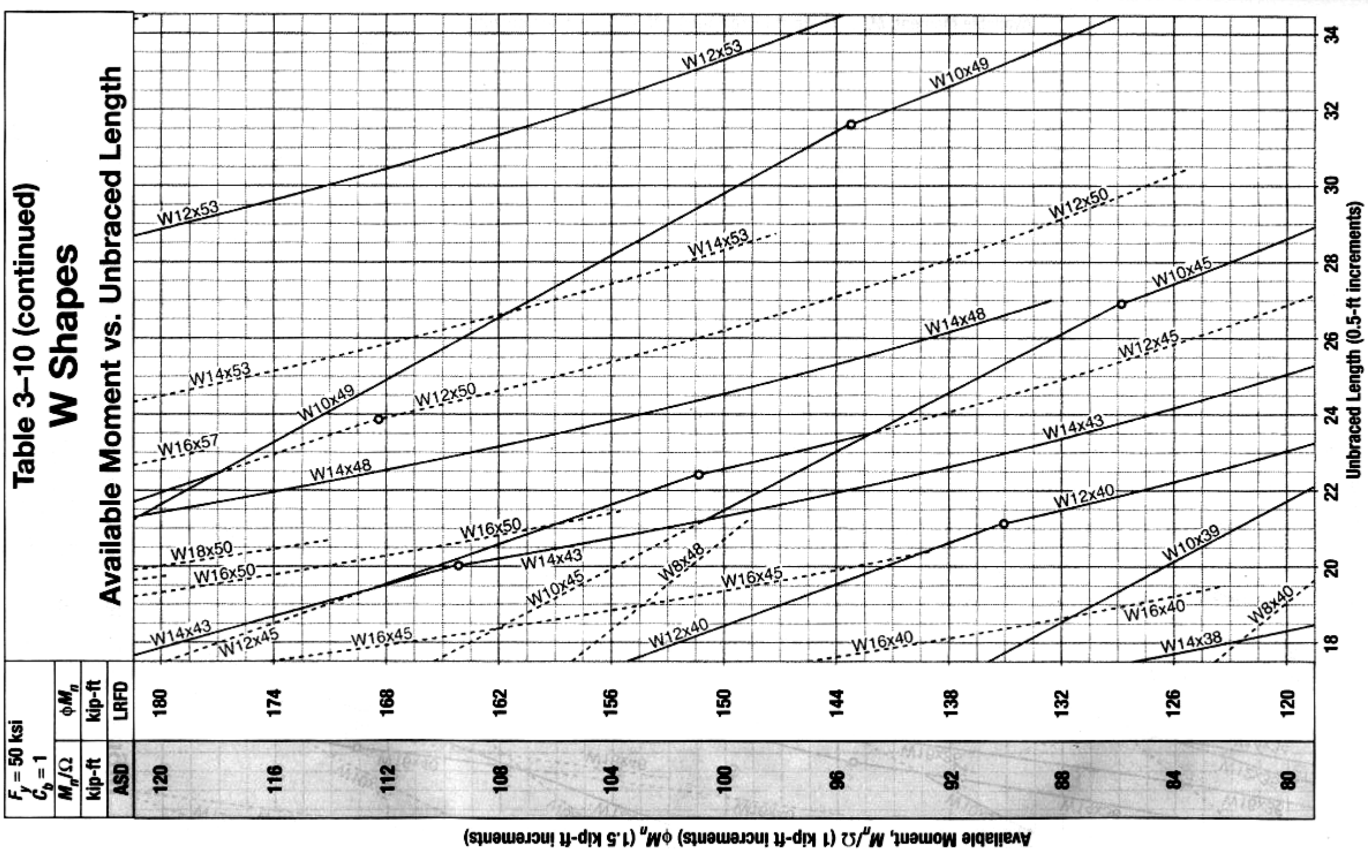


Table 3-10 (continued)
W Shapes
Available Moment vs. Unbraced Length
$F_y$ = 50 ksi
$C_b$ = 1
$M_n/\Omega$
kip-ft
ASD
$\phi M_n$
kip-ft
LRFD
Available Moment, $M_n/\Omega$ (1 kip-ft increments) $\phi M_n$ (1.5 kip-ft increments)
Unbraced Length (0.5-ft increments)
W12x53
W10x49
W12x50
W14x53
W10x45
W14x48
W12x45
W16x57
W14x43
W12x40
W16x50
W18x50
W8x48
W16x45
W10x45
W10x39
W16x40
W8x40
W14x38
W14x43
W12x45
W16x45
W12x40
W16x40

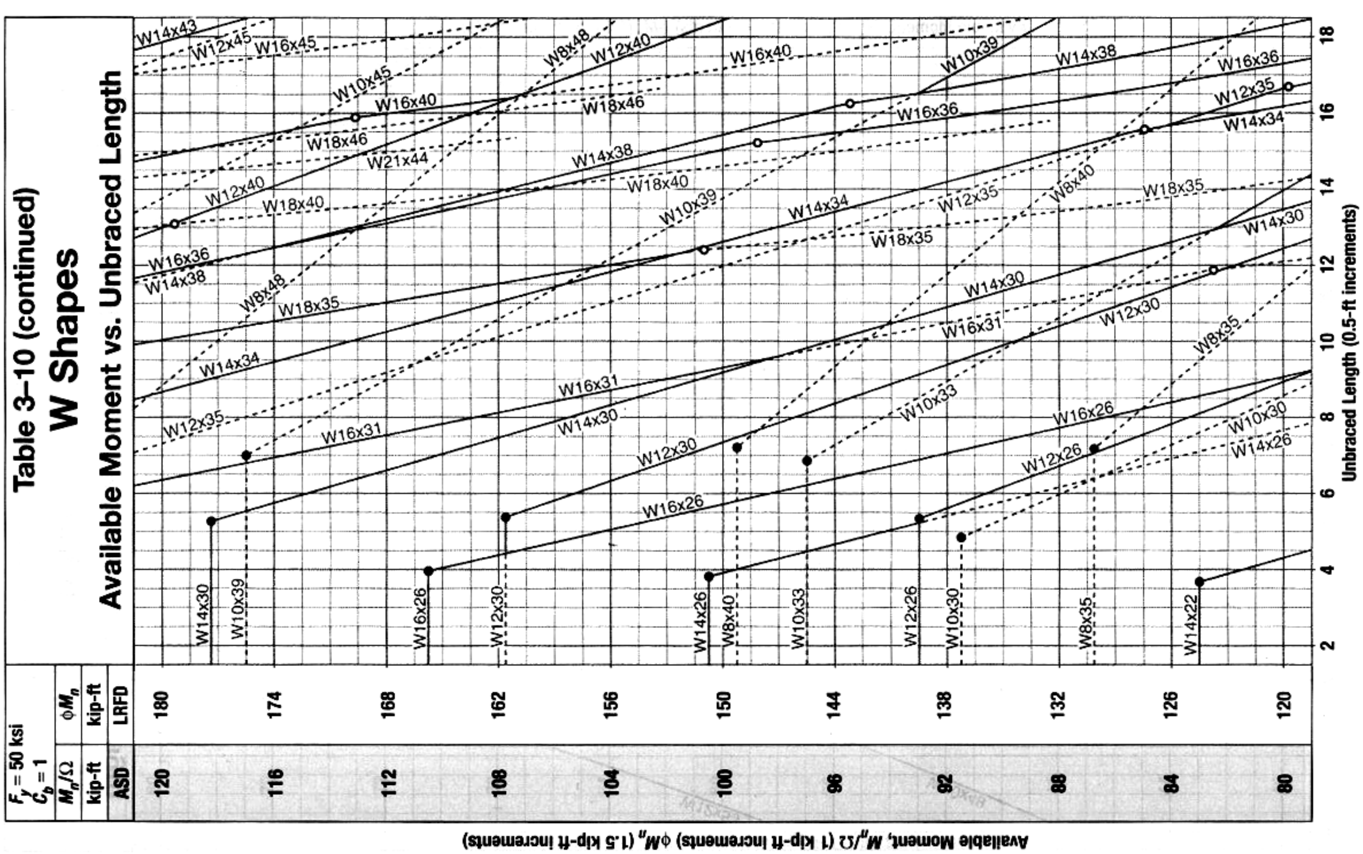
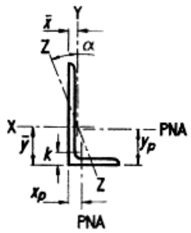


Table 3-10 (continued)
W Shapes
Available Moment vs. Unbraced Length
$F_y$ = 50 ksi
$C_b$ = 1
$M_n/\Omega$
kip-ft
ASD
$\phi M_n$
kip-ft
LRFD
Available Moment, $M_n/\Omega$ (1 kip-ft increments) $\phi M_n$ (1.5 kip-ft increments)
Unbraced Length (0.5-ft increments)
W14x30
W10x39
W16x26
W12x30
W14x26
W8x40
W10x33
W12x26
W10x30
W8x35
W14x22



## Table 1–7 Angles Properties

(Values with respect to orientation with longer leg vertical)

Table 1–7 (continu
Angles
Properties

| Shape | k | Wt. | Area, A | Axis X-X | | | | | | Flexural-Torsional Properties | | | Axis Y-Y | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | I | S | r | $\bar{y}$ | Z | $y_p$ | J | $C_w$ | $\bar{r}_o$ | I | S | r | $\bar{x}$ | Z | $x_p$ |
| | in. | lb/ft | in.$^2$ | in.$^4$ | in.$^3$ | in. | in. | in.$^3$ | in. | in.$^4$ | in.$^6$ | in. | in.$^4$ | in.$^3$ | in. | in. | in.$^3$ | in. |
| L4×4×3/4 | 1 1/8 | 18.5 | 5.44 | 7.62 | 2.79 | 1.18 | 1.27 | 5.02 | 0.679 | 1.02 | 1.12 | 2.10 | 7.62 | 2.79 | 1.18 | 1.27 | 5.01 | 0.679 |
| ×5/8 | 1 | 15.7 | 4.61 | 6.62 | 2.38 | 1.20 | 1.22 | 4.28 | 0.576 | 0.610 | 0.680 | 2.13 | 6.62 | 2.38 | 1.20 | 1.22 | 4.28 | 0.576 |
| ×1/2 | 7/8 | 12.8 | 3.75 | 5.52 | 1.96 | 1.21 | 1.18 | 3.50 | 0.468 | 0.322 | 0.366 | 2.16 | 5.52 | 1.96 | 1.21 | 1.18 | 3.50 | 0.468 |
| ×7/16 | 13/16 | 11.3 | 3.31 | 4.93 | 1.73 | 1.22 | 1.15 | 3.10 | 0.413 | 0.220 | 0.252 | 2.18 | 4.93 | 1.73 | 1.22 | 1.15 | 3.10 | 0.413 |
| ×3/8 | 3/4 | 9.80 | 2.86 | 4.32 | 1.50 | 1.23 | 1.13 | 2.69 | 0.357 | 0.141 | 0.162 | 2.19 | 4.32 | 1.50 | 1.23 | 1.13 | 2.68 | 0.357 |
| ×5/16 | 11/16 | 8.20 | 2.40 | 3.67 | 1.27 | 1.24 | 1.11 | 2.26 | 0.300 | 0.0832 | 0.0963 | 2.21 | 3.67 | 1.27 | 1.24 | 1.11 | 2.26 | 0.300 |
| ×1/4 | 5/8 | 6.60 | 1.94 | 3.00 | 1.03 | 1.25 | 1.08 | 1.82 | 0.242 | 0.0438 | 0.0505 | 2.22 | 3.00 | 1.03 | 1.25 | 1.08 | 1.82 | 0.242 |
| L4×3 1/2×1/2 | 7/8 | 11.9 | 3.50 | 5.30 | 1.92 | 1.23 | 1.24 | 3.46 | 0.497 | 0.301 | 0.302 | 2.03 | 3.76 | 1.50 | 1.04 | 0.994 | 2.69 | 0.438 |
| ×3/8 | 3/4 | 9.10 | 2.67 | 4.15 | 1.48 | 1.25 | 1.20 | 2.66 | 0.433 | 0.132 | 0.134 | 2.06 | 2.96 | 1.16 | 1.05 | 0.947 | 2.06 | 0.334 |
| ×5/16 | 11/16 | 7.70 | 2.25 | 3.53 | 1.25 | 1.25 | 1.17 | 2.24 | 0.401 | 0.0782 | 0.0798 | 2.08 | 2.52 | 0.980 | 1.06 | 0.923 | 1.74 | 0.281 |
| ×1/4 | 5/8 | 6.20 | 1.81 | 2.89 | 1.01 | 1.26 | 1.14 | 1.81 | 0.368 | 0.0412 | 0.0419 | 2.09 | 2.07 | 0.794 | 1.07 | 0.897 | 1.40 | 0.227 |
| L4×3×5/8 | 1 | 13.6 | 3.89 | 6.01 | 2.28 | 1.23 | 1.37 | 4.08 | 0.810 | 0.529 | 0.472 | 1.91 | 2.85 | 1.34 | 0.845 | 0.867 | 2.45 | 0.498 |
| ×1/2 | 7/8 | 11.1 | 3.25 | 5.02 | 1.87 | 1.24 | 1.32 | 3.36 | 0.747 | 0.281 | 0.255 | 1.94 | 2.40 | 1.10 | 0.858 | 0.822 | 1.99 | 0.407 |
| ×3/8 | 3/4 | 8.50 | 2.48 | 3.94 | 1.44 | 1.26 | 1.27 | 2.60 | 0.683 | 0.123 | 0.114 | 1.97 | 1.89 | 0.851 | 0.873 | 0.775 | 1.52 | 0.311 |

Available Critical Stress, $\phi_c F_{cr}$, for Compression Members, ksi ($F_y = 36$ ksi and $\phi_c = 0.90$)

| $KL/r$ | $\phi_c F_{cr}$ | $KL/r$ | $\phi_c F_{cr}$ | $KL/r$ | $\phi_c F_{cr}$ | $KL/r$ | $\phi_c F_{cr}$ | $KL/r$ | $\phi_c F_{cr}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 32.4 | 41 | 29.7 | 81 | 22.9 | 121 | 15.0 | 161 | 8.72 |
| 2 | 32.4 | 42 | 29.5 | 82 | 22.7 | 122 | 14.8 | 162 | 8.61 |
| 3 | 32.4 | 43 | 29.4 | 83 | 22.5 | 123 | 14.6 | 163 | 8.50 |
| 4 | 32.4 | 44 | 29.3 | 84 | 22.3 | 124 | 14.4 | 164 | 8.40 |
| 5 | 32.4 | 45 | 29.1 | 85 | 22.1 | 125 | 14.2 | 165 | 8.30 |
| 6 | 32.3 | 46 | 29.0 | 86 | 22.0 | 126 | 14.0 | 166 | 8.20 |
| 7 | 32.3 | 47 | 28.8 | 87 | 21.8 | 127 | 13.9 | 167 | 8.10 |
| 8 | 32.3 | 48 | 28.7 | 88 | 21.6 | 128 | 13.7 | 168 | 8.00 |
| 9 | 32.3 | 49 | 28.6 | 89 | 21.4 | 129 | 13.5 | 169 | 7.91 |
| 10 | 32.2 | 50 | 28.4 | 90 | 21.2 | 130 | 13.3 | 170 | 7.82 |
| 11 | 32.2 | 51 | 28.3 | 91 | 21.0 | 131 | 13.1 | 171 | 7.73 |
| 12 | 32.2 | 52 | 28.1 | 92 | 20.8 | 132 | 12.9 | 172 | 7.64 |
| 13 | 32.1 | 53 | 27.9 | 93 | 20.5 | 133 | 12.8 | 173 | 7.55 |
| 14 | 32.1 | 54 | 27.8 | 94 | 20.3 | 134 | 12.6 | 174 | 7.46 |
| 15 | 32.0 | 55 | 27.6 | 95 | 20.1 | 135 | 12.4 | 175 | 7.38 |
| 16 | 32.0 | 56 | 27.5 | 96 | 19.9 | 136 | 12.2 | 176 | 7.29 |
| 17 | 31.9 | 57 | 27.3 | 97 | 19.7 | 137 | 12.0 | 177 | 7.21 |
| 18 | 31.9 | 58 | 27.1 | 98 | 19.5 | 138 | 11.9 | 178 | 7.13 |
| 19 | 31.8 | 59 | 27.0 | 99 | 19.3 | 139 | 11.7 | 179 | 7.05 |
| 20 | 31.7 | 60 | 26.8 | 100 | 19.1 | 140 | 11.5 | 180 | 6.97 |
| 21 | 31.7 | 61 | 26.6 | 101 | 18.9 | 141 | 11.4 | 181 | 6.90 |
| 22 | 31.6 | 62 | 26.5 | 102 | 18.7 | 142 | 11.2 | 182 | 6.82 |
| 23 | 31.5 | 63 | 26.3 | 103 | 18.5 | 143 | 11.0 | 183 | 6.75 |
| 24 | 31.4 | 64 | 26.1 | 104 | 18.3 | 144 | 10.9 | 184 | 6.67 |
| 25 | 31.4 | 65 | 25.9 | 105 | 18.1 | 145 | 10.7 | 185 | 6.60 |
| 26 | 31.3 | 66 | 25.8 | 106 | 17.9 | 146 | 10.6 | 186 | 6.53 |
| 27 | 31.2 | 67 | 25.6 | 107 | 17.7 | 147 | 10.5 | 187 | 6.46 |
| 28 | 31.1 | 68 | 25.4 | 108 | 17.5 | 148 | 10.3 | 188 | 6.39 |
| 29 | 31.0 | 69 | 25.2 | 109 | 17.3 | 149 | 10.2 | 189 | 6.32 |
| 30 | 30.9 | 70 | 25.0 | 110 | 17.1 | 150 | 10.0 | 190 | 6.26 |
| 31 | 30.8 | 71 | 24.8 | 111 | 16.9 | 151 | 9.91 | 191 | 6.19 |
| 32 | 30.7 | 72 | 24.7 | 112 | 16.7 | 152 | 9.78 | 192 | 6.13 |
| 33 | 30.6 | 73 | 24.5 | 113 | 16.5 | 153 | 9.65 | 193 | 6.06 |
| 34 | 30.5 | 74 | 24.3 | 114 | 16.3 | 154 | 9.53 | 194 | 6.00 |
| 35 | 30.4 | 75 | 24.1 | 115 | 16.2 | 155 | 9.40 | 195 | 5.94 |
| 36 | 30.3 | 76 | 23.9 | 116 | 16.0 | 156 | 9.28 | 196 | 5.88 |
| 37 | 30.1 | 77 | 23.7 | 117 | 15.8 | 157 | 9.17 | 197 | 5.82 |
| 38 | 30.0 | 78 | 23.5 | 118 | 15.6 | 158 | 9.05 | 198 | 5.76 |
| 39 | 29.9 | 79 | 23.3 | 119 | 15.4 | 159 | 8.94 | 199 | 5.70 |
| 40 | 29.8 | 80 | 23.1 | 120 | 15.2 | 160 | 8.82 | 200 | 5.65 |