ARCH 324 - Structures 2, Winter 2009

von Buelow, Peter

<http://hdl.handle.net/2027.42/64938>
http://hdl.handle.net/2027.42/64938
Reinforced Concrete by Ultimate Strength Design

- LRFD vs. ASD
- Failure Modes
- Flexure Equations
- Analysis of Rectangular Beams
- Design of Rectangular Beams
- Analysis of Non-rectangular Beams
- Design of Non-rectangular Beams
Allowable Stress – WSD (ASD)

\[ f_{\text{actual}} \leq (F.S.)F_{\text{failure}} \]

- Actual loads used to determine stress
- Allowable stress reduced by factor of safety

Ultimate Strength – (LRFD)

- Loads increased depending on type load
  \( \gamma \) Factors: DL=1.4  LL=1.7  WL=1.3
  U=1.4DL+1.7LL

- Strength reduced depending on type force
  \( \phi \) Factors: flexure=0.9  shear=0.85  column=0.7

\[ M_u \leq \phi M_n \]

Examples:

WSD

\[ f_b \leq 0.45 f^{'c} \]
\[ f_v \leq 0.1 \sqrt{f^{'c}} \]

Ultimate Strength

\[ M_u \leq 0.9 M_n \]
\[ V_u \leq 0.85 V_n \]
\[ P_u \leq 0.70 P_n \]
Strength Measurement

• Compressive strength
  – 12”x6” cylinder
  – 28 day moist cure
  – Ultimate (failure) strength

• Tensile strength
  – 12”x6” cylinder
  – 28 day moist cure
  – Ultimate (failure) strength
  – Split cylinder test
  – Ca. 10% to 20% of f’c

Photos: Source: Xb-70 (wikipedia)
Failure Modes

\[ \rho = \frac{A_s}{bd} \]

- No Reinforcing
  - Brittle failure

- Reinforcing < balance
  - Steel yields before concrete fails
  - Ductile failure

- Reinforcing = balance
  - Concrete fails just as steel yields

- Reinforcing > balance
  - Concrete fails before steel yields
  - Sudden failure

\[ \rho_{\text{min}} = \frac{200}{f_y} \]

\[ \rho_{\text{max}} = 0.75 \rho_{bal} \]

\[ \rho_{bal} = \left( \frac{0.85 \beta_1 f'_c}{f_y} \right) \left( \frac{87000}{87000 + f_y} \right) \]

\[ \rho > \rho_{\text{max}} \quad \text{SuddenDeath!!} \]
\( \beta_1 \) is a factor to account for the non-linear shape of the compression stress block.

\[
a = \beta_1 c
\]

<table>
<thead>
<tr>
<th>( f'c )</th>
<th>( \beta_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.85</td>
</tr>
<tr>
<td>1000</td>
<td>0.85</td>
</tr>
<tr>
<td>2000</td>
<td>0.85</td>
</tr>
<tr>
<td>3000</td>
<td>0.85</td>
</tr>
<tr>
<td>4000</td>
<td>0.85</td>
</tr>
<tr>
<td>5000</td>
<td>0.8</td>
</tr>
<tr>
<td>6000</td>
<td>0.75</td>
</tr>
<tr>
<td>7000</td>
<td>0.7</td>
</tr>
<tr>
<td>8000</td>
<td>0.65</td>
</tr>
<tr>
<td>9000</td>
<td>0.65</td>
</tr>
<tr>
<td>10000</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Image Sources: University of Michigan, Department of Architecture
Flexure Equations

actual stress block

\[ C = T \]

\[ 0.85f_c'ab = A_s f_y \]

solving for \( a \),

\[ a = \frac{A_s f_y}{0.85f_c'b} = \frac{\rho f_y d}{0.85f_c'} \]

\[ \rho = \frac{A_s}{bd} \]

ACI equivalent stress block

\[ a = \beta_c c \]

\[ C = 0.85f_c'ab \]

\[ T = A_s f_y \]

Image Sources: University of Michigan, Department of Architecture

\[ M_n = T\left(d - \frac{a}{2}\right) = A_s f_y \left(d - \frac{a}{2}\right) \]

\[ M_u = \phi M_n \]

\[ M_u = \phi A_s f_y \left(d - \frac{a}{2}\right) \]

\[ M_u = \phi A_s f_y d \left(1 - 0.59 \frac{\rho f_y}{f_c'}\right) \]
Balance Condition

From similar triangles at balance condition:

\[
\frac{c}{d} = \frac{0.003}{0.003 + \left(\frac{f_y}{E_s}\right)} = \frac{0.003}{0.003 + \left(\frac{f_y}{29 \times 10^6}\right)}
\]

\[
c = \frac{87,000}{87,000 + f_y} d
\]

Use equation for \(a\). Substitute into \(c = a/\beta_1\)

\[
a = \frac{\rho f_y d}{0.85 f'_c'}
\]

\[
c = \frac{a}{\beta_1} = \frac{\rho f_y d}{0.85 \beta_1 f'_c'}
\]

Equate expressions for \(c\):

\[
\frac{\rho f_y d}{0.85 \beta_1 f'_c'} = \frac{87,000}{87,000 + f_y} d
\]

\[
\rho_b = \left(\frac{0.85 \beta_1 f'_c'}{f_y}\right) \left(\frac{87,000}{87,000 + f_y}\right)
\]
Rectangular Beam Analysis

Data:
- Section dimensions – b, h, d, (span)
- Steel area - As
- Material properties – f’c,  fy

Required:
- Strength (of beam) Moment - Mn
- Required (by load) Moment – Mu
- Load capacity

1. Find ρ = As/bd
   (check ρ min< ρ < ρ max)
2. Find a
3. Find Mn
4. Calculate Mu <= φ Mn
5. Determine max. loading (or span)
Rectangular Beam Analysis

Data:
- dimensions – b, h, d, (span)
- Steel area - As
- Material properties – f_c, f_y

Required:
- Required Moment – Mu

1. Find $\rho = \frac{A_s}{bd}$
   (check $\rho_{\text{min}} < \rho < \rho_{\text{max}}$)

\[
\rho = \frac{A_s}{bd} = \frac{2.37}{12(17.5)} = 0.0113
\]

CHECK $\rho$:

\[
\rho_{\text{BALANCE}} = \rho_B = \left(\frac{0.85f_c}{f_y}\right)\left(\frac{82000}{87000 + f_y}\right)
\]

\[
= \left(\frac{0.85(4)(0.85)}{60}\right)\left(\frac{87000}{87000 + 60000}\right)
\]

\[
= 0.0285
\]

$\rho_{\text{max}} = 0.75\rho_B = 0.75(0.0285) = 0.0214$

$\rho_{\text{min}} = \frac{200}{f_y} = \frac{200}{60000} = 0.0033$

$0.0214 > 0.0113 > 0.0033 \checkmark$
Rectangular Beam Analysis cont.

2. Find \( a \)

\[
a = \frac{A_{sfy}}{0.85 f_{c} b} = \frac{(2.37)(60000)}{0.85(4000)(12)} = 3.49
\]

3. Find \( M_n \)

\[
M_n = A_{sfy} \left( d - \frac{a}{2} \right)
\]

4. Find \( M_u \)

\[
M_u = \phi A_{sfy} \left( d - \frac{a}{2} \right)
\]

\[
M_u = 0.9 \times (2.37)(60000) \times (17.5 - \frac{3.49}{2})
\]

\[
M_u = 2017000 \text{ in-lb}
\]

\[
M_u = 168 \text{ ft-k}
\]
Slab Analysis

Data:
- Section dimensions – h, span
  take b = 12”
- Steel area - As
- Material properties – f’c, fy

Required:
- Required Moment – Mu
- Maximum LL in PSF

\[ f_y = 60 \text{ksi (GR 60)} \]
\[ f'_c = 3000 \text{ psi} \]
\[ c' = 150 \text{pcf} \]
\[ d = 11 - \frac{1}{2} - \frac{3}{4} = 9.75” \]
\[ A_s = \frac{12}{18} \times (0.79 \text{in}^2) = 0.5267 \text{in}^2/\text{ft} \]
Slab Analysis

1. Find a
2. Find force T
3. Find moment arm z
4. Find strength moment Mn
Slab Analysis

5. Find slab DL

6. Find Mu

7. Determine max. loading

\[ w_{DL} = \gamma_c \frac{\text{AREA}}{144} = 150 \times \frac{11(12)}{144} = 137.5 \text{ psf} \]

\[ w_{UPL} = 1.4(w_{DL}) = 1.4(137.5) = 192.5 \]

\[ w_{ULL} = 1.7(w_{UL}) \]

\[ M_u = \frac{(w_{UPL} + w_{ULL})L^2}{8} = 4 \times M_n \]

\[ 0.9(243.17) = \left[ \frac{192.5 + 1.7(w_{UL})}{8} \right] \times 18^2 \]

\[ w_{UL} = 204.6 \text{ psf} \]
Rectangular Beam Design

Data:
• Load and Span
• Material properties – $f'_c$, $f_y$
• All section dimensions – $b$ and $h$

Required:
• Steel area - $A_s$

1. Calculate the dead load and find $M_u$
2. $d = h – \text{cover} – \text{stirrup} – \frac{d_b}{2}$ (one layer)
3. Estimate moment arm $jd$ (or $z$) ≈ 0.9 $d$ and find $A_s$
4. Use $A_s$ to find $a$
5. Use $a$ to find $A_s$ (repeat…)
6. Choose bars for $A_s$ and check $\rho$ max & min
7. Check $M_u < \phi M_n$ (final condition)

8. Design shear reinforcement (stirrups)
9. Check deflection, crack control, steel development length.

$$M_u = \frac{(1.4w_{DL} + 1.7w_{LL})l^2}{8}$$

$$A_s = \frac{M_u}{\phi f_y \left(d - \frac{a}{2}\right)}$$

$$a = \frac{A_s f_y}{0.85 f'_c b}$$

$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$
Rectangular Slab Design

Data:
- Load and Span
- Material properties – f’c, fy

Required:
- All section dimensions – h
- Steel area - As

1. Calculate the dead load and find Mu
2. Estimate moment arm
   jd (or z) = 0.9 d and find As
3. Use As to find a
4. Use a to find As (repeat…)

DATA:
- ONE-WAY FLOOR SLAB - SPAN = 18 FEET
  - f_y = 60,000 psi
  - f_c = 3000 psi
  - Density = 150 psi
  - p = 1/2 \rho_{max} = 0.008

REQUIRED: h and As

Assume h

h = \frac{f_{20}}{10.8} = 10.8 \text{ in. use 11”}

Calculate loads

DL = 137.5 \text{ psf}
LL = 200 \text{ psf}

W = 1.4(137) + 1.7(200) = 540

Calculate Mu

Mu = \frac{wL^2}{8} = 21.7 \text{ k-ft}

Initial As Trial

As = \frac{Mu}{f_y(d - \frac{a}{2})} = \frac{21.7 \times 12}{.9(60)(9)} = 0.536

Initial a

a = \frac{As f_y}{.85 f_c b} = \frac{.536(60)}{.85(3)(12)} = 1.05”
Rectangular Slab Design

3. Use As to find a
4. Use a to find As (repeat…)
5. Choose bars for As and check As min & As max
6. Check Mu<\phi Mn (final condition)

7. Check deflection, crack control, steel development length.
Quiz 9

Can \( f = \frac{Mc}{I} \) be used in Ult. Strength concrete beam calculations? (yes or no)

HINT:

WSD stress

Ult. Strength stress

Source: University of Michigan, Department of Architecture
Rectangular Beam Design

Data:
- Load and Span
- Some section dimensions – b or d
- Material properties – f’c, f_y

Required:
- Steel area - As
- Beam dimensions – b or d

1. Choose $\rho$ (e.g. 0.5 $\rho_{\text{max}}$ or 0.18f’c/f_y)
2. Estimate the dead load and find $M_u$
3. Calculate $bd^2$
4. Choose b and solve for d
   - b is based on form size – try several to find best
5. Estimate h and correct weight and $M_u$
6. Find $A_s = \rho bd$
7. Choose bars for $A_s$ and determine spacing and cover. Recheck h and weight.
8. Design shear reinforcement (stirrups)
9. Check deflection, crack control, steel development length.

\[
M_u = \frac{(1.4w_{DL} + 1.7w_{LL})l^2}{8}
\]

\[
bd^2 = \frac{M_u}{\phi f_y (1 - 0.59 \rho \left( f_y / f'_c \right))}
\]

\[
A_s = \rho bd
\]
Rectangular Beam Design

Data:
- Load and Span
- Material properties – f’c, fy

Required:
- Steel area - As
- Beam dimensions – b and d

1. Estimate the dead load and find Mu
2. Choose \( \rho \) (e.g. 0.5 \( \rho \) max or 0.18f’c/fy)

\[
\text{FACTORED DL} = P_c = 1.7(L) = 1.7(20) = 34 \text{ k}
\]
\[
\text{FACTORED DL} = W_o = 1.4 \text{ (APPLIED LOAD + BEAM WEIGHT ESTIMATE)} = 1.4(2 + 6) = 3.64 \text{ k/ft}
\]
\[
M_u = \frac{P_c \cdot d}{4} + \frac{W_o \cdot \rho^2}{8} = 34(10) + \frac{3.64 \times 30^2}{8} = 340 + 409.5 = 749.5 \text{ k-ft}
\]
\[
M_u = 8994000 \text{ in}-\text{lb}
\]
\[
\rho = \frac{.18 f_c}{f_y} = .009
\]
Rectangular Beam Design cont

3. Calculate $bd^2$

$$bd^2 = \frac{Mu}{4f_y (1-0.59\rho (f_y/f_c))}$$

$$bd^2 = \frac{8994}{(0.9)(0.009)(60)(1-.59(0.009)(60/3))}$$

$$bd^2 = 20705 \text{ in}^3$$

4. Choose $b$ and solve for $d$
   - $b$ is based on form size.
   - Try several to find best

POSSIBILITIES

- \( b = 14'' \) \( d = 38.5'' \)
- \( b = 16'' \) \( d = 35.97'' \)
- \( b = 18'' \) \( d = 33.9'' \)
5. Estimate h and correct weight and Mu
6. Find $A_s = \rho bd$
7. Choose bars for $A_s$ and determine spacing and cover. Recheck h and weight.
8. Design shear reinforcement (stirrups)
9. Check deflection, crack control, steel development length.

**Table A-4**

<table>
<thead>
<tr>
<th>Number of Bars</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar No.</td>
<td>4</td>
<td>0.39</td>
<td>0.58</td>
<td>0.78</td>
<td>0.98</td>
<td>1.18</td>
<td>1.37</td>
<td>1.57</td>
<td>1.77</td>
<td>1.96</td>
<td>2.16</td>
<td>2.36</td>
<td>2.55</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.61</td>
<td>0.91</td>
<td>1.23</td>
<td>1.53</td>
<td>1.84</td>
<td>2.15</td>
<td>2.45</td>
<td>2.76</td>
<td>3.07</td>
<td>3.37</td>
<td>3.68</td>
<td>3.99</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.88</td>
<td>1.32</td>
<td>1.77</td>
<td>2.21</td>
<td>2.65</td>
<td>3.09</td>
<td>3.53</td>
<td>3.98</td>
<td>4.42</td>
<td>4.86</td>
<td>5.30</td>
<td>5.74</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>1.20</td>
<td>1.80</td>
<td>2.41</td>
<td>3.01</td>
<td>3.61</td>
<td>4.21</td>
<td>4.81</td>
<td>5.41</td>
<td>6.01</td>
<td>6.61</td>
<td>7.22</td>
<td>7.82</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>1.57</td>
<td>2.35</td>
<td>3.14</td>
<td>3.93</td>
<td>4.71</td>
<td>5.50</td>
<td>6.28</td>
<td>7.07</td>
<td>7.85</td>
<td>8.64</td>
<td>9.43</td>
<td>10.21</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
<td>7.00</td>
<td>8.00</td>
<td>9.00</td>
<td>10.00</td>
<td>11.00</td>
<td>12.00</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2.53</td>
<td>3.79</td>
<td>5.06</td>
<td>6.33</td>
<td>7.59</td>
<td>8.86</td>
<td>10.12</td>
<td>11.39</td>
<td>12.66</td>
<td>13.92</td>
<td>15.19</td>
<td>16.45</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>4.50</td>
<td>6.75</td>
<td>9.00</td>
<td>11.25</td>
<td>13.50</td>
<td>15.75</td>
<td>18.00</td>
<td>20.25</td>
<td>22.50</td>
<td>24.75</td>
<td>27.00</td>
<td>29.25</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>8.00</td>
<td>12.00</td>
<td>16.00</td>
<td>20.00</td>
<td>24.00</td>
<td>28.00</td>
<td>32.00</td>
<td>36.00</td>
<td>40.00</td>
<td>44.00</td>
<td>48.00</td>
<td>52.00</td>
</tr>
</tbody>
</table>

Non-Rectangular Beam Analysis

Data:
• Section dimensions – b, h, d, (span)
• Steel area - As
• Material properties – f’c, fy

Required:
• Required Moment – Mu (or load, or span)

1. Draw and label diagrams for section and stress
   1. Determining b effective (for T-beams)
   2. Locate T and C (or C₁ and C₂)
2. Set T=C and write force equations (P=FA)
   1. T = As fy
   2. C = 0.85 f’c Ac
3. Determine the Ac required for C
4. Working from the top down, add up area to make Ac
5. Find moment arms (z) for each block of area
6. Find Mn = Cz
7. Find Mu = φ Mn  φ =0.90
8. Check As min < As < As max

Source: University of Michigan, Department of Architecture
Analysis Example

Given:
- $f'_c = 3000$ psi
- $f_y = 60$ ksi
- $A_s = 6$ in$^2$

Req’d:
- Capacity, $M_u$

1. Find $T$
2. Find $C$ in terms of $A_c$
3. Set $T = C$ and solve for $A_c$

\[ T = A_s f_y = 6 \text{ in}^2 \times (60000 \text{ psi}) \]
\[ T = 360000 \text{ kN} = 360 \text{ k} \]

\[ C = 0.85 f'_c A_c = 0.85 (3000 \text{ psi}) A_c \text{ in}^2 \]
\[ C = (2550 A_c) = (2.55 A_c)^k \]

\[ T = C \]
\[ 360^k = 2.55^k A_c^k \]
\[ A_c = 142 \text{ in}^2 \]
Example

4. Draw section and determine areas to make Ac

5. Solve C for each area in compression.

\[
A_c = 142 \, \text{in}^2 = A_{c_1} + A_{c_2} + A_{c_3}
\]

\[
142 = 48 + 30 + A_{c_3}
\]

\[
A_{c_3} = 44 \, \text{in}^2
\]

\[
C_1 = 48 (2.55) = 122.4 \, \text{k}
\]

\[
C_2 = 30 (2.55) = 76.5 \, \text{k}
\]

\[
C_3 = 44 (2.55) = 113.2 \, \text{k}
\]
Example

6. Determine moment arms to areas, z.

7. Calculate Mn by summing the Cz moments.

8. Find $Mu = \frac{Mn}{z}$

$z_1 = 22 - 1.5 = 20.5''$
$z_2 = 22 - (3+2.5) = 16.5''$
$z_3 = 22 - (8+2) = 12.0''$

$Mn = \Sigma Cz$
$Mn = (C_1 z_1) + (C_2 z_2) + (C_3 z_3)$
$Mn = 2509 + 1262 + 1959$
$Mn = 5730$
$Mu = \phi Mn = 0.9(5730) = 5157 k-''$
### Other Useful Tables:

#### Table A.1 Values of Modulus of Elasticity for Normal-Weight Concrete

<table>
<thead>
<tr>
<th>Customary Units</th>
<th>SI Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f'_c$ (psi)</td>
<td>$E_c$ (psi)</td>
</tr>
<tr>
<td>3,000</td>
<td>3,140,000</td>
</tr>
<tr>
<td>3,500</td>
<td>3,390,000</td>
</tr>
<tr>
<td>4,000</td>
<td>3,620,000</td>
</tr>
<tr>
<td>4,500</td>
<td>3,850,000</td>
</tr>
<tr>
<td>5,000</td>
<td>4,050,000</td>
</tr>
</tbody>
</table>

#### Table A.2 Designations, Areas, Perimeters, and Weights of Standard Bars

<table>
<thead>
<tr>
<th>Customary Units</th>
<th>SI Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar No.</td>
<td>Diameter (in.)</td>
</tr>
<tr>
<td>3</td>
<td>0.375</td>
</tr>
<tr>
<td>4</td>
<td>0.500</td>
</tr>
<tr>
<td>5</td>
<td>0.625</td>
</tr>
<tr>
<td>6</td>
<td>0.750</td>
</tr>
<tr>
<td>7</td>
<td>0.875</td>
</tr>
<tr>
<td>8</td>
<td>1.000</td>
</tr>
<tr>
<td>9</td>
<td>1.128</td>
</tr>
<tr>
<td>10</td>
<td>1.270</td>
</tr>
<tr>
<td>11</td>
<td>1.410</td>
</tr>
<tr>
<td>12</td>
<td>1.693</td>
</tr>
<tr>
<td>13</td>
<td>2.257</td>
</tr>
</tbody>
</table>

#### Table A.4 Areas of Groups of Standard Bars (in.$^2$)

<table>
<thead>
<tr>
<th>Bar No.</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.39</td>
<td>0.58</td>
<td>0.78</td>
<td>0.98</td>
<td>1.18</td>
<td>1.37</td>
<td>1.57</td>
<td>1.77</td>
<td>1.96</td>
<td>2.16</td>
<td>2.36</td>
<td>2.55</td>
<td>2.75</td>
</tr>
<tr>
<td>5</td>
<td>0.61</td>
<td>0.91</td>
<td>1.23</td>
<td>1.53</td>
<td>1.84</td>
<td>2.15</td>
<td>2.45</td>
<td>2.76</td>
<td>3.07</td>
<td>3.37</td>
<td>3.68</td>
<td>3.99</td>
<td>4.30</td>
</tr>
<tr>
<td>6</td>
<td>0.88</td>
<td>1.32</td>
<td>1.77</td>
<td>2.21</td>
<td>2.65</td>
<td>3.09</td>
<td>3.53</td>
<td>3.98</td>
<td>4.42</td>
<td>4.86</td>
<td>5.30</td>
<td>5.74</td>
<td>6.19</td>
</tr>
<tr>
<td>7</td>
<td>1.20</td>
<td>1.80</td>
<td>2.41</td>
<td>3.01</td>
<td>3.61</td>
<td>4.21</td>
<td>4.81</td>
<td>5.41</td>
<td>6.01</td>
<td>6.61</td>
<td>7.22</td>
<td>7.82</td>
<td>8.42</td>
</tr>
<tr>
<td>8</td>
<td>1.57</td>
<td>2.35</td>
<td>3.14</td>
<td>3.93</td>
<td>4.71</td>
<td>5.50</td>
<td>6.28</td>
<td>7.07</td>
<td>7.85</td>
<td>8.64</td>
<td>9.43</td>
<td>10.21</td>
<td>11.00</td>
</tr>
<tr>
<td>9</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
<td>7.00</td>
<td>8.00</td>
<td>9.00</td>
<td>10.00</td>
<td>11.00</td>
<td>12.00</td>
<td>13.00</td>
<td>14.00</td>
</tr>
<tr>
<td>10</td>
<td>2.53</td>
<td>3.79</td>
<td>5.06</td>
<td>6.33</td>
<td>7.59</td>
<td>8.86</td>
<td>10.12</td>
<td>11.39</td>
<td>12.66</td>
<td>13.92</td>
<td>15.19</td>
<td>16.45</td>
<td>17.72</td>
</tr>
<tr>
<td>12</td>
<td>4.50</td>
<td>6.75</td>
<td>9.00</td>
<td>11.25</td>
<td>13.50</td>
<td>15.75</td>
<td>18.00</td>
<td>20.25</td>
<td>22.50</td>
<td>24.75</td>
<td>27.00</td>
<td>29.25</td>
<td>31.50</td>
</tr>
<tr>
<td>13</td>
<td>8.00</td>
<td>12.00</td>
<td>16.00</td>
<td>20.00</td>
<td>24.00</td>
<td>28.00</td>
<td>32.00</td>
<td>36.00</td>
<td>40.00</td>
<td>44.00</td>
<td>48.00</td>
<td>52.00</td>
<td>56.00</td>
</tr>
</tbody>
</table>