Chapter 2. Origins of Soil and Grain Size.

2.1 \[ C_{a} = \frac{D_{60}}{D_{10}} = \frac{0.42}{0.16} = 2.625 \approx 2.63 \; ; \; C_{c} = \frac{\bar{D}_{30}}{\bar{D}_{10}} = \frac{0.21^2}{(0.42)(0.16)} = 0.656 \approx 0.66 \]

2.2 \[ C_{a} = \frac{D_{60}}{D_{10}} = \frac{0.81}{0.27} = 3.0 \; ; \; C_{c} = \frac{\bar{D}_{30}}{\bar{D}_{10}} = \frac{0.41^2}{(0.81)(0.27)} = 0.768 \approx 0.77 \]

2.3 a.

<table>
<thead>
<tr>
<th>Sieve no.</th>
<th>Mass of soil retained on each sieve (g)</th>
<th>Percent retained on each sieve</th>
<th>Percent finer</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>28</td>
<td>4.54</td>
<td>95.46</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>6.81</td>
<td>88.65</td>
</tr>
<tr>
<td>20</td>
<td>48</td>
<td>7.78</td>
<td>80.88</td>
</tr>
<tr>
<td>40</td>
<td>128</td>
<td>20.75</td>
<td>79.25</td>
</tr>
<tr>
<td>60</td>
<td>221</td>
<td>35.82</td>
<td>64.18</td>
</tr>
<tr>
<td>100</td>
<td>86</td>
<td>13.94</td>
<td>86.06</td>
</tr>
<tr>
<td>200</td>
<td>40</td>
<td>6.48</td>
<td>93.52</td>
</tr>
<tr>
<td>Pan</td>
<td>24</td>
<td>3.89</td>
<td>96.11</td>
</tr>
</tbody>
</table>

Σ 617 g
b. $D_{10} = 0.16 \text{ mm}; D_{30} = 0.29 \text{ mm}; D_{60} = 0.45 \text{ mm}$

c. $C = \frac{D_{60}}{D_{10}} = \frac{0.45}{0.16} = 2.812 \approx 2.81$

d. $C_c = \frac{D_{30}^2}{(D_{60})(D_{10})} = \frac{0.29^2}{(0.45)(0.16)} = 1.168 \approx 1.17$

2.4 a. 

<table>
<thead>
<tr>
<th>Sieve no.</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>6.0</td>
<td>94.0</td>
</tr>
<tr>
<td>10</td>
<td>48.7</td>
<td>9.74</td>
<td>84.26</td>
</tr>
<tr>
<td>20</td>
<td>127.3</td>
<td>25.46</td>
<td>58.80</td>
</tr>
<tr>
<td>40</td>
<td>96.8</td>
<td>19.36</td>
<td>39.44</td>
</tr>
<tr>
<td>60</td>
<td>76.6</td>
<td>15.32</td>
<td>24.12</td>
</tr>
<tr>
<td>100</td>
<td>55.2</td>
<td>11.04</td>
<td>13.08</td>
</tr>
<tr>
<td>200</td>
<td>43.4</td>
<td>8.68</td>
<td>4.40</td>
</tr>
<tr>
<td>Pan</td>
<td>22</td>
<td>4.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Σ 500 g</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b. $D_{10} = 0.13$ mm; $D_{30} = 0.3$ mm; $D_{60} = 0.9$ mm

c. $C_u = \frac{D_{60}}{D_{10}} = \frac{0.9}{0.13} = 6.923 \approx 6.92$

d. $C_c = \frac{D_{30}^2}{(D_{60})(D_{10})} \times \frac{0.3^2}{(0.9)(0.13)} = 0.769 \approx 0.77$

2.5 a.

<table>
<thead>
<tr>
<th>Sieve no.</th>
<th>Mass of soil retained on each sieve (g)</th>
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<tr>
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<td>0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>5.49</td>
<td>94.51</td>
</tr>
<tr>
<td>20</td>
<td>60</td>
<td>8.23</td>
<td>86.28</td>
</tr>
<tr>
<td>40</td>
<td>89</td>
<td>12.21</td>
<td>74.07</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
<td>19.20</td>
<td>54.87</td>
</tr>
<tr>
<td>80</td>
<td>122</td>
<td>16.74</td>
<td>38.13</td>
</tr>
<tr>
<td>100</td>
<td>210</td>
<td>28.81</td>
<td>9.33</td>
</tr>
<tr>
<td>200</td>
<td>56</td>
<td>7.68</td>
<td>1.65</td>
</tr>
<tr>
<td>Pan</td>
<td>12</td>
<td>1.65</td>
<td>0.00</td>
</tr>
</tbody>
</table>

$\Sigma 729$ g
b. $D_{10} = 0.17 \text{ mm}; D_{30} = 0.18 \text{ mm}; D_{60} = 0.28 \text{ mm}$

c. 
\[
C = \frac{D_{60}}{D_{10}} = \frac{0.28}{0.17} = 1.647 \approx 1.65
\]

d. 
\[
C_c = \frac{\bar{x}_{30} D^2}{(D_{60})(D_{10})} = \frac{0.18^2}{(0.28)(0.17)} = 0.68
\]

2.6  

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<thead>
<tr>
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<td>4</td>
<td>0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td>20</td>
<td>9.1</td>
<td>1.82</td>
<td>98.18</td>
</tr>
<tr>
<td>40</td>
<td>249.4</td>
<td>49.88</td>
<td>48.3</td>
</tr>
<tr>
<td>60</td>
<td>179.8</td>
<td>35.96</td>
<td>12.34</td>
</tr>
<tr>
<td>100</td>
<td>22.7</td>
<td>4.54</td>
<td>7.8</td>
</tr>
<tr>
<td>200</td>
<td>15.5</td>
<td>3.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Pan</td>
<td>23.5</td>
<td>4.7</td>
<td>0.00</td>
</tr>
</tbody>
</table>

$\Sigma 500 \text{ g}$
b. \( D_{10} = 0.21 \, \text{mm} \); \( D_{30} = 0.39 \, \text{mm} \); \( D_{60} = 0.45 \, \text{mm} \)

c. \[ C = \frac{D_{60}}{D_{10}} = \frac{0.45}{0.21} \approx 2.14 \]

d. \[ C_c = \frac{\bar{x}_{30}}{(D_{60})(D_{10})} = \frac{(0.45)(0.21)}{(0.45)(0.21)} = 1.609 \approx 1.61 \]
a.  

b. Percent passing 2 mm = 100  
   passing 0.06 mm = 73  
   passing 0.002 mm = 9  
   GRAVEL: 100 – 100 = 0% Percent  
   SAND: 100 – 73 = 27% Percent  
   SILT: 73 – 9 = 64%  
   CLAY: 9 – 0 = 9%

c. Percent passing 2 mm = 100  
   passing 0.05 mm = 68  
   passing 0.002 mm = 9  
   GRAVEL: 100 – 100 = 0% Percent  
   SAND: 100 – 68 = 32% Percent  
   SILT: 68 – 9 = 59%  
   CLAY: 9 – 0 = 9%

d. Percent passing 2 mm = 100  
   passing 0.075 mm = 80  
   passing 0.002 mm = 9  
   GRAVEL: 100 – 100 = 0% Percent  
   SAND: 100 – 80 = 20% Percent  
   SILT: 80 – 9 = 71%  
   CLAY: 9 – 0 = 9%
a. Percent passing 2 mm = 100
   GRAVEL: 100 – 100 = 0% Percent
   Percent passing 0.06 mm = 30
   SAND: 100 – 30 = 70% Percent
   Percent passing 0.002 mm = 5
   SILT: 70 – 5 = 65%
   Percent passing 0.002 mm = 5
   CLAY: 5 – 0 = 5%

b. Percent passing 2 mm = 100
   GRAVEL: 100 – 100 = 0% Percent
   passing 0.05 mm = 28
   SAND: 100 – 28 = 72% Percent
   passing 0.002 mm = 5
   SILT: 72 – 5 = 67%
   passing 0.002 mm = 5
   CLAY: 5 – 0 = 5%

c. Percent passing 2 mm = 100
   GRAVEL: 100 – 100 = 0% Percent
   passing 0.075 mm = 34
   SAND: 100 – 34 = 66% Percent
   passing 0.002 mm = 5
   SILT: 66 – 5 = 61%
   passing 0.002 mm = 5
   CLAY: 5 – 0 = 5%

da. Percent passing 2 mm = 100
   GRAVEL: 100 – 100 = 0% Percent
   passing 0.075 mm = 34
   SAND: 100 – 34 = 66% Percent
   passing 0.002 mm = 5
   SILT: 66 – 5 = 61%
   passing 0.002 mm = 5
   CLAY: 5 – 0 = 5%
b. Percent passing 2 mm = 100

\[ \text{GRAVEL: } 100 - 100 = 0\% \]

Percent passing 0.06 mm = 84

\[ \text{SAND: } 100 - 84 = 16\% \]

Percent passing 0.002 mm = 28

\[ \text{SILT: } 84 - 28 = 56\% \]

\[ \text{CLAY: } 28 - 0 = 28\% \]

c. Percent passing 2 mm = 100

\[ \text{GRAVEL: } 100 - 100 = 0\% \]

Percent passing 0.05 mm = 83

\[ \text{SAND: } 100 - 83 = 17\% \]

Percent passing 0.002 mm = 28

\[ \text{SILT: } 83 - 28 = 55\% \]

\[ \text{CLAY: } 28 - 0 = 28\% \]

d. Percent passing 2 mm = 100

\[ \text{GRAVEL: } 100 - 100 = 0\% \]

Percent passing 0.075 mm = 90

\[ \text{SAND: } 100 - 90 = 10\% \]

Percent passing 0.002 mm = 28

\[ \text{SILT: } 90 - 28 = 62\% \]

\[ \text{CLAY: } 28 - 0 = 28\% \]
a. 

![Grain Size Distribution Graph]

\[ \text{Percent passing 2 mm} = 100 \]

\[ \text{GRAVEL:} \quad 100 - 100 = 0\% \text{ Percent} \]

\[ \text{Percent passing 0.06 mm} = 65 \]

\[ \text{SAND:} \quad 100 - 65 = 35\% \text{ Percent} \]

\[ \text{Percent passing 0.002 mm} = 35 \]

\[ \text{SILT:} \quad 65 - 35 = 30\% \]

\[ \text{CLAY:} \quad 35 - 0 = 35\% \]

\[ \text{Percent passing 0.05 mm} = 62 \]

\[ \text{GRAVEL:} \quad 100 - 62 = 38\% \text{ Percent} \]

\[ \text{SAND:} \quad 62 - 35 = 27\% \]

\[ \text{CLAY:} \quad 35 - 0 = 35\% \]

\[ \text{Percent passing 0.075 mm} = 70 \]

\[ \text{GRAVEL:} \quad 100 - 70 = 0\% \text{ Percent} \]

\[ \text{SAND:} \quad 100 - 70 = 30\% \text{ Percent} \]

\[ \text{SILT:} \quad 70 - 35 = 35\% \]

\[ \text{CLAY:} \quad 35 - 0 = 35\% \]

\[ G_s = 2.7; \quad \text{temperature} = 24^\circ; \quad \text{time} = 60 \text{ min}; \quad L = 9.2 \text{ cm} \]

\[ \sqrt{\frac{L (cm)}{t (min)}} \]
\[ D \text{ (mm)} = K \]
From Table 2.6 for \( G_s = 2.7 \) and temperature = 24°, \( K = 0.01282 \)

\[
D = 0.01282 \sqrt[60]{9.2} = 0.005 \text{ mm}
\]

\( G_s = 2.75; \) temperature = 23° C; time = 100 min; \( L = 12.8 \) cm

Eq. (2.5): \( D (\text{mm}) = K \sqrt[100]{L} (\text{min}) \)

From Table 2.6 for \( G_s = 2.75 \) and temperature = 23°, \( K = 0.01279 \)

\[
D = 0.01279 \sqrt[100]{12.8} = 0.0046 \text{ mm}
\]

CRITICAL THINKING PROBLEM

2.C.1 a. Soil A: \( C_u = \frac{D_{60}}{D_{10}} = \frac{11}{0.6} = 18.33 \); \( C_c = \frac{\bar{x}_{30} D^2}{(D_{60})(D_{10})} = \frac{5^2}{(11)(0.6)} = 3.78 \)

Soil B:

\( C = \frac{D_{60}}{D_{10}} = \frac{7}{0.2} = 35 \); \( C_c = \frac{\bar{x}_{30} D^2}{(D_{60})(D_{10})} = \frac{2.1}{7(0.2)} = 3.15 \)

Soil C:

\( C_u = \frac{D_{60}}{D_{10}} = \frac{4.5}{0.15} = 30 \); \( C_c = \frac{\bar{x}_{30} D^2}{(D_{60})(D_{10})} = \frac{1^2}{4.5(0.15)} = 1.48 \)
b. Soil A is coarser than Soil C. A higher percentage of soil C is finer than any given size compared to Soil A. For example, about 15% is finer than 1 mm for Soil A, whereas almost 30% is finer than 1 mm in case of soil C.

c. Particle segregation may take place in aggregate stockpiles such that there is a separation of coarser and finer particles. This makes representative sampling difficult. Therefore Soils A, B, and C demonstrate quite different particle size distribution.
d. Soil A:
   Percent passing 4.75 mm = 29
   GRAVEL: 100 − 29 = 71%
   Percent passing 0.075 mm = 1
   SAND: 29 − 1 = 28%
   FINES: 1 − 0 = 1%

Soil B:
   Percent passing 4.75 mm = 45
   GRAVEL: 100 − 45 = 55%
   Percent passing 0.075 mm = 2
   SAND: 45 − 2 = 43%
   FINES: 2 − 0 = 2%

Soil C:
   Percent passing 4.75 mm = 53
   GRAVEL: 100 − 53 = 47%
   Percent passing 0.075 mm = 3
   SAND: 47 − 3 = 44%
   FINES: 3 − 0 = 3%