ACI Mix Design Example #2

- Consider the following example: The 28-day compressive strength should be 7,000 psi. The slump should be between 3 and 4 in. and the maximum aggregate size should not exceed ¾ in. The coarse and fine aggregates in the storage bins are wet.
- The properties of the materials are as follows:
  - Cement: Type I, specific gravity = 3.15
  - Coarse Aggregate: Bulk specific gravity (SSD) = 2.65; absorption capacity = 0.5%; dry-rodded unit weight = 100 lb./ft.³; surface moisture = 1%
  - Fine Aggregate: Bulk specific gravity (SSD) = 2.60; absorption capacity = 1.1%; fineness modulus = 2.70; surface moisture = 3.0%

Step 1. Required material information (already given).
Step 2. The slump is given, consistent with Table 1.
Step 4. Estimation of mixing water and air content. From Table 2, the recommended air content is 2.0%; the water requirement is 340 lb./yd.³.
Step 5. Water/cement ratio. From Table 3, the estimate for required w/c ratio to give a 28-day strength of 7,000 psi is 0.33.
Step 6. Calculation of cement content. Based on steps 4 and 5, the required cement content is:

\[
\text{weight of cement} = \frac{340 \text{ lb./yd.}^3}{0.33} = 1,030 \text{ lb./yd.}^3
\]

Class ACI Mix Design Example

- Step 4. Estimation of mixing water and air content. From Table 2, the recommended air content is 2.0%; the water requirement is 340 lb./yd.³.

<table>
<thead>
<tr>
<th>Slump (in)</th>
<th>0.375</th>
<th>0.35</th>
<th>0.30</th>
<th>0.35</th>
<th>0.40</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.375</td>
<td>0.87</td>
<td>0.82</td>
<td>0.67</td>
<td>0.52</td>
<td>0.46</td>
<td>0.40</td>
<td>0.30</td>
<td>0.23</td>
</tr>
<tr>
<td>0.35</td>
<td>0.82</td>
<td>0.74</td>
<td>0.59</td>
<td>0.44</td>
<td>0.39</td>
<td>0.33</td>
<td>0.24</td>
<td>0.19</td>
</tr>
<tr>
<td>0.30</td>
<td>0.74</td>
<td>0.68</td>
<td>0.53</td>
<td>0.40</td>
<td>0.35</td>
<td>0.30</td>
<td>0.21</td>
<td>0.16</td>
</tr>
<tr>
<td>0.40</td>
<td>0.40</td>
<td>0.19</td>
<td>0.14</td>
<td>0.10</td>
<td>0.06</td>
<td>0.03</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>0.50</td>
<td>0.33</td>
<td>0.28</td>
<td>0.23</td>
<td>0.19</td>
<td>0.15</td>
<td>0.11</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>0.75</td>
<td>0.22</td>
<td>0.18</td>
<td>0.14</td>
<td>0.11</td>
<td>0.08</td>
<td>0.06</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>1.00</td>
<td>0.14</td>
<td>0.11</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>3.00</td>
<td>0.08</td>
<td>0.07</td>
<td>0.06</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>2.00</td>
<td>0.04</td>
<td>0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Class ACI Mix Design Example

- Step 6. Calculation of cement content. Based on steps 4 and 5, the required cement content is:

\[
\text{weight of cement} = \frac{340 \text{ lb./yd.}^3}{0.33} = 1,030 \text{ lb./yd.}^3
\]

Class ACI Mix Design Example

- Step 7. Estimation of coarse aggregate content. Interpolating Table 4 for the fineness modulus of the fine aggregate of 2.70

<table>
<thead>
<tr>
<th>Fineness Modulus</th>
<th>2.4</th>
<th>2.5</th>
<th>2.6</th>
<th>2.7</th>
<th>2.8</th>
<th>2.9</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.375</td>
<td>0.53</td>
<td>0.49</td>
<td>0.46</td>
<td>0.43</td>
<td>0.41</td>
<td>0.39</td>
<td>0.37</td>
</tr>
<tr>
<td>0.500</td>
<td>0.64</td>
<td>0.60</td>
<td>0.56</td>
<td>0.53</td>
<td>0.50</td>
<td>0.47</td>
<td>0.45</td>
</tr>
<tr>
<td>0.750</td>
<td>0.75</td>
<td>0.72</td>
<td>0.69</td>
<td>0.66</td>
<td>0.63</td>
<td>0.61</td>
<td>0.59</td>
</tr>
<tr>
<td>1.000</td>
<td>0.77</td>
<td>0.74</td>
<td>0.71</td>
<td>0.68</td>
<td>0.65</td>
<td>0.63</td>
<td>0.61</td>
</tr>
<tr>
<td>1.500</td>
<td>0.79</td>
<td>0.77</td>
<td>0.75</td>
<td>0.73</td>
<td>0.71</td>
<td>0.69</td>
<td>0.67</td>
</tr>
<tr>
<td>2.000</td>
<td>0.82</td>
<td>0.80</td>
<td>0.78</td>
<td>0.76</td>
<td>0.74</td>
<td>0.72</td>
<td>0.70</td>
</tr>
<tr>
<td>3.000</td>
<td>0.85</td>
<td>0.83</td>
<td>0.81</td>
<td>0.79</td>
<td>0.77</td>
<td>0.76</td>
<td>0.74</td>
</tr>
<tr>
<td>6.000</td>
<td>0.92</td>
<td>0.89</td>
<td>0.87</td>
<td>0.85</td>
<td>0.83</td>
<td>0.81</td>
<td>0.79</td>
</tr>
</tbody>
</table>
Class ACI Mix Design Example

- The coarse aggregate will occupy:
  \[0.63 \times 27 \text{ ft.}^3/\text{yd.}^3 = 17.01 \text{ ft.}^3/\text{yd.}^3\]

- The OD weight of the coarse aggregate
  \[17.01 \text{ ft.}^3/\text{yd.}^3 \times 100 \text{ lb.} / \text{ft.}^3 = 1,701 \text{ lb.} / \text{yd.}^3\]

Class ACI Mix Design Example

- Therefore, the fine aggregate must occupy a volume of:
  \[27 \text{ ft.}^3 - 21.54 \text{ ft.}^3 = 5.48 \text{ ft.}^3\]

- The SSD weight of the fine aggregate is:
  \[5.48 \text{ ft.}^3 \times 2.60 \times 62.4 \text{ lb.} / \text{ft.}^3 = 889 \text{ lb.}\]

Class ACI Mix Design Example

- Step 8. Estimation of fine aggregate content by the absolute volume method.
  - Water: \(340 \text{ lb.} / 62.4 \text{ lb.} / \text{ft.}^3 = 5.45 \text{ ft.}^3\)
  - Cement: \(1,030 \text{ lb.} / (3.15 \times 62.4 \text{ lb.} / \text{ft.}^3) = 5.24 \text{ ft.}^3\)
  - Coarse Aggregate: \(1,701 \text{ lb.} / (2.65 \times 62.4 \text{ lb.} / \text{ft.}^3) = 10.29 \text{ ft.}^3\)
  - Air: \(2.0\% \times 27 \text{ ft.}^3 / \text{yd.}^3 = 0.54 \text{ ft.}^3\)
  
  \[\text{Total} = 21.52 \text{ ft.}^3\]

Class ACI Mix Design Example

- Step 9. Adjustment for moisture in the aggregate.
  
  The weight of aggregate from the stockpile is:
  \[\text{Weight}_{\text{Stock Pile}} = \text{Weight}_{\text{OD}} (1 + MC)\]

  The change in the weight water due to the moisture of the aggregate from the stockpile is:
  \[\Delta \text{Weight}_{\text{Water}} = \text{Weight}_{\text{Water}} (SM)\]

  \[\text{AdjustedWeight}_{\text{Water}} = \text{Weight}_{\text{Water}} - \Delta \text{Weight}_{\text{Water}}\]

Class ACI Mix Design Example

- Step 9. Compute stockpile weight based on moisture content
  - Fine aggregate required from the stockpile is:
    \[889 \text{ lb.} (1 + 0.041) = 925 \text{ lb.} / \text{yd.}^3\]
    
    \[\text{Moisture Content 4.1}\%\]

  - Coarse aggregate required from the stockpile is:
    \[1,701 \text{ lb.} (1 + 0.015) = 1,727 \text{ lb.} / \text{yd.}^3\]
    
    \[\text{Moisture Content 1.5}\%\]

Class ACI Mix Design Example

- Step 9. Adjust the amount of water based on moisture content
  
  The required mixing water required is:
  
  \[340 \text{ lb.} - 889 \text{ lb.} (0.03) \rightarrow \text{fine aggregate}\]

  \[= 296 \text{ lb.} / \text{yd.}^3\]

  \[\text{Surface moisture 3.0}\%\]

  \[- 1,701 \text{ lb.} (0.01) \rightarrow \text{coarse aggregate}\]

  \[= 296 \text{ lb.} / \text{yd.}^3\]

  \[\text{Surface moisture 1}\%\]
## Class ACI Mix Design Example

Thus the estimated batch weights per yd.\(^3\) are:

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>296</td>
</tr>
<tr>
<td>Cement</td>
<td>1,030</td>
</tr>
<tr>
<td>Coarse aggregate (wet)</td>
<td>1,727</td>
</tr>
<tr>
<td>Fine aggregate (wet)</td>
<td>925</td>
</tr>
</tbody>
</table>

**Total**

\[= 3,978 \text{ lb./yd.}^3\]

\[= 147.3 \text{ lb./ft.}^3\]