The total chloride content of concrete can be summarized in Table 3.

### Table 3. Effects of Admixtures on Calculated Chloride Contents of Concrete

<table>
<thead>
<tr>
<th>Concrete Component</th>
<th>Calculated Total Chloride Content (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plain Concrete</strong></td>
<td>0.300</td>
</tr>
<tr>
<td><strong>HRWRA</strong></td>
<td>0.080</td>
</tr>
<tr>
<td><strong>Calcium Chloride</strong></td>
<td>0.079</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.460</td>
</tr>
</tbody>
</table>

### References
4. ACI 318-16 Specifications for Structural Concrete, American Concrete Institute, Farmington Hills, Michigan, 64 pp.
7. ACI 201.2R-16 Guide to Durable Concrete, American Concrete Institute, Farmington Hills, Michigan, 519 pp.

### Introduction
Concrete technology in focus: Chlorides and Admixtures

Concrete is composed of three primary materials: portland cement, water, and aggregate. The chemistry and properties of these materials influence the performance of concrete in various applications. Chlorides are derived from chlorine, a nonmetal which, like oxygen, is one of the basic elements that exists in nature. Chlorides can be found in the environment as a result of natural processes or human activities. Chlorides are used in various applications such as deicing agents, industrial processes, and construction materials. Chlorides can affect the durability and service life of concrete structures.

### Calculation of Chloride Ion Contents
1. **Calculation of Chloride Ion Contents of Concrete**
   - Chloride ion contents are typically expressed in parts per million (ppm) or parts per billion (ppb).
   - The chloride ion content can be calculated using the following formula:
     \[ \text{Chloride Ion Content (ppm)} = \frac{\text{Chloride Mass (kg)}}{\text{Concrete Volume (m³)}} \times 10^6 \]
   - Where:
     - Chloride Mass (kg) is the mass of chloride ions present in the concrete.
     - Concrete Volume (m³) is the volume of concrete.

2. **Effect of Nonchloride-Bearing Admixtures**
   - Nonchloride-bearing admixtures are admixtures with a chloride ion content of 0.0024 kg Cl⁻/m³.
   - The use of nonchloride-bearing admixtures with a chloride ion content of 0.0024 kg Cl⁻/m³ will only result in a marginal increase in the total chloride ion content of the concrete.

3. **Effect of Chloride-Bearing Admixtures**
   - Chloride-bearing admixtures are admixtures with a chloride ion content of 2.261 kg Cl⁻/m³.
   - The use of chloride-bearing admixtures with a chloride ion content of 2.261 kg Cl⁻/m³ will increase the total chloride ion content of the concrete by 0.001 percent by mass of cement.

4. **Comparison of Chloride Ion Contents**
   - The comparison of chloride ion contents can be made using the following formula:
     \[ \text{Chloride Ion Content Ratio} = \frac{\text{Chloride Ion Content of Concrete with Admixture}}{\text{Chloride Ion Content of Plain Concrete}} \]
   - Where:
     - Chloride Ion Content of Concrete with Admixture is the chloride ion content of concrete with admixture.
     - Chloride Ion Content of Plain Concrete is the chloride ion content of plain concrete.

### More Information
Master Builders Solutions provides all its expertise to help its customers find the right solutions for their specific construction challenges. We combine close proximity to our customers with our deep expertise in the construction industry to offer custom solutions tailored to your needs. Our comprehensive portfolio of products and services includes concrete admixtures, waterproofing solutions, and equipment to help you achieve the best performance in your projects.

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An initial evaluation of the chloride ion content of the proposed concrete mixture may be obtained by testing individual concrete ingredients. The amount of chlorides contributed by the chlorides-bearing admixture is:

\[
\text{Chloride ions contributed by the admixture (kg/m³) = Admixture Dosage (kg/m³) x Chloride Ion Content (% of cement)}
\]

3. To determine the amount of chloride ion content contributed by each ingredient, perform the following calculation for each ingredient except the admixture:

\[
\text{Chloride ions contributed by the ingredient (kg/m³) = Ingredient Quantity (kg/m³) x Chloride Ion Content (% of cement)}
\]

### Table 1. ACMI Recommended Chloride Limits for Concrete Prior to Service Exposure

<table>
<thead>
<tr>
<th>Category</th>
<th>Acidity</th>
<th>Limit</th>
<th>Water-soluble Chloride limit</th>
<th>Inorganic Acidity</th>
<th>Total Acidity</th>
<th>Total Chloride</th>
<th>Type of Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precast Concrete</td>
<td>0.050</td>
<td>0.065</td>
<td>0.130</td>
<td>0.22</td>
<td>0.22</td>
<td>0.44</td>
<td>ACI 318</td>
</tr>
<tr>
<td>Reinforced Concrete in wet conditions</td>
<td>0.065</td>
<td>0.130</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.44</td>
<td>ACI 318</td>
</tr>
<tr>
<td>Reinforced Concrete in dry conditions</td>
<td>0.10</td>
<td>0.15</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.50</td>
<td>ACI 318</td>
</tr>
<tr>
<td>Prestressed Concrete</td>
<td>0.030</td>
<td>0.050</td>
<td>0.080</td>
<td>0.08</td>
<td>0.08</td>
<td>0.16</td>
<td>ACI 318</td>
</tr>
<tr>
<td>Prestressed Concrete in wet conditions</td>
<td>0.065</td>
<td>0.130</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
<td>0.44</td>
<td>ACI 318</td>
</tr>
<tr>
<td>Prestressed Concrete in dry conditions</td>
<td>0.130</td>
<td>0.26</td>
<td>0.42</td>
<td>0.42</td>
<td>0.42</td>
<td>0.84</td>
<td>ACI 318</td>
</tr>
</tbody>
</table>

The water-soluble chloride test method on the other hand only measures that chloride which is extractable in water under specific conditions. Compared to the acid-soluble test, this method is less reliable because of the effect that factors such as extraction time, temperature, sample size and concrete age have on the results.

The water-soluble test method is preferred in many cases since it measures the fraction of chlorides that are readily available for leaching. Among the limitations of the water-soluble test method is the inherent variability in the water-soluble chloride test method, this range is not absolute.

The inherent variability in the water-soluble chloride test method, this range is not absolute.

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