### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1</td>
<td>Basic corrosion process in steel reinforced concrete</td>
<td>3</td>
</tr>
<tr>
<td>Figure 1.2</td>
<td>Schematic depiction of Tuutti’s simplified service life model</td>
<td>6</td>
</tr>
<tr>
<td>Figure 1.3</td>
<td>Corrosion-induced damage conditions</td>
<td>17</td>
</tr>
<tr>
<td>Figure 2.1</td>
<td>Illustration of $E_{oc}$ measurement technique</td>
<td>26</td>
</tr>
<tr>
<td>Figure 2.2</td>
<td>Schematic diagram of surface potential measurement</td>
<td>27</td>
</tr>
<tr>
<td>Figure 2.3</td>
<td>Typical potentiodynamic polarization curve</td>
<td>30</td>
</tr>
<tr>
<td>Figure 2.4</td>
<td>Typical cyclic polarization curve</td>
<td>31</td>
</tr>
<tr>
<td>Figure 2.5</td>
<td>Typical linear polarization plot</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2.6</td>
<td>Rendles electrical equivalent circuit for steel reinforcement</td>
<td>34</td>
</tr>
<tr>
<td>Figure 2.7</td>
<td>Typical Nyquist plot for steel reinforcement</td>
<td>35</td>
</tr>
<tr>
<td>Figure 2.8</td>
<td>Impedance components in steel concrete interface</td>
<td>35</td>
</tr>
<tr>
<td>Figure 2.9</td>
<td>Electrochemical potential response of corroding steel</td>
<td>37</td>
</tr>
<tr>
<td>Figure 2.10</td>
<td>A typical plot of Eq. 2.11</td>
<td>38</td>
</tr>
<tr>
<td>Figure 2.11</td>
<td>Illustrations of the Wenner four-probe resistivity measurement</td>
<td>39</td>
</tr>
<tr>
<td>Figure 2.12</td>
<td>Impressed current cathodic protection system</td>
<td>42</td>
</tr>
<tr>
<td>Figure 2.13</td>
<td>Illustration of the chloride extraction technique</td>
<td>43</td>
</tr>
<tr>
<td>Figure 3.1</td>
<td>Scanning electron microscope</td>
<td>94</td>
</tr>
<tr>
<td>Figure 3.2</td>
<td>X-ray Diffractometer</td>
<td>95</td>
</tr>
<tr>
<td>Figure 3.3</td>
<td>SEM micrograph of unhydrated OPC</td>
<td>96</td>
</tr>
<tr>
<td>Figure 3.4</td>
<td>EDX spectrum and EDX analysis results of unhydrated OPC</td>
<td>96</td>
</tr>
<tr>
<td>Figure 3.5</td>
<td>XRD pattern of unhydrated OPC</td>
<td>97</td>
</tr>
<tr>
<td>Figure 3.6</td>
<td>Particle size distribution curve of fine aggregate</td>
<td>98</td>
</tr>
<tr>
<td>Figure 3.7</td>
<td>SEM micrograph of calcium nitrite</td>
<td>101</td>
</tr>
<tr>
<td>Figure 3.8</td>
<td>EDX spectrum and EDX analysis results of calcium nitrite</td>
<td>101</td>
</tr>
<tr>
<td>Figure 3.9</td>
<td>XRD pattern of calcium nitrite</td>
<td>102</td>
</tr>
<tr>
<td>Figure 3.10</td>
<td>XRD pattern of ethanolamine</td>
<td>103</td>
</tr>
<tr>
<td>Figure 3.11</td>
<td>SEM micrograph of nano-TiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>104</td>
</tr>
<tr>
<td>Figure 3.12</td>
<td>EDX spectrum and EDX analysis results of nano-TiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>105</td>
</tr>
<tr>
<td>Figure 3.13</td>
<td>XRD pattern of nano-TiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>105</td>
</tr>
<tr>
<td>Figure 3.14</td>
<td>SEM micrograph of nano-SiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>106</td>
</tr>
<tr>
<td>Figure 3.15</td>
<td>EDX spectrum and EDX analysis results of nano-SiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>107</td>
</tr>
<tr>
<td>Figure 3.16</td>
<td>XRD pattern of nano-SiO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>107</td>
</tr>
<tr>
<td>Figure 3.17</td>
<td>SEM micrograph of mild steel</td>
<td>108</td>
</tr>
<tr>
<td>Figure 3.18</td>
<td>EDX spectrum and EDX analysis results of mild steel</td>
<td>108</td>
</tr>
<tr>
<td>Figure 4.1</td>
<td>Dispersion of nanoparticles through magnetic stirrer</td>
<td>114</td>
</tr>
<tr>
<td>Figure 4.2</td>
<td>Mortar cube specimen for compressive strength test</td>
<td>117</td>
</tr>
<tr>
<td>Figure 4.3</td>
<td>Compression testing machine during testing of a specimen</td>
<td>117</td>
</tr>
<tr>
<td>Figure 4.4</td>
<td>Compressive strength of CN admixed mortar cubes (First series)</td>
<td>118</td>
</tr>
<tr>
<td>Figure 4.5</td>
<td>Compressive strength of EA admixed mortar cubes (First series)</td>
<td>119</td>
</tr>
<tr>
<td>Figure 4.6</td>
<td>Compressive strength of NT admixed mortar cubes (First series)</td>
<td>119</td>
</tr>
<tr>
<td>Figure 4.7</td>
<td>Compressive strength of NS admixed mortar cubes (First series)</td>
<td>120</td>
</tr>
<tr>
<td>Figure 4.8</td>
<td>Compressive strength of CN admixed mortar cubes (Second series)</td>
<td>121</td>
</tr>
<tr>
<td>Figure 4.9</td>
<td>Compressive strength of EA admixed mortar cubes (Second series)</td>
<td>121</td>
</tr>
<tr>
<td>Figure 4.10</td>
<td>Compressive strength of NT admixed mortar cubes (Second series)</td>
<td>122</td>
</tr>
<tr>
<td>Figure 4.11</td>
<td>Compressive strength of NS admixed mortar cubes (Second series)</td>
<td>122</td>
</tr>
</tbody>
</table>
Figure 5.10  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 180 days of exposure in tap water .......................................................... 172
Figure 5.11  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 270 days of exposure in tap water .......................................................... 173
Figure 5.12  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 360 days of exposure in tap water .......................................................... 173
Figure 5.13  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 30 days of exposure in saline solution ...................................................... 175
Figure 5.14  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 90 days of exposure in saline solution ...................................................... 175
Figure 5.15  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 180 days of exposure in saline solution ...................................................... 176
Figure 5.16  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 270 days of exposure in saline solution ...................................................... 176
Figure 5.17  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 360 days of exposure in saline solution ...................................................... 177
Figure 5.18  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 30 days of exposure in acidic solution ....................................................... 178
Figure 5.19  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 90 days of exposure in acidic solution ....................................................... 178
Figure 5.20  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 180 days of exposure in acidic solution ....................................................... 179
Figure 5.21  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 270 days of exposure in acidic solution ....................................................... 179
Figure 5.22  Potentiodynamic polarization curves of the calcium nitrite admixed specimens after 360 days of exposure in acidic solution ....................................................... 180
Figure 5.23  Linear polarization plots of the calcium nitrite admixed specimens after 30 days of exposure in tap water ................................................................. 181
Figure 5.24  Linear polarization plots of the calcium nitrite admixed specimens after 90 days of exposure in tap water ................................................................. 181
Figure 5.25  Linear polarization plots of the calcium nitrite admixed specimens after 180 days of exposure in tap water ................................................................. 182
Figure 5.26  Linear polarization plots of the calcium nitrite admixed specimens after 270 days of exposure in tap water ................................................................. 182
Figure 5.27  Linear polarization plots of the calcium nitrite admixed specimens after 360 days of exposure in tap water ................................................................. 183
Figure 5.28  Linear polarization plots of the calcium nitrite admixed specimens after 30 days of exposure in saline solution .......................................................... 184
Figure 5.29  Linear polarization plots of the calcium nitrite admixed specimens after 90 days of exposure in saline solution .......................................................... 184
Figure 5.30  Linear polarization plots of the calcium nitrite admixed specimens after 180 days of exposure in saline solution .......................................................... 185
Figure 5.31  Linear polarization plots of the calcium nitrite admixed specimens after 270 days of exposure in saline solution .......................................................... 185
Figure 5.32  Linear polarization plots of the calcium nitrite admixed specimens after 360 days of exposure in saline solution .......................................................... 186
Figure 5.33  Linear polarization plots of the calcium nitrite admixed specimens after 30 days of exposure in acidic solution ....................................................... 187
Figure 5.34  Linear polarization plots of the calcium nitrite admixed specimens after 90 days of exposure in acidic solution ....................................................... 187
Figure 5.35  Linear polarization plots of the calcium nitrite admixed specimens after 180 days of exposure in acidic solution ..................................................188
Figure 5.36  Linear polarization plots of the calcium nitrite admixed specimens after 270 days of exposure in acidic solution ..................................................188
Figure 5.37  Linear polarization plots of the calcium nitrite admixed specimens after 360 days of exposure in acidic solution ..................................................189
Figure 5.38  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 30 days of exposure in tap water .............................................191
Figure 5.39  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 90 days of exposure in tap water .............................................191
Figure 5.40  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 180 days of exposure in tap water ............................................192
Figure 5.41  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 270 days of exposure in tap water ............................................192
Figure 5.42  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 360 days of exposure in tap water ............................................193
Figure 5.43  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 30 days of exposure in saline solution ...........................................194
Figure 5.44  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 90 days of exposure in saline solution ...........................................195
Figure 5.45  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 180 days of exposure in saline solution ...........................................195
Figure 5.46  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 270 days of exposure in saline solution ...........................................196
Figure 5.47  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 360 days of exposure in saline solution ...........................................196
Figure 5.48  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 30 days of exposure in acidic solution ...........................................198
Figure 5.49  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 90 days of exposure in acidic solution ...........................................198
Figure 5.50  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 180 days of exposure in acidic solution ...........................................199
Figure 5.51  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 270 days of exposure in acidic solution ...........................................199
Figure 5.52  Potentiodynamic polarization curves of the ethanolamine admixed specimens after 360 days of exposure in acidic solution ...........................................200
Figure 5.53  Linear polarization plots of the ethanolamine admixed specimens after 30 days of exposure in tap water .................................................................201
Figure 5.54  Linear polarization plots of the ethanolamine admixed specimens after 90 days of exposure in tap water .................................................................202
Figure 5.55  Linear polarization plots of the ethanolamine admixed specimens after 180 days of exposure in tap water .................................................................202
Figure 5.56  Linear polarization plots of the ethanolamine admixed specimens after 270 days of exposure in tap water .................................................................203
Figure 5.57  Linear polarization plots of the ethanolamine admixed specimens after 360 days of exposure in tap water .................................................................203
Figure 5.58  Linear polarization plots of the ethanolamine admixed specimens after 30 days of exposure in saline solution ............................................................204
Figure 5.59  Linear polarization plots of the ethanolamine admixed specimens after 90 days of exposure in saline solution ............................................................205
Figure 5.60  Linear polarization plots of the ethanolamine admixed specimens after 180 days of exposure in saline solution ................................................................. 205
Figure 5.61  Linear polarization plots of the ethanolamine admixed specimens after 270 days of exposure in saline solution ................................................................. 206
Figure 5.62  Linear polarization plots of the ethanolamine admixed specimens after 360 days of exposure in saline solution ................................................................. 206
Figure 5.63  Linear polarization plots of the ethanolamine admixed specimens after 30 days of exposure in acidic solution ................................................................. 207
Figure 5.64  Linear polarization plots of the ethanolamine admixed specimens after 90 days of exposure in acidic solution ................................................................. 208
Figure 5.65  Linear polarization plots of the ethanolamine admixed specimens after 180 days of exposure in acidic solution ................................................................. 208
Figure 5.66  Linear polarization plots of the ethanolamine admixed specimens after 270 days of exposure in acidic solution ................................................................. 209
Figure 5.67  Linear polarization plots of the ethanolamine admixed specimens after 360 days of exposure in acidic solution ................................................................. 209
Figure 5.68  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 30 days of exposure in tap water ................................................................. 211
Figure 5.69  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 90 days of exposure in tap water ................................................................. 212
Figure 5.70  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 180 days of exposure in tap water ................................................................. 212
Figure 5.71  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 270 days of exposure in tap water ................................................................. 213
Figure 5.72  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 360 days of exposure in tap water ................................................................. 213
Figure 5.73  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 30 days of exposure in saline solution ................................................................. 215
Figure 5.74  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 90 days of exposure in saline solution ................................................................. 215
Figure 5.75  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 180 days of exposure in saline solution ................................................................. 216
Figure 5.76  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 270 days of exposure in saline solution ................................................................. 216
Figure 5.77  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 360 days of exposure in saline solution ................................................................. 217
Figure 5.78  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 30 days of exposure in acidic solution ................................................................. 218
Figure 5.79  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 90 days of exposure in acidic solution ................................................................. 219
Figure 5.80  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 180 days of exposure in acidic solution ................................................................. 219
Figure 5.81  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 270 days of exposure in acidic solution ................................................................. 220
Figure 5.82  Potentiodynamic polarization curves of the nano-TiO\(_2\) admixed specimens after 360 days of exposure in acidic solution ................................................................. 220
Figure 5.83  Linear polarization plots of the nano-TiO\(_2\) admixed specimens after 30 days of exposure in tap water ................................................................. 222
Figure 5.84  Linear polarization plots of the nano-TiO\(_2\) admixed specimens after 90 days of exposure in tap water ................................................................. 222
Figure 5.85  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 180 days of exposure in tap water .................................................................223
Figure 5.86  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 270 days of exposure in tap water .................................................................223
Figure 5.87  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 360 days of exposure in tap water .................................................................224
Figure 5.88  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 30 days of exposure in saline solution ...............................................................225
Figure 5.89  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 90 days of exposure in saline solution ...............................................................225
Figure 5.90  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 180 days of exposure in saline solution .........................................................226
Figure 5.91  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 270 days of exposure in saline solution .........................................................226
Figure 5.92  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 360 days of exposure in saline solution .........................................................227
Figure 5.93  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 30 days of exposure in acidic solution ..............................................................228
Figure 5.94  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 90 days of exposure in acidic solution ..............................................................228
Figure 5.95  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 180 days of exposure in acidic solution ..............................................................229
Figure 5.96  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 270 days of exposure in acidic solution ..............................................................229
Figure 5.97  Linear polarization plots of the nano-TiO$_2$ admixed specimens after 360 days of exposure in acidic solution ..............................................................230
Figure 5.98  Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 30 days of exposure in tap water .......................................................232
Figure 5.99  Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 90 days of exposure in tap water .......................................................232
Figure 5.100 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 180 days of exposure in tap water .......................................................233
Figure 5.101 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 270 days of exposure in tap water .......................................................233
Figure 5.102 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 360 days of exposure in tap water .......................................................234
Figure 5.103 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 30 days of exposure in saline solution .............................................235
Figure 5.104 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 90 days of exposure in saline solution .............................................235
Figure 5.105 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 180 days of exposure in saline solution .............................................236
Figure 5.106 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 270 days of exposure in saline solution .............................................237
Figure 5.107 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 360 days of exposure in saline solution .............................................237
Figure 5.108 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 30 days of exposure in acidic solution ..........................................239
Figure 5.109 Potentiodynamic polarization curves of the nano-SiO$_2$ admixed specimens after 90 days of exposure in acidic solution ..........................................239
5% of different admixtures, exposed under tap water for 360 days.
Figure 5.135 Corrosion inhibition efficiencies of 1% admixtures content in saline solution environment ................................................................. 257
Figure 5.136 Corrosion inhibition efficiencies of 3% admixtures content in saline solution environment ................................................................. 257
Figure 5.137 Corrosion inhibition efficiencies of 5% admixtures content in saline solution environment ................................................................. 258
Figure 5.138 Specimens containing different admixtures (a) 1% (b) 3% and (c) 5%, after 360 days of exposure in saline solution ........................................... 258
Figure 5.139 Corrosion condition of embedded steels after splitting the specimens containing 1% of different admixtures, exposed under saline solution for 360 days .......... 259
Figure 5.140 Corrosion condition of embedded steels after splitting the specimens containing 3% of different admixtures, exposed under saline solution for 360 days .......... 259
Figure 5.141 Corrosion condition of embedded steels after splitting the specimens containing 5% of different admixtures, exposed under saline solution for 360 days .......... 260
Figure 5.142 Corrosion inhibition efficiencies of 1% admixtures content in acidic solution environment ........................................................................... 261
Figure 5.143 Corrosion inhibition efficiencies of 3% admixtures content in acidic solution environment ........................................................................... 261
Figure 5.144 Corrosion inhibition efficiencies of 5% admixtures content in acidic solution environment ........................................................................... 262
Figure 5.145 Specimens containing different admixtures (a) 1% (b) 3% and (c) 5%, after 360 days of exposure in acidic solution ........................................... 262
Figure 5.146 Corrosion condition of embedded steels after splitting the specimens containing 1% of different admixtures, exposed under acidic solution for 360 days .......... 263
Figure 5.147 Corrosion condition of embedded steels after splitting the specimens containing 3% of different admixtures, exposed under acidic solution for 360 days .......... 263
Figure 5.148 Corrosion condition of embedded steels after splitting the specimens containing 5% of different admixtures, exposed under acidic solution for 360 days .......... 264
Figure 5.149 Specimens after 360 days of exposure under (a) tap water (b) saline solution and (c) acidic solution ................................................................. 267
Figure 5.150 Corrosion condition of embedded steel rods after splitting the specimens exposed in tap water ........................................................................... 267
Figure 5.151 Corrosion condition of embedded steel rods after splitting the specimens exposed in saline solution ........................................................................... 269
Figure 5.152 Corrosion condition of embedded steel rods after splitting the specimens exposed in acidic solution ........................................................................... 270
Figure 6.1 Cross-section of RC beam .............................................................................................................................................................................. 275
Figure 6.2 RC Beams after 360 days of exposure under tap water .......................................................................................................................... 276
Figure 6.3 RC Beams after 360 days of exposure under saline solution ................................................................................................................... 276
Figure 6.4 RC Beams after 360 days of exposure under acidic solution .................................................................................................................... 277
Figure 6.5 Schematic diagram for test set up for RC beam ............................................................................................................................................ 278
Figure 6.6 Specimens before test ................................................................................................................................................................................... 278
Figure 6.7 Specimen under flexural test ........................................................................................................................................................................... 279
Figure 6.8 Load deflection curves for the specimens exposed under tap water ........................................................................................................ 280
Figure 6.9 Load deflection curves for the specimens exposed under saline solution .................................................................................................. 280
Figure 6.10 Load deflection curves for the specimens exposed under acidic solution .............................................................................................. 281
Figure 6.11 RC beams after flexural test ................................................................................................................................................................. 281