APPENDIX 1

MIXTURE PROPORTIONING OF
GEOPOLYMER CONCRETE

Unit weight of Geopolymer concrete = 2400 kg/m³

Aggregates = 77% of unit weigh
= 77 % of 2400
= 1848 kg/m³

Coarse aggregate = 70% of 1848
= 1294 kg/m³

Fine aggregate = 30 % of 1848
= 554 kg/m³

FOR M30 GRADE

Alkaline liquid to fly ash ratio by mass = 0.46

Mass of fly ash and liquid = 2400 – 1848
= 552 kg/m³

Mass of fly ash = \frac{552}{1 + 0.46}
= 378 kg/m³

Mass of alkaline liquid = 552 – 378
= 174 kg/m³

Ratio of sodium silicate to sodium hydroxide = 2.5

Mass of NaOH = \frac{174}{1 + 2.5}
= 50 kg / m³

Mass of Sodium silicate solution = 174 - 50
= 124 kg/m³
For 12M,

NaOH solids = 36.09% of 50
= 18.05 kg/m³

Water = 31.95 kg/m³

Super plasticizer = 2% of fly ash mass
= 2% of 378
= 7.5 kg/m³

FOR G50 GRADE (Hardjito et al 2005)

Alkaline liquid to fly ash ratio by mass = 0.35

Mass of fly ash = \[ \frac{552}{1 + 0.35} \]
= 408 kg/m³

Mass of alkaline liquid = 552 – 408
= 146 kg/m³

Ratio of sodium silicate to sodium hydroxide = 2.5

Mass of NaOH = \[ \frac{146}{1 + 2.5} \]
= 42 kg/m³

Mass of sodium silicate = 104 kg/m³

For 12M,

NaOH solids = 36.09% of 42
= 15.15 kg/m³

Water = 26.85 kg/m³

Super plasticizer = 2% of fly ash mass
= 8.0 kg/m³

The water-to-Geopolymer solids ratio by mass is calculated as follows:

In sodium silicate solution, solids = 45.76 kg/m³

Water = 58.24 kg/m³
In sodium hydroxide solution, solids = 15.15 kg/m³
Water = 26.85 kg/m³
Therefore, total mass of water = 26.85 + 58.24 = 85.09 kg/m³
Mass of Geopolymer solids = Mass of (fly ash + NaOH solids + silicate solids)
= 408 kg/m³ + 15.15 kg/m³ + 45.76
= 468.91 kg/m³
Water-to-Geopolymer solids ratio = 85.09 / 468.91 = 0.18

(Refer Table C)
Hence the required strength of cube is achieved.
APPENDIX 2

DATA FOR THE DESIGN OF GEOPOLYMER CONCRETE MIX

In order to determine the alkaline liquid and the fly ash required for preparing the mixture, the ratio of alkaline liquid to fly ash by mass is needed. Table A2.1 shows the data used for finding the ratio of alkaline liquid to fly ash ratio.

Table A2.1  Ratio of alkaline liquid to fly ash, by mass

<table>
<thead>
<tr>
<th>Alkaline liquid / fly ash, by mass</th>
<th>Water / Geopolymer solids, by mass</th>
<th>Workability</th>
<th>Compressive Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>0.165</td>
<td>Stiff</td>
<td>58</td>
</tr>
<tr>
<td>0.35</td>
<td>0.190</td>
<td>Moderate</td>
<td>45</td>
</tr>
<tr>
<td>0.40</td>
<td>0.210</td>
<td>Moderate</td>
<td>37</td>
</tr>
<tr>
<td>0.45</td>
<td>0.230</td>
<td>High</td>
<td>32</td>
</tr>
</tbody>
</table>

The sodium hydroxide with 97-98% purity, in flake or pellet form, is commercially available. The solids must be dissolved in water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in the range between 8 Molar and 16 Molar. The mass of NaOH solids in a solution varies depending on the concentration of the solution. For instance, NaOH solution with a concentration of 8 Molar consists of 8 x 40 = 320 grams of NaOH solids per litre of the solution, where 40 is the molecular weight of NaOH. The mass of NaOH solids was measured as 262 grams per kg of NaOH solution with a concentration of 8 Molar. Similarly, the mass of NaOH solids per kg of the solution for other concentrations is measured and
expressed as percentage in Table A2.2. The designed compressive strength was compared with the quality given in Table A2.3.

### Table A2.2 Percentage of NaOH flakes in various molarity

<table>
<thead>
<tr>
<th>NaOH Solution</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8M</td>
<td>26.23</td>
</tr>
<tr>
<td>10M</td>
<td>31.37</td>
</tr>
<tr>
<td>12M</td>
<td>36.09</td>
</tr>
<tr>
<td>14M</td>
<td>40.43</td>
</tr>
<tr>
<td>16M</td>
<td>44.44</td>
</tr>
</tbody>
</table>

### Table A2.3 Design compressive strength

<table>
<thead>
<tr>
<th>Water-to-Geopolymer solids ratio, by mass</th>
<th>Workability</th>
<th>Design compressive strength, Mpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16</td>
<td>Very stiff</td>
<td>60</td>
</tr>
<tr>
<td>0.18</td>
<td>Stiff</td>
<td>50</td>
</tr>
<tr>
<td>0.2</td>
<td>Moderate</td>
<td>40</td>
</tr>
<tr>
<td>0.22</td>
<td>High</td>
<td>35</td>
</tr>
<tr>
<td>0.24</td>
<td>High</td>
<td>30</td>
</tr>
</tbody>
</table>