APPENDIX 1

MIX DESIGN OF FGQWS MIXTURE

Steps

- For any known mass of fly ash, volume of fly ash is obtained.
- The volume of gypsum is found by considering mass of gypsum as 10 % by mass of fly ash.
- Mass of quarry waste is fixed based on mass of fly ash and gypsum as mentioned in 3.2.1. Similarly, volume of quarry waste is computed.
- The volume of water is arrived for each mixture based on combined mass of fly ash and gypsum.
- Proportion of the ingredients of mixture is arrived for each flowability based on trial and error.
- The mass of each ingredient is calculated per cubic metre of slurry with the help of proportions of ingredient and their specific gravity.
- Trial mixture proportion is checked for the flowability.

Computations of mixture proportion for $B_{10}$ FGQWS

- Known mass of fly ash is taken as = 100 gm
- Volume of fly ash = 100 / 2.47 x 1 = 40.48 cm$^3$
- Mass of gypsum required = 10 % by mass of fly ash
  = 10 x 100/ 100 = 10 gm
- Volume of gypsum = 10 / 2.7 x 1 = 3.7 cm$^3$
- Mass of QW required for $B_{10}$ FGQWS = 10 % by combined mass of fly ash and gypsum
  = 10 x 110 / 100 = 11 gm
Volume of QW $= 11 / 2.75 \times 1 = 4 \text{ cm}^3$

Volume of water required to obtain flow of 425±25mm

$= 60 \% \text{ by combined mass of fly ash and gypsum}

= 60 \times 110/100$

= 66 \text{ cm}^3$

Mixture proportions

$= FA : G : QW : W$

$= 1 : 0.09 : 0.1 : 1.63$

Total parts of proportion of ingredient $= 2.82$

Therefore mass of each ingredient in $B_{10}$ FGQWS for one cubic metre:

Fly ash

$= 1 \times 1000 \times 2.47 / 2.82$

$= 875.88 \text{ kg}$

Gypsum

$= 0.09 \times 1000 \times 2.7 / 2.82$

$= 87.58 \text{ kg}$

Quarry Waste

$= 0.1 \times 1000 \times 2.75 / 2.82$

$= 96.33 \text{ kg}$

Water

$= 1.63 \times 1000 \times 1 / 2.82$

$= 578.01 \text{ kg}$
APPENDIX 2

COMPUTATION OF COARSE AGGREGATE QUANTITY FOR PREPARING FGSBA SPECIMEN

\[ a) \quad \text{For cubical specimen of size 150 mm x 150 mm x 150 mm} \]

Volume of cube \( = 3375 \text{ cm}^3 \)

Required density of coarse aggregate \( = 1.67 \text{ gm/ cm}^3 \)

Therefore required quantity of coarse aggregate for one cubical mould \( = 3375 \times 1.67 \text{ gm/cm}^3 \)
\( = 5636.25 \text{ gm.} \)

\[ b) \quad \text{For cylindrical specimen of size 150 mm dia x 300 mm height} \]

Volume of cylinders \( = 5301 \text{ cm}^3 \)

Required density of coarse aggregate \( = 1.67 \text{ gm/ cm}^3 \)

Therefore required quantity of coarse aggregate for one cylindrical mould \( = 5301 \times 1.67 \text{ gm/cm}^3 \)
\( = 8852.7 \text{ gm.} \)

Computation of F-G Slurry for Preparing FGSBA Specimen

\[ a) \quad \text{For cubical mould} \]

Computation of volume of voids, \( V_v = \frac{(G - \gamma)}{G} \times 100 \)

Where \( \gamma \) - density in g/cc and \( G \) - Specific gravity

Volume of mould \( = 3375 \text{ cm}^3 \)

Percentage of voids within the aggregate \( = \frac{(2.68 - 1.67) \times 100}{2.68} \)
\( = 37.68 \% \)
Volume of solids in the cube = \[\frac{100 - (G - \gamma) \times 100}{G}\]
= 62.32 %

Volume of voids in the cube = 3375 \times 37.68/100
= 1271.7 \text{ cm}^3.

Slurry hardened density = 1.72 g/cm\(^3\).

Therefore required for one cube = 1271.7 \times 1.72
= 2187 \text{ gm}

Wet slurry density required as per 4.1.2 (Table 4.4)
= 2187 \times 100/98.3
= 2225 \text{ gm}

\[b) \quad For \text{ cylindrical specimen}\]

Volume of voids in the cylinder = \(\frac{(G - \gamma) \times 100}{G}\)
= 62.32 %

Percentage of solids within the aggregate = 100 - 62.32
= 37.68 %

Volume of voids in the cylinder = \((5301 \times 37.68)/100\)
= 1997.4 \text{ cm}^3

Slurry hardened density = 1.72 g/cm\(^3\).

Therefore quantity of slurry for one cylindrical mould = 1997.4 \times 1.72
= 3435.5 \text{ gm.}

Wet slurry density required as per 4.1.2 (Table 4.4)
= 3435.5 \times 100/98.3
= 3495 \text{ gm}
Computation of ingredients used in the slurry with flow of 425±25mm

Proportioning of ingredients is adopted based on 425 mm flow mix with 10 % quarry waste content as 1: 0.1:0.11:0.66 [i.e. fly ash: gypsum: quarry waste: water]

a) Materials required for one cubical specimen

Quantity of slurry required for each cubical mould = 2225 gm

Hence, the materials used for each cube is follows:

Fly ash

\[= 2225 \times \frac{1.0}{1.87} = 1189.8 \text{ gm}\]

Gypsum

\[= 2225 \times \frac{0.1}{1.87} = 119 \text{ gm}\]

Quarry waste

\[= 2225 \times \frac{0.11}{1.87} = 130.9 \text{ gm}\]

Water

\[= 2225 \times \frac{0.66}{1.87} = 785.3 \text{ gm}\]

Therefore net quantity of each material required for one cube is as follows:

Fly ash alone = 1189.8 gm
Gypsum = 119 gm
Quarry waste = 130.9 gm
Water = 785.3 gm
Total = 2225 gm
b) **Quantity of materials for one cylindrical specimen**

Quantity of slurry required for one cylindrical mould = 3495 gm

Hence, the materials used for one cylinder is computed and shown below:

<table>
<thead>
<tr>
<th>Material</th>
<th>Equation</th>
<th>Result (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash</td>
<td>$3495 \times \frac{1.0}{1.87}$</td>
<td>1869</td>
</tr>
<tr>
<td>Fly ash</td>
<td></td>
<td>1869</td>
</tr>
<tr>
<td>Gypsum</td>
<td>$3495 \times \frac{0.1}{1.87}$</td>
<td>18.69</td>
</tr>
<tr>
<td>Gypsum</td>
<td></td>
<td>18.69</td>
</tr>
<tr>
<td>Quarry Waste</td>
<td>$3495 \times \frac{0.11}{1.87}$</td>
<td>205.6</td>
</tr>
<tr>
<td>Quarry Waste</td>
<td></td>
<td>205.6</td>
</tr>
<tr>
<td>Water</td>
<td>$3495 \times \frac{0.66}{1.87}$</td>
<td>1233.5</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>1233.5</td>
</tr>
</tbody>
</table>

Therefore net quantity of each material used for one cylinder

<table>
<thead>
<tr>
<th>Material</th>
<th>Result (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash alone</td>
<td>1869</td>
</tr>
<tr>
<td>Gypsum</td>
<td>18.69</td>
</tr>
<tr>
<td>Quarry Waste</td>
<td>205.6</td>
</tr>
<tr>
<td>Water</td>
<td>1233.5</td>
</tr>
<tr>
<td>Total</td>
<td>3495</td>
</tr>
</tbody>
</table>
APPENDIX 3

COMPUTATION OF F-G SLURRY FOR FG SLURRY BOUND MACADAM BASE

Volume of solids = 100 $\gamma$ /G

Where $\rho$-Density of coarse aggregate in kg/cum and G - Specific gravity

Volume of solids in the base = $\frac{100 \times 1330}{2.68 \times 1000}$
= 49.63 %

Percentage of voids with in the aggregate = 100 – 49.63
= 50.37%

Volume of base = $1.20m \times 1.20m \times 0.20m$
= 0.288 m$^3$

Volume of voids in the base to be filled with the slurry = $0.288 \times 50.37/100$
= 0.145 m$^3$

Slurry hardened density for F-G slurry = 1720 kg/ m$^3$

Therefore required quantity of F-G slurry for base = 0.145 × 1720
= 249.4 kg

Wet slurry density required as per 4.1.2 (Table 4.4) = $249.4 \times 100/98.3$
= 253.7 kg
Computation of Ingredients used in the F-G Slurry Bound Aggregate Base

*Quantity of materials for F-G slurry base macadam*

Quantity of slurry required for preparing this base = 253.7 kg

Hence the materials used for this base is computed and shown below:

- **Fly ash**
  
  \[ \text{Fly ash} = 253.7 \times \frac{1.0}{1.87} \]
  
  \[ = 135.7 \text{ kg} \]

- **Gypsum**
  
  \[ \text{Gypsum} = 253.7 \times \frac{0.1}{1.87} \]
  
  \[ = 13.5 \text{ kg} \]

- **Quarry Waste**
  
  \[ \text{Quarry Waste} = 253.7 \times \frac{0.11}{1.87} \]
  
  \[ = 15 \text{ kg} \]

- **Water**
  
  \[ \text{Water} = 253.7 \times \frac{0.66}{1.87} \]
  
  \[ = 89.5 \text{ kg} \]

Therefore net quantities of each material used for this base are as follows:

- **Fly ash alone** = 135.7 kg
- **Gypsum** = 13.5 kg
- **Quarry Waste** = 15 kg
- **Water** = 89.5 kg
- **Total** = 282.3 kg
APPENDIX 4

COMPUTATION OF ABSOLUTE VOLUME OF INGREDIENTS USED IN THE SLURRY WITH FLOW OF 425 ± 25 mm

Mass of ingredients

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash</td>
<td>875.88</td>
</tr>
<tr>
<td>Gypsum</td>
<td>87.58</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>96.33</td>
</tr>
<tr>
<td>Water</td>
<td>578.01</td>
</tr>
</tbody>
</table>

Absolute volume

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Volume (cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly ash</td>
<td>$875.88 \times 10^3 / 2.47$</td>
</tr>
<tr>
<td></td>
<td>$354.60 \times 10^3$</td>
</tr>
<tr>
<td>Gypsum</td>
<td>$87.58 \times 10^3 / 2.7$</td>
</tr>
<tr>
<td></td>
<td>$32.43 \times 10^3$</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>$96.33 \times 10^3 / 2.75$</td>
</tr>
<tr>
<td></td>
<td>$35.03 \times 10^3$</td>
</tr>
<tr>
<td>Water</td>
<td>$578.01 \times 10^3$</td>
</tr>
<tr>
<td></td>
<td>$578.01 \times 10^3$</td>
</tr>
<tr>
<td>Total volume</td>
<td>$1000 \times 10^3$</td>
</tr>
</tbody>
</table>
Percentage of volume of ingredients

Fly ash \[= 354.6 \times 10^3 \times \frac{100}{1000} \times 10^3\]
\[= 35.4\%\]

Gypsum \[= 32.4 \times 10^3 \times \frac{100}{1000} \times 10^3\]
\[= 3.3\%\]

Fine aggregate \[= 35.03 \times 10^3 \times \frac{100}{1000} \times 10^3\]
\[= 3.5\%\]

Water \[= 578 \times 10^3 \times \frac{100}{1000} \times 10^3\]
\[= 57.8\%\]