Supplementary material : Study on the effect of amorphous silica from waste granite powder on the strength development of cement-treated clay–stone powder composites

Chemically bound water content

$$Chemically\ bound\ water\ = \frac{\{m_{0°C\ (TG\ value)} - m_{105°C\ (TG\ value)}\} - (11.76\% m_{clay} + 1.96\% m_{stone\ powder})\ (TG\ Value)}{m_{0°C\ (TG\ value)}} \times 100\ [\%] \qquad (S1)$$

The TG-DTA results for untreated Tokuyama clay and stone powder indicated mass losses of 11.76% and 1.96% at 0°C–1000°C, respectively These losses for untreated clay and stone powder should be accounted for when calculating the $Ca(OH)_2$ content of cement-treated clay. If the TG-DTA sample is assumed to have the same composition as that of the prepared sample, the initial mass of the sample before the test is given by

$$intial\ sample\ mass, m_{0°C} = m_{cement} + m_{clay} + m_{stone\ powder} + m_{water}. \qquad (S2)$$

The mass of clay is obtained by substituting the masses of cement, stone powder and water given by Eqs. 15, 16 and 17, respectively, in Eq. 18.

$$m_{cement} = \frac{C*}{1-C*} \times m_{clay}, \qquad (S3)$$

$$m_{stone\ powder} = \frac{SP}{1-SP} \times m_{clay}, \qquad (S4)$$

$$m_{water} = 1.5LL \times (m_{clay} + m_{stone\ powder}), \qquad (S5)$$

$$m_{clay} = \frac{m_{0^0C}}{\left[1 + \frac{C*}{1-C*} + \frac{SP}{1-SP} + 1.5LL(1 + \frac{SP}{1-SP})\right]}. \qquad (S6)$$

The values of $C*$, SP and LL are divided by 100.

$Ca(OH)_2$ content due to cement hydration

Because TG-DTA detects the water dehydrated from $Ca(OH)_2$ at 400°C–500°C, the equivalent mass of $Ca(OH)_2$ was determined by stoichiometry. The dehydroxylation of $Ca(OH)_2$ produces CaO and water:

$$Ca(OH)_2 \rightarrow CaO + H_20. \qquad (S7)$$

By stoichiometry, the equivalent mass of $Ca(OH)_2$ can be calculated while considering the clay loss:

$$Ca(OH)_2 = \frac{Molar\ mass\ of\ Ca(OH)_2}{Molar\ mass\ of\ H_2O} \times mass\ of\ H_2\text{O} - (2.448\%m_{clay} + 0.308\%m_{stone\ powder})\ (TG\ Value), \quad \text{(S8)}$$

where the molar masses of $Ca(OH)_2$ and H_2O are 74.092 and 18.015 g/mol, respectively.

The TG-DTA results for untreated Tokuyama clay indicated mass losses of 2.448% and 0.308% at 400°C–500°C and 600°C–800°C, respectively.

4.2.2 $CaCO_3$ content

TG-DTA detects the mass of CO_2 decomposed from $CaCO_3$ at 600°C–800°C. The equivalent mass of $CaCO_3$ must be determined by stoichiometry. The decomposition of $CaCO_3$ produces CaO and CO_2:

$$CaCO_3 \rightarrow CaO + CO_2. \quad \text{(S9)}$$

By stoichiometry, the equivalent mass of $CaCO_3$ is

$$\text{Mass of } CaCO_3 = \frac{Molar\ mass\ of\ CaCO_3}{Molar\ mass\ of\ CO_2} \times mass\ of\ CO_2 - (1.480\%m_{clay} + 0.243\%m_{stone\ powder})(TG\ Value), \quad \text{(S10)}$$

where the molar masses of $CaCO_3$ and CO_2 are 100.09 and 44.01 g/mol, respectively.

4.2.3 $Ca(OH)_2$ consumption by carbonation

$Ca(OH)_2$ is consumed by carbonation to produce $CaCO_3$ and water:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O. \quad \text{(S11)}$$

The amount of $Ca(OH)_2$ consumed by carbonation is determined with stoichiometry:

$$Ca(OH)_2 = \frac{Molar\ mass\ of\ Ca(OH)_2}{Molar\ mass\ of\ CaCO_3} \times mass\ of\ CaCO_3. \quad \text{(S12)}$$