Advanced Construction Materials

Homework #3

Due: April 23rd at 6 pm

1. 100 cm^3 cement was mixed with W/C of 0.5. Determine porosity of cement hydrates with 0%, 25%, 50%, and 100% degrees of hydration, respectively. Assume density of cement as 3.14 cm^3/g. **(20pt)**

2. High temperature XRD (HTXRD) experiment was performed on portlandite ($Ca(OH)_2$). Based on the obtained peak positions (d-space, Å) at different temperatures, calculate thermal expansion coefficient (α_V) of portlandite.

    $\Delta V/V_0 = \alpha_V \Delta T$

    where ΔV is volume variation, V_0 is initial volume at ambient temperature of 30°C, and ΔT is temperature variation. Discuss thermal expansion behavior of different lattice parameters of *a* and *c*. **(30pt)**

Temp (°C)	30	100	200	300	400
(h,k,l)=(0,0,1)	4.9115	4.9312	4.9615	4.9911	5.0212
(h,k,l)=(1,0,0)	3.6005	3.6031	3.6071	3.6111	3.6151
(h,k,l)=(0,0,2)	2.4560	2.4657	2.4806	2.4956	2.5107

3. Quantitative X-ray diffraction (QXRD) was performed to evaluate the chemical reactivity of new cement admixture (X). To consider the amount of amorphous material (from chemical reaction of X), internal standard method was adopted by mixing 20wt.% of TiO_2 in total weight of measured sample after removing free water in samples. Thus prepared samples for XRD do not contain free water. They consist of 20wt.% of TiO_2 and 80wt.% of sum of unreacted cement and cement hydrates.

Anticipated chemical reaction from the admixture X is:

　　C + X + water -> C-S-H + CH
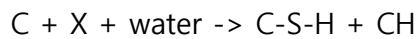
where C is cement (all X-ray detectable crystalline phases), C-S-H is non-crystalline phase (X-ray non-detectable), CH is $Ca(OH)_2$.

Thermal gravimetric analysis (TGA) was also performed for quantification of chemically bound water (BW). Mass of bound water (BW) was determined by (100%-mass% of solid at 600°C)

All data of XRD and TGA is separately attached. Draw following curves considering normalization to anhydrous materials.

1. BW versus time

2. CH content versus time

3. C-S-H content versus time

Above three plots, which one do you think is the most appropriate to express the degree of hydration of this binary system? **(50pt)**