53:086 Civil Engineering Materials

Dept. of Civil & Environmental Engineering
The University of Iowa
Spring Semester 2006, Mid-Term Exam #2
Instructor: C.C. Swan

Question #1: (20 points)

Within hydrated cement paste (hcp) there are essentially two types of voids. Please describe these two types of voids and the effect that each has on the strength of the hcp, and why.

Question #2: (20 points)

For normal strength, normal weight portland cement concrete, please provide reasonable estimates for the ranges of the following properties in both English and SI units.

a. unit weight;
b. 28-day unconfined compressive strength;
c. strain to failure in unconfined compression;
d. 28-day tensile strength (un-reinforced)
e. Young's modulus

For each of the above properties, please indicate whether the values are greater than or smaller than those of mild structural steel.

Question #3: (30 points)

a. A mixture of fresh portland cement paste has a water to cement ratio of 0.5. In a volume of 1cm^3 of paste, compute the mass of cement and the mass of water.
b. This fresh paste then cures under wet conditions. Calculate the volume composition of the hcp in terms of: (1) unhydrated cement; (2) gel products; and (3) capillary voids or pores.
c. Calculate the volume composition of the same hcp under sealed curing.

Phase	Mass density (g/cm^3)	Specific volume (cm^3/g)
Mix water	ρ_f=1.00	υ_f=1.00
Cement particles	ρ_c=3.17	υ_c=.315
Gel products	ρ_g=1.76	υ_g=.568

$$m \le \frac{\frac{M_0^f}{M_0^c} * \upsilon_f}{(1.2\upsilon_g - \upsilon_c)} = m_{max} \le 1 \quad \text{: wet curing}$$

$$m \le \frac{\frac{M_0^f}{M_0^c} * \upsilon_f}{1.282\upsilon_g - \upsilon_c} = m_{max} \le 1 \quad \text{: sealed curing}$$

Question #5: (30 points)

Answer the following true-false questions. If you think the question is ambiguously worded, you can add a few words of explanation with your answer.

a. A large fineness modulus for concrete aggregate generally indicates a very fine aggregate.
b. The cement hydration reaction is endothermic, taking in heat from the environment.
c. Type III ordinary portland cement has the cement particles ground to a finer size, and this helps lead to more rapid hydration.
d. It is generally best to use high early strength portland cement in large concrete pours so that the forms can be removed as soon as possible.
e. In normal strength pcc, the strength of the aggregate particles should typically be larger than that of the hcp.
f. Three common cement replacement materials are: (1) pulverized fly ash [pfa] ; (2) ground granulated blast-furnace slag [ggbs]; and (3) condensed silica fume [csf]. Of these three, care must be used with csf as it can result in very low-slump concrete.
g. About 5 percent gypsum (chalk) is typically added to ordinary portland cement to give it a whiter appearance that is sometimes desirable for architectural applications.
h. The permeability or hydraulic conductivity of pcc is typically much larger than that of either the hcp or the aggregate particles.
i. The cement replacement material pfa tends to lead to high early strength although somewhat lower mature strength of pcc.
j. Cement replacement materials can lead to hydrated cement paste have lower permeability and higher durability.
k. Aggregates with high absorption capacities may have problems with degradation under freeze-thaw action.
l. They key to making a pcc mix that resists attack from sulfates is to decrease the alite C_3S content of the portland cement.
m. Usage of cement replacement materials can also increase the sulfate resistance of the pcc.