High Performance Concrete Engineering

Homework #2 (Deadline by 6pm on Oct 11th)

Submission of hand-written homework will be accepted.

Total 100 marks

(a) In supplementary cementitious materials, list two cementitious materials [10 marks]

Slag, Fly ash type C

(b) What is the pozzolanic reaction? List three reasons why we can achieve higher strength at later age when OPC is replaced with pozzolanic materials [20 marks]

CH 사용. porosity ↓ C-S-H ↑ binding capacity

1. CH 사용
2. additional formation C-S-H
3. occurs later hydration ⇒ strength gaining advantage.

(c) Explain the mechanism how air-entraining admixture can enhance workability of concrete. [10 marks]

ball-bearing effect.

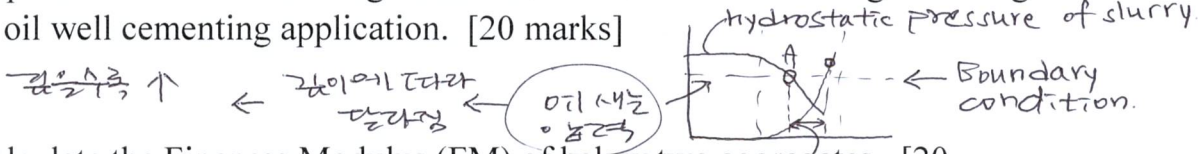
(d) Calculate the porosity of cement paste with w/c = 0.6 and degree of hydration (α) = 0.4. A specific gravity of cement is 3.14 [20 marks]

w/c = 0.6/0.32 = 1/3.14

W ~~0.32~~ (0.6) − 0.32×0.4
CP 0.32×0.4×2
C 0.32×0.6

$\therefore P = \frac{0.472}{0.92} = 51\%$

(e) Explain how set-accelerating admixture can reduce the risk of gas leaking in oil well cementing application. [20 marks]



(f) Calculate the Fineness Modulus (FM) of below two aggregates. [20 marks]

transition time 증가

Aggregate #1 & Aggregate #2

Sieve type	Weight retained (aggregate #1)	Weight retained (aggregate #2)
75 mm	15	
37.5 mm	30	
19 mm	330	

High Performance Concrete Engineering HW#2

2018-31976
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100

(○) In supplementary cementitious meterials, list two cementitious materials.

- In order to improve workability or to enhance the durability of hardened concrete, etc., the supplementary cementitious are added in concrete ✓
- There are mainly three kinds of SCM.
  i) Pozzolanic materials.
  ii) Cementitious materials. ✓
  iii) Non-reactive materials.
- Here, the representative cementitious material is Ground Granulated Blast-Furnace slag (GGBFS).①
  The typical composition of GGBFS is shown as below. ✓
  { CaO = 35-45%, SiO_2 = 32-38%, Al_2O_3 = 8-16% }
  { MgO = 5-15%, Fe_2O_3 < 2%, sulfur = 1-2% }
  Due to the sulfur contents, the ettringite can be formed.
- Since GGBFS reacts slowly with water, strength development occurs very slowly.
- The products of slag hydration are a mixture of C-S-H and AFm (monosulphealuminate) and/or AFt (ettringite)

- Also, Class C fly ash is a kind of cementitious material and pozzolanic material at the same time.
  Class C fly ash has higher amount of CaO that has self-cementing ability.

(1) What is the pozzolanic reaction? List three reasons why we can achieve higher strength at later age when OPC is replaced with pozzolanic materials.

- The primary reaction of pozzolanic reaction can be presented as below

$$SiO_2 + Ca(OH)_2 + H_2O \rightarrow C\text{-}S\text{-}H$$

The major components of pozzolan, the amorphous or glassy silica, react with calcium hydroxide formed from the cement hydration.

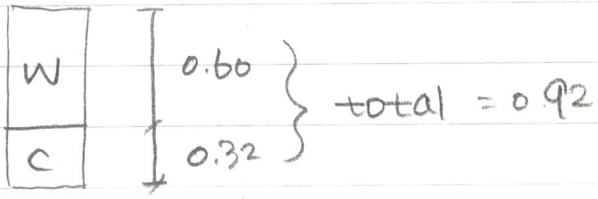
- Since the slow rate of the pozzolan reaction, it requires a prolonged period of moist curing. Therefore, this makes concrete achieve higher strength at later age.
- Moreover, the pozzolan reaction reduce porosity and permeability due to the necessity of water during the reaction. As a result, the durability is increased.
- In addition, the pozzolan reaction keep producing C-S-H slowly after the initial pozzolan reaction
- Due to these reasons, it can be possible to achieve the higher strength at later age than using OPC only.

(c) Explain the mechanism how air-entraining admixture can enhance workability of concrete.

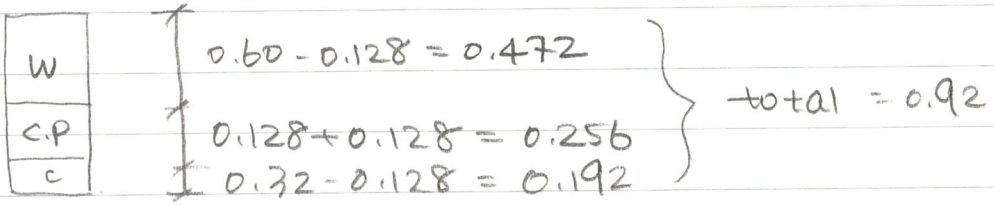
- Tiny air bubbles induced by the usage of the air-entraining admixture act as low-friction and elastic fine aggregates that reduce interaction between large aggregate particles.
- Im addition, the surface-active ingredient to some extent act as a solid-water interface in the same way as a water-reducing admixture.
  That is, electrostatic repulsion and steric hindrance.

(d) Calculate the porosity of cement paste with w/c = 0.6 and degree of hydration (α) = 0.4. A specific gravity of cement is 3.14.

- The weight ratio of water and cement is 0.6.
  Then, the volume ratio is
  water = 0.6
  cement = $1/3.14 = 0.32$
- Assume the volumetric change can be ignored
- Before the hydration.



- After the hydration with a degree of $\alpha = 0.4$
  (The volume of cement that is hydrated is,
  $0.32 \times 0.4 = 0.128$)



- Therefore, the porosity can be obtained as below.

$$\text{Porosity} = \frac{0.472}{0.92} \times 100 = \underline{51.3\%}$$

(f) Calculate the Fineness Modulus (FM) of below two aggregates.

i) Aggregate #1 : Coarse aggregate

Sieve type	Weight retained (g)	Amount retained (%)	Cumulative amount retained (%)
75 mm	15	1.49	1.49
37.5 mm	30	2.99	4.48
19 mm	330	32.84	37.32
9.5 mm	350	34.83	72.15
4.75 mm	170	16.92	89.07
2.36 mm	80	7.96	97.03
1.18 mm	25	2.49	$\Sigma = 301.54$
900 µm	5	0.50	+ 400
600 µm			701.54
300 µm			
150 µm			

Total 1005 g

$\therefore FM = \frac{701.54}{100} = 7.02$

ii) Aggregate #2 : Fine aggregate

Sieve type	Weight retained (g)	Amount retained (%)	Cumulative amount retained (%)
4.75 mm	3	0.6	0.6
2.36 mm	8	1.6	2.2
1.18 mm	39	7.8	10
~~900 µm~~	~~300~~	~~60~~	~~70~~
600 µm	~~100~~ 400	~~20~~ 80	90
300 µm	50	10	100
150 µm			100

Total = 500g $\Sigma = 302.8$

$\therefore FM = \frac{302.8}{100} = 3.03$