University Of Technology
Building and Construction Eng. Dept.
Final Exam – First Attempt – 2nd Term / 2015-2016

Subject :Concrete Technology — Year: 2nd
Time : 3 Hours — Date : 09/06/ 2016

Branch : All

Note: Answer only FOUR questions

Q1: A: Concrete is required for a heavy bridge pier that will be exposed to sea water and freezing and thawing cycles. Use the ACI 211 (American) method to design a trial mix of 0.025 m^3. The needed slump is 80 mm and the maximum size of aggregate is 20 mm. The average required strength at 28 days is 35 MPa for standard cubes and 28 MPa for standard cylinders. The specific gravity of coarse aggregate is 2.52 and for fine aggregate is 2.65. The dry rodded unit weight of coarse aggregate is 1580 kg/m^3 and the fineness modulus of fine aggregate is 2.9. The specific gravity of cement is 3.15 and the minimum content of cement is 300 kg/m^3.

Readjust the weight of mix ingredients because the coarse aggregate was dry and the fine aggregate was wet according to the following data:

Property	Coarse aggregate	Fine aggregate
Absorption, %	0.5	0.8
Free moisture, %	1.0	2.5

Answer:

Step no.	Detail	Result	Remarks
1	Slump:	80 mm	given
2	MSA:	20 mm	given
3	Water content: from table: air content: from table:	180 kg/m^3 6.0 %	air-entrained mix
4	Water to cement ratio:		
	a. for strength= 28 MPa from table:	0.49	air-entrained mix
	b. for durability: from table: exposure : sea water + freezing & thawing cycles	0.45	Use 0.45
5.	Cement content: = 180/0.45	= 400 kg/m^3	> 300 ok
6.	Coarse aggregate content:		
	from table: Vol. of CA= 0.61 m3 W_{CA}= 1580 ×0.61	= 964 kg/m^3	
7.	Fine aggregate content:		

	from table: fresh density= 2280 kg/m^3 WFA= 2280 - (180+400+964)	= 736 kg/m^3	air-entrained mix
8.	Trial mix of 0.025m^3:		
	cement = 400 × 0.025 water = 180 × 0.025 FA = 736 × 0.025 CA = 964 × 0.025	10.0 kg 2.0 kg 18.40 kg 24.10 kg	

Recalculations of materials due to moisture condition of aggregate other than SSD:

a. Dry coarse aggregate:

Absorption % = 964 × (0.5/100) = 4.82 kg

b. Wet fine aggregate:

Free moisture % = 736 × (2.5/100) = 18.40 kg

Actual used mixing water = 180 + 4.82 – 18.4 = 166.42 kg/m^3

Weight of CA (dry) = 964 kg/m^3

Weight of FA (wet) = 754.4 kg/m^3

Q1: B: In general, chemical admixtures could be used to improve the properties of hardened concrete, list five of these uses.

Answer:

1. Accelerating the rate of strength gain of in the early ages.
2. Increase the strength of all kinds of concrete (to resist compression, tensile and bending).
3. Increase the durability of concrete and improve the strength to the harsh conditions exposure, including the exposure to salts.
4. Reduce the permeability of concrete.
5. Reduce the happened expansion due to interactions between the alkali in cement and some types of silica active in the aggregate.

Q2: A: Use the British method to design an air-entrained concrete trial mix with a volume of 0.05 m^3, if you know the following:

- The characteristic compressive strength at 28 days is 20 MPa, and k = 2.33, s = 8 MPa.
- The used cement is sulphate resisting Portland cement.
- The slump = 100 mm.
- The minimum cement content = 300 kg/m^3.
- Air content = 6.0 %.
- Maximum size of aggregate = 10 mm.
- Type of aggregate: coarse: uncrushed, fine: crushed.
- % passing (0.6) mm sieve for fine aggregate = 70%.
- Relative density of aggregate: coarse = 2.60, fine = 2.60.

Answer:

Step no.	Detail	Result	Remarks
1.	f'_m and free w/c ratio:		
	$f'_m = (f_c + ks) / (1 - r\ a)$ $f_c = 20$ MPa $k = 2.33$ $s = 8$ MPa $r = 0.055$ $a = 6.0$ %	$f'_m = 58$ MPa	
	$f_{m0.5} = 42$ MPa (from table) free w/c ratio (from figure)	Free w/c = 0.39	No limit ok
2.	Free water content:		
	From table: MSA = 10 mm Slump = 100 mm Water for unc. Agg. = 205 kg/m^3 Water for cru. Agg. = 230 kg/m^3 Free water = $(W_{CA}/3) + (2W_{FA}/3)$	= 222 kg/m^3	
3.	Cement content:		
	= 222 / 0.39	= 569 kg/m^3	> 300 ok
4.	Total aggregate content:		
	from figure: D = 2325 kg/m^3 D' = 2325 – 10 (2.6)(6) D' = 2169 kg/m^3 W_{agg} = 2169 - (222+569)	= 1378 kg/m^3	
5.	Fine and coarse aggregate content:		
	From figure: % FA = 40.5 % W_{FA} = 0.405 (1378) W_{CA} = 1378 - 558	= 558 kg/m^3 = 820 kg/m^3	
6.	Trial mix of 0.05m^3:		
	cement = 569 × 0.05 water = 222 × 0.05 FA = 558 × 0.05 CA = 820× 0.05	28.45 kg 11.10 kg 27.90 kg 41.00 kg	

Q2: B: Show how does the quality of mixing water affect the strength of concrete?

Answer:

The quality of the water plays a significant role on strength of concrete, as:

1. Impurities in water may interfere with the setting of the cement.
2. May adversely affect the strength of the concrete.

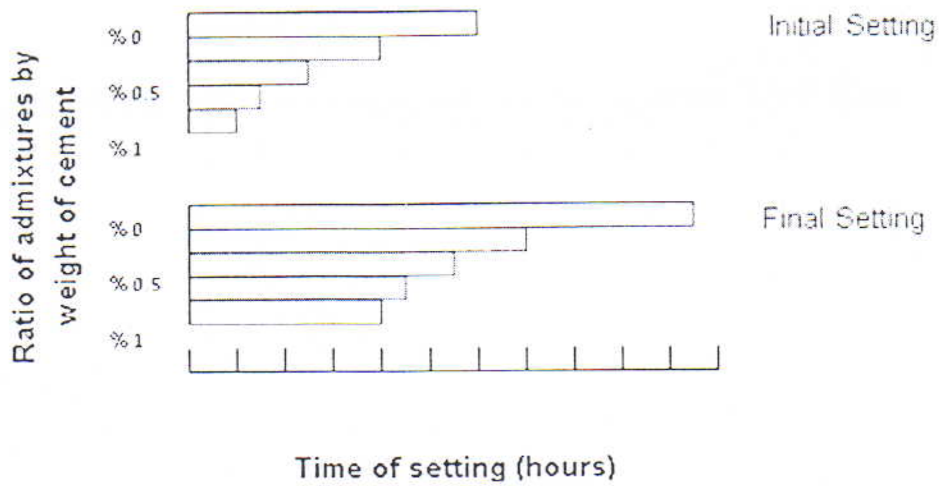
3. Cause staining of its surface.
4. Lead to corrosion of the reinforcement.

Q3: A: Discuss in details the effects of the accelerated admixtures on the setting time, heat of hydration and strength of concrete.

Answer:

Effect of the accelerated admixtures on:
Setting Time:

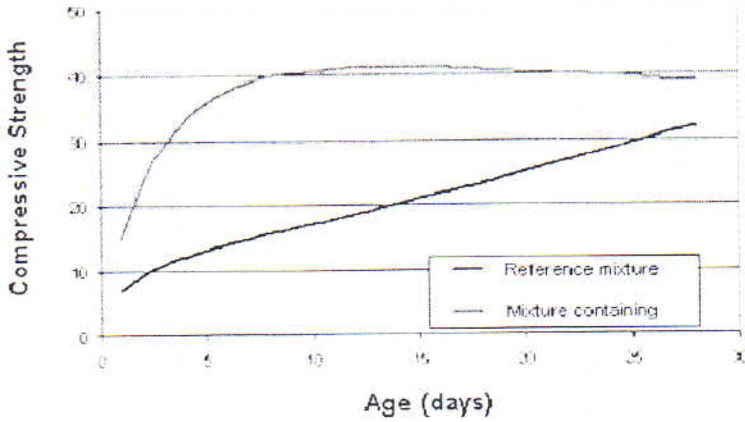
Iraqi standard No. 5 - 1984 indicates that the time of the primary setting of cement it should be not be less than 45 minutes and the final one not more than 10 hours. Time of primary setting is less with the use of accelerated admixtures, and the amount of this decrease depends on the proportion of the used admixtures, the temperature of the concrete and the weather, where the use of calcium chloride in the range of 1.5-2% by weight of cement reduces the setting time of most types of Portland cement to almost half compared with reference mixtures. In the figure below shows the effect of use of different dosages of accelerated admixtures on the primary and final setting.



Heat of Hydration:
The rate of heat evolution is increase early by use of accelerated admixtures but there is no effect can be estimated on the total hydration heat. The presence of calcium chloride, accelerate setting and hardening of concrete and accelerate the rate of cement hydration in concrete. The hydration of cement shall be accompanied by heat evolution and accelerate the hydration reactions working on the evolution of heat at a faster rate. And this property appears during the early period of mixing (the first 10-12 hours), especially in the manufacture of concrete in cold weather.

Strength of Concrete:
The compressive strength of the cement paste, mortar and concrete containing accelerated admixtures in the early ages increase compared with the reference mix

and this due to the increase in the rate of chemical reactions between water and cement, and this has actually been approved by measuring the speed rate of paste hydration compounds outputs C_3S compound on the basis of measurement non evaporation water content. The Figure below shows the increase in compressive strength when using the accelerated admixtures with 2% by weight of cement.
The increase in compressive strength at early ages with the presence of added accelerator cannot be attributed only to the increase in the amount of hydration product results, but they relate to other factors as porosity, morphological (i.e., the form of particles, size and nature of its net system), chemical installation, surface area and density.



Q3: B: There are two types of strength test in tension, what are they? Describe each test briefly.

Answer:

a. Direct tension test:
It is the application of a pure tension force free from eccentricity, although it is very difficult but some success with the use of lazy-tong grips has been achieved. It is difficult to avoid secondary stresses such as those induced by grips or by embedded studs.

b. Splitting tension test:
In this test, a concrete cylinder, of the type used for compression tests, is placed with its axis horizontal between the platens of a testing machine, and the load is increased until failure by indirect tension in the form of splitting along the vertical diameter takes place.
However, immediately under the load, a high compressive stress would be induced and, in practice, narrow strips of a packing material, such as plywood are interposed between the cylinder and the platens. Without packing strips, the recorded strength is lower, typically by 8 per cent. **ASTM C 496-90** prescribes plywood strips, 3 mm (3/8 in.) thick and 25 mm (1 in.) wide. British Standard **BS 1881:117:1983** specifies a hardboard strips, 4 mm thick and 15 mm wide. With such an arrangement, the distribution of the horizontal stress will be almost uniform.

Q4: A: Explain the effects of the following factors on strength of concrete:
a. Effective water in the mix.
b. Age of concrete.
c. Aggregate to cement ratio.

Answer:

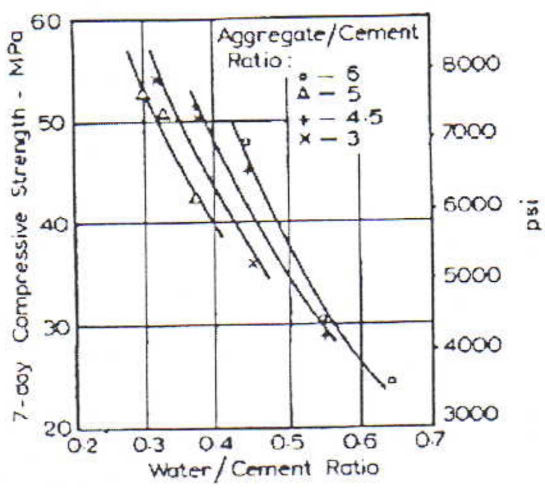
a. Effective water in the mix:
The practical relations discussed so far involve the quantity of water in the mix. This needs a more careful definition. We consider as effective that water which occupies space outside the aggregate particles when the gross volume of concrete becomes stabilized, i.e. approximately at the time of setting. Hence the terms effective, free, or net water/cement ratio.
Generally, water in concrete consists of that added to the mix and that held by the aggregate at the time when it enters the mixers. A part of the latter water is absorbed within the pore structure of the aggregate while some exists as free water on the surface of the aggregate and is therefore not different from the water added direct into the mixer. Conversely, when the aggregate is not saturated and some of its pores are therefore air-filled, a part of the water added to the mix will be absorbed by the aggregate during the first half-hour or so after mixing. Under such circumstances the demarcation between absorbed and free water is a little difficult.

b. Effect of age on strength:
The relation between the water/cement ratio and the strength of concrete applies to one type of cement and one age only, and also assumes wet-curing conditions. On the other hand, the strength versus gel/space ratio relationship has a more general application because the amount of gel present in the cement paste at any time is itself a function of age and type of cement. The latter relation thus allows for the fact that different cements require a different length of time to produce the same quantity of gel.
In concrete practice, the strength of concrete is traditionally characterized by the 28-day value, and some other properties of concrete are often referred to the 28-day strength. If, for some reason, the 28-day strength is to be estimated from the strength determined at an earlier age, say 7 days, then the relation between the 28-day and the 7-day strengths has to be established experimentally for the given mix. Anyway, the following relations could be used as rough estimations only:

$$S_{28}(MPa) = 1.4\,S_7 + 1.0$$
$$S_{28}\,(MPa) = 1.7\,S_7 + 5.9$$

c. Influence of aggregate/cement ratio:
There is no doubt that the aggregate/cement ratio, is only a secondary factor in the strength of concrete but it has been found that, for a constant water/cement ratio, a leaner mix leads to a higher strength (see Figure below).

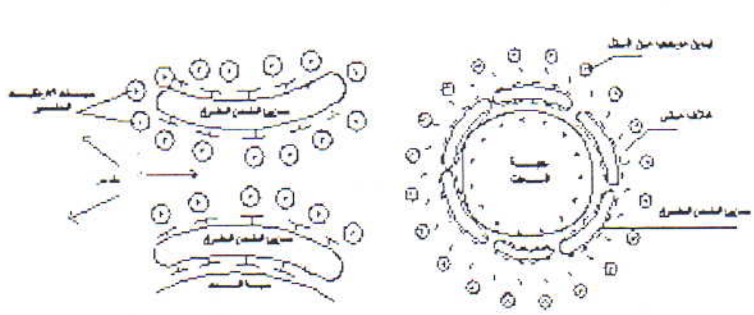
The reasons for this behavior are not clear. In certain cases, some water may be absorbed by the aggregate: a larger amount of aggregate absorbs a greater quantity of water, the effective water/cement ratio being thus reduced. In other cases, a higher aggregate content would lead to lower shrinkage and lower bleeding, and therefore to less damage to the bond between the aggregate and the cement paste; likewise, the thermal changes caused by the heat of hydration of cement would be smaller. The most likely explanation, however, lies in the fact that the total water content per cubic meter of concrete is lower in a leaner mix than in a rich one. As a result, in a leaner mix, the voids form a smaller fraction of the total volume of concrete, and it is these voids that have an adverse effect on strength.



Q4: B: What is the style of performance for the high-range water reducing admixtures?

Answer:

Superplasticizer are ions carry negative electric charges and these admixtures are characterized by their high surface effectiveness, as they gravitate toward the surface of cement grains leading to strong repulsion between them causing a significant increase in the liquidity of the mixture. And rapid mixing is desirable to do this effectively. These admixtures are effect after a period of hydration and that by deployment of the cover water ettringite on the cement grains, causing liberation of small ettringite needles from there hydrosphere during the process of attracting particles admixtures as shown in Figure below:



Q5: A: Discuss in details the classification of the water-proofing admixtures.

Answer:

Waterproofing admixtures for water permeability can be classified into three major categories:

a. Admixtures reducing the permeability:

Admixtures work through this group to reduce both the hydraulic permeability and porosity for concrete and fill its porosity and they include the small particles material like sand powder, pure chalk powder, pure ash powder, dust diatomic, limestone, slag, and others. Where most of these materials are characterized by its pozzolanic effectiveness which are contribute to increase the proportion of rate of cement / gel formed. It can be also inclusion plasticizers admixtures, super plasticizers, and air entered plasticizers within the kinds of admixtures reducing water permeability and that can be used to reduce the water content in the mixture and then less the size of voids, and capillary pores, and so less concrete permeability.

b. Waterproofing admixtures:

The material of this group reduce the passage of water through the dry concrete, which could happen as a result of the capillary characteristics and not as a result for the external water pressure. This group includes soap materials citrate biotite and petroleum oil.

c. Different admixtures:

There are a variety group of available admixtures which have the effect repellence of water in the concrete but most of these admixtures have a negative effect on the strength of concrete and as example:

- Barium sulfate and magnesium and calcium silicate.
- Micro soft silicate and naphthalene.
- Colloid silicate.
- Jelly petroleum and slime.
- Cellulosic materials.
- Silica and aluminum.
- Coal tar oil-diluted.
- Sodium silicate.

Q5: B: Define the membrane curing method of concrete and describe the concept, used materials and requirements.

Answer:

Membrane curing:

This method of curing relies on the prevention of loss of water from the surface of the concrete, without the possibility of external water ingressing into it. This could be called a water-barrier method. The techniques used include:

- Covering the surface of the concrete with overlapping polyethylene sheeting, laid flat or with reinforced paper. The sheeting can be black, which is preferable in cold weather, or white, which has the advantage of reflection of solar radiation in hot weather. Paper with a white surface is also available. Sheeting can cause discoloration or mottling because of non-uniform condensation of water on the underside.
- Spray-applied curing compounds which form a membrane. The common ones are solutions of synthetic hydrocarbon resins in high-volatility solvents, sometimes including a fugitive bright-color dye. The dye makes obvious the areas not properly sprayed. A white or alumina pigment can be included to reduce the solar heat gain; this is very effective. Other resin solutions are available acrylic, vinyl or styrene butadiene and chlorinated rubber. Wax emulsions can also be used, but they result in a slippery finish which is not easy to remove, whereas the hydrocarbon resins have poor adhesion to concrete and are degraded by ultraviolet light; both these features are desirable.

A specification for liquid membrane-forming curing compounds is given in **ASTM C 309-93**, and for sheet materials in **ASTM C 171-92**.

It is obvious that the membrane must be continuous and undamaged. The timing of spraying is also critical. The curing spray should be applied after bleeding has stopped bringing water to the surface of the concrete but before the surface has dried out: the optimum time is the instant when the free water on the surface of the concrete has disappeared so that the water sheen is no longer visible. However, if bleeding has not stopped, the curing membrane should not be applied even if the surface of the concrete appears dry in consequence of a high rate of evaporation.