

Government Engineering College, Ajmer
CIVIL ENGINEERING
 B.Tech IV Semester Mid Term-I Examination-2018-19
 Concrete Technology

Time:- 1Hr

1. Describe the term Cement and also explain its types? (3)
2. Explain hydration of cement and its basic compounds (3)
3. Write short notes on : (a) heat of hydration (b) C-S-H gel (2)
4. Comment on effect of low water cement ratio on strength and workability. (2)

SOLUTIONS :

Ans.1- refer to class notes

Ans.2- refer to class notes

Ans.3-

that water attacks cement compounds in the solid state converting the compounds into hydrated products starting from the surface and proceeding to the interior of the compounds with time. It is probable that both "through solution" and "solid state" types of mechanism may occur during the course of reactions between cement and water. The former mechanism being predominate in the early stages of hydration in view of large quantities of water being available, and the latter mechanism may operate during the later stages of hydration.

Heat of Hydration

The reaction of cement with water is exothermic. The reaction liberates a considerable quantity of heat. This liberation of heat is called heat of hydration. This is clearly seen if freshly mixed cement is put in a vacuum flask and the temperature of the mass is read at intervals. The study and control of the heat of hydration becomes important in the construction of concrete dams and other mass concrete constructions. It has been observed that the temperature in the interior of large mass concrete is 50°C above the original temperature of the concrete mass at the time of placing and this high temperature is found to persist for a prolonged period. Fig 1.2 shows the pattern of liberation of heat from setting cement^{1,4} and during early hardening period.

On mixing cement with water, a rapid heat evolution, lasting a few minutes, occurs. This heat evolution is probably due to the reaction of solution of aluminates and sulphates (descending peak A). This initial heat evolution ceases quickly when the solubility of aluminate is depressed by gypsum. (descending peak A). Next heat evolution is on account of formation of ettringite and also may be due to the reaction of C₃S (ascending peak B). Refer Fig. 1.2.

Different compounds hydrate at different rates and liberate different quantities of heat. Fig. 1.3 shows the rate of hydration of pure compounds. Since retarders are added to control the final setting properties of C₃A, actually the early heat of hydration is mainly contributed from the hydration of C₃S. Fineness of cement also influences the rate of development of heat and thus the total heat. The total quantity of heat generated in the complete hydration will depend upon the relative quantities of the major compounds present in a cement.

Analysis of heat of hydration data of large number of cements, Verbec and Foster⁵ determined heat evolution of four major compounds of cement. Table 1.7. Shows the heats of hydration of four compounds.

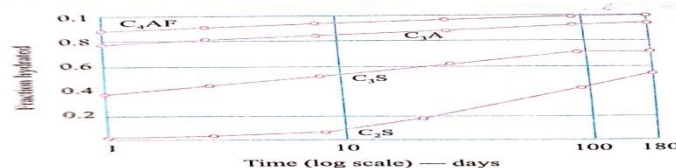


Table 1.7. Heat of Hydration^{1,5}

Compound	Heat of hydration at the given age (cal/g)		
	3 days	90 days	13 years
C ₃ S	58	104	122
C ₂ S	12	42	59
C ₃ A	212	311	324
C ₄ AF	69	98	102

Since the heat of hydration of cement is an additive property, it can be predicted from an expression of the type $H = aA + bB + cC + dD$

Where H represents the heat of hydration, A , B , C , and D are the percentage contents of C₃S, C₂S, C₃A and C₄AF. and a , b , c and d are coefficients representing the contribution of 1 per cent of the corresponding compound to the heat of hydration.

Normal cement generally produces 89-90 cal/g in 7 days and 90 to 100 cal/g in 28 days.

The hydration process is not an instantaneous one. The reaction is faster in the early period and continues indefinitely at a decreasing rate. Complete hydration cannot be obtained under a period of one year or more unless the cement is very finely ground and reground with excess of water to expose fresh surfaces at intervals. Otherwise, the product obtained shows unattacked cores of tricalcium silicate surrounded by a layer of hydrated silicate, which being relatively impervious to water, renders further attack slow. It has been observed that after 28 days of curing, cement grains have been found to have hydrated to a depth of only 4 μ . It has also been observed that complete hydration under normal condition is possible only for cement particles smaller than 50 μ .

A grain of cement may contain many crystals of C₃S or others. The largest crystals of C₃S or C₂S are about 40 μ . An average size would be 15-20 μ . It is probable that the C₂S crystals present in the surface of a cement grain may get hydrated and a more reactive compound like C₃S lying in the interior of a cement grain may not get hydrated.

The hydrated product of the cement compound in a grain of cement adheres firmly to the unhydrated core in the grains of cement. That is to say unhydrated cement left in a grain of cement will not reduce the strength of cement mortar or concrete, as long as the products of hydration are well compacted. Abrams obtained strength of the order of 280 MPa using mixes with a water/cement ratio as low as 0.08. Essentially he has applied tremendous pressure to obtain proper compaction of such a mixture. Owing to such a low water/cement ratio, hydration must have been possible only at the surface of cement grains, and a considerable portion of cement grains must have remained in an unhydrated condition.

The present day High Performance concrete is made with water cement ratio in the region of 0.25 in which case it is possible that a considerable portion of cement grain remains unhydrated in the core. Only surface hydration takes place. The unhydrated core of cement grain can be deemed to work as very fine aggregates in the whole system.

of cement paste. The various setting phenomena affected by an imbalance in the V/S ratio is of practical significance in concrete technology.

Many theories have been put forward to explain what actually is formed in the hydration of cement compounds with water. It has been said earlier that product consisting of $(CaO.SiO_2.H_2O)$ and $Ca(OH)_2$ are formed in the hydration of calcium silicates. $Ca(OH)_2$ is an unimportant product, and the really significant product is $(CaO.SiO_2.H_2O)$. For simplicity's sake this product of hydration is sometime called tobermorite gel because of its structural similarity to a naturally occurring mineral tobermorite. But very commonly the product of hydration is referred to as C – S – H gel.

It may not be exactly correct to call the product of hydrations as gel. Le chatelier identified the products as crystalline in nature and put forward his crystalline theory. He explained that the precipitates resemble crystals interlocked with each other. Later on Michaelis put forward his colloidal theory wherein he considered the precipitates as colloidal mass, gelatinous in nature. It is agreed that an element of truth exists in both these theories. It is accepted now that the product of hydration is more like gel, consisting of poorly formed, thin, fibrous crystals that are infinitely small. A variety of transitional forms are also believed to exist and the whole is seen as bundle of fibres, a fluffy mass with a refractive index of 1.5 to 1.55, increasing with age.

Since the gel consists of crystals, it is porous in nature. It is estimated that the porosity of gel is to the extent of 28%. The gel pores are filled with water. The pores are so small that the specific surface of cement gel is of the order of 2 million sq. cm. per gm. of cement. The porosity of gel can be found out by the capillary condensation method or by the mercury porosimetry method.

Ans.4- refer to class notes