Civil Engineering Materials Quiz 3

1. **Why is it essential to decrease Portland cement (PC) in concrete?**

It is essential to decrease portland cement in concrete because it will reduce the cost and amount of CO2 emissions. Also, it will reduce the shrinkage from the drying process and the amount of heat released during hydration which in turn will lessen the amount of cracks made. As well, it will increase the durability of the concrete long term since it will reduce the permeability and volumetric change. All of these factors are significant as they provide advantages relating to not only the quality of the concrete, but the company and environment as well.

2. **Describe briefly the manufacturing process of PC.**

The manufacturing process of portland cement begins with the gathering of the raw materials including limestone, sand, iron ore, clay, and shale. These materials are grinded until they are approximately 120mm in size and then again until they are 20mm, then stored separately. Following this, they are completely grinded until they are reduced to a powder form and mixed together. Afterwards, the process of calcination begins where the powder is heated using a preheater, flash furnace, and shorter kiln. The burning at around 1450℃ causes a chemical change in the materials and as a result produces cement clinker. Lastly, the clinker is mixed with gypsum and grinded together to form portland cement which is then available to be shipped for usage.

3. **Which of the following components is not part of the clinker?**

   d) gypsum

4. **Which of the following components contribute to the development of concrete strength?**

   C3A andC4AF that impacts setting

   c) C3S and C2S

5. **Why do one normally consider the concrete strength at 28 days for structural purposes?**

This is because during the hydration process, it takes approximately 28 days until the calcium silicate hydrate (CSH) has more than 95% developed and it begins to stay consistent/ stop growing. The CSH is primarily responsible for the strength of the concrete, thus the ending of its growth will allow us to properly evaluate the initial strength of the concrete.

6. **What are the main hydrated components of PC? Cite their names and functions.**

Tricalcium Silicate (C3S) - greatly impacts the strength of the concrete.

Dicalcium Silicate (C2S) - impacts the strength of the concrete, but less than C3S.

Tricalcium Aluminate (C3A) - helps to produce hydrated calcium aluminate and calcium sulfoaluminate (ettringite). The ettringite creates a passage from the concrete's fluid to hardened state. in a sense, setting

Tetracalcium Aluminoferrite (C4AF) - helps to produce hydrated calcium aluminate.

7. **Describe briefly the 5 phases of PC hydration.**

The five phases of hydration are pre-induction, induction, acceleration, deceleration, and consolidation. The pre-induction phase only lasts minutes and involves the addition of water to the unhydrated cement, thus resulting in a protective layer forming on the surface of grains. The induction phase is also considered the dormant phase because it consists of a period of low chemical activity and heat release. At this point, the concrete is workable meaning it is in a state where it can be molded or casted. The partial breaking of the protective layer indicates the ending of the phase. The third phase is called the acceleration and it consists of the highest chemical activity and heat release. The concrete becomes to set and harden, and is not workable anymore. This is due to the CSH and portlandite that develops between the grains. The fourth and fifth phase, deceleration and consolidation, consists of a decrease in chemical activity and heat evolution. It leads to the ending of the hydration process as three limiting factors: not enough C3S to make CSH, no more water can penetrate the protective barrier, and lack of space for CSH to grow. As well, at this point no more diffusion can occur and thus the reaction finishes.

8. **Explain the difference between a "hydraulic" and "pozzolanic" reaction. In other words, why is a product classified as a "binder" instead of a "supplementary cementing material (SCM)"?**

Hydraulics reactions are caused by a reaction between a substance and water, while a pozzolanic reaction is caused by a reaction between a pozzolan material and portlandite, Ca(OH)2. A product is to be considered a binder if it has high concentrations of CaO within it, while SCMs are more likely to have greater concentrations of Al2O3 and SiO2 within it.

production of calcium and ability to react w water

Examples of reactions:

Hydraulic Reaction

$$C3S \text{ and } C2S + water \rightarrow Ca(OH)2 + calcium\ silicate\ hydrate\ (CSH)$$

Pozzolanic Reaction

$$Pozzolan + Ca(OH)2 + water \rightarrow calcium\ silicate\ hydrate\ (CSH)p$$

9. **You work for a consulting company that is participating in a project with a contractor to build a concrete tunnel (total thickness: 60 cm; concrete cover: 10 cm). You were told that the structure will be in contact with a soil in presence of a high amount of sulphates. Moreover, the service life (i.e. life span) of the structure should be 75 years or more. What is the advice you would provide the contractor with regarding the materials selection? Please, discuss on the selection of the following materials:**

a) Coarse and fine aggregates to be used (see the course of aggregates);

select the max nominal size of the coarse agg. & select fine agg. that doesnt react

When choosing aggregates, I would recommend using coarse aggregates because it is better for larger structures. They are typically created from crushed gravel or stones, thus their rougher texture provides more strength. Also, aim to use normal specific gravity aggregates since a lightweight or heavyweight aggregate is not ideal as the tunnel will be large and have to withstand a lot of weight. In addition, ensure that continuous grading is used since this will reduce the cost as well as better compact the components together.

ANS = USE WELL GRADED SIZE DISTRIBUTION

b) Cement type or supplementary cementing materials to be used.

Considering the objective and environment of the structure, I would recommend the contractor to select high sulphate resistant (HS) portland concrete. This is because this material will be able to withstand the high concentrations of sulphate in the environment, thus allowing it to have a longer life span as desired. However, as a result of their high resistance to sulphate, it has a lower initial strength in comparison. The addition of supplementary cementing materials (SCMs) would aid in balancing this, specifically fly ash and silica fumes as both help to increase strength and durability.