OPTIMUM COMPOSITION AND PYSICOCHEMICAL CONDITIONS FOR THE PRODUCTION OF BLENDED - CEMENT CONTAINING THE KILN DUST

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N O T E

The student in addition to this theses has attended lectures dealing with the branches heareafter. He passed successfully the examination as well. These courses are :

- Advanced Electrochemistry.
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- Advanced Chemical Kinetics.
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IA. INTRODUCTION

IA.1. Introductory Remarks

A.1.(i)- Blended Cements :

Blended or composite cements are cement products ground from a blend of Portland Cement clinker and substitute materials. The substitute materials can be a naturally occuring rocks, like a pozzolan or limestone, or an industrial by-product like granulated blast-furnace slag or fly-ash. Blended cements have been produced for decandes in some countries and in the recent years a renewed in production of such cements is found all over the world. The main reason for this is the lower production cost, a fact which has been strongly accentuated with the increase in fuel prices. However, the possibility of utilization of industrial by-products is also an important stimulus.

The materials commonly used for partial replacement of clinker in blended cements are usually divided into the following categories :- Slags-Pozzolans-Fly Ash-Others (Inert fillers). In the first group granulated blast-furnace slag is by far the most important type of substitute materials. Pozzolans can be divided into natural and artificial materials. The artificial materials include calcined clay , shales and fly ash. Condensed silica fume and rice husk ash are special artificial pozzolans to which attention has been done at 100% relative humidity for 24 hours, then all pastes were cured under water for longer hydration periods.

Compressive strength tests were done on the hardened pastes and mortars. Kinetics and mechanism of the hydration reactions were studied for all the solid mixtures investigated. In addition the phase compositions of the formed hydration products were related to the compressive strength of the various hydrated specimens.

The main conclusions derived from this investigation are summarized as follows :

A. Slag-Kiln Dust System :

A.I. Compressive strength :

1. The compressive strength of the hardened slag-cement kiln dust pastes shows that Mix I_A possess low strength values at the early hydration ages while Mixes I_B and I_C develop their strength only after 3 days of hydrtion.

2. For all of the pastes investigated the strength increases up to 90 days. This is due to the relatively high hydraulic properties of the formed hydration products and their accumulation.

3. After 90 days of hydration a reduction in compressive strength is encountered; this result may be attributed to crystallization of the initial hydrates and/or their transformation into hydrates having a weakly hydraulic character.

growing in the recent years. The materials mentioned so far undergo chemical reactions during the hardening of the cement, whereas the last group "others" is mainly represented by inert fillers, first and for most limestone.

A.1.(ii)- Granulated Blast-Furnace Slag :

As by-product in the production of pig-iron, blast-furnace slags are produced in huge quantities (0.3-1 ton/ton pig-iron). Chemically, they consist mainly of CaO (35-45%), SiO_2 (20-30%), Al_2O_3 (10-20%) and MgO (2-10%). The lime content is somewhat lower than that of Portland cement, and the normally crystallized product contains no hydraulic minerals. When the slag melt is quenched with water, however, it is possible to prevent crystallization and to stabilize a glassy material which is called granulated blast-furnace slag. This material is able to react in an alkaline or sulphatic medium to form hydrates of the same kind as formed by Portland cement hydration. This so called latent hydraulic property is the basis for the use of granulated blast-furnace slag in blended cements and slag cements. The water quenching process generates a product with a physical appearance as coarse sand. Hence, the word "granulated" blast-furnace slag or the German name "Hütten sand". Just after granulation the material can contain up to 30% of water. This will be reduced during transport and storage, but still the moisture content is a factor that must be dealt with when grinding slag and slag cement. As granulated blast-furnace slag is dominated by a dense glassy structure with few large pores it is generally difficult to grind. Hence, as in an average it needs 50%, more grinding energy than clinker to reach the typical cement fineness of 300-500 m^2/kg (Blaine area).

A.1.(iii)- Cement Klin Dust :

The intermediate as well as the final product in the cement industry is in powdered form. The accompanying phenomenon of comminution, handling and processing of the material component which finally form Portland cement, is the generation of dust. To prevent the dust from escaping into the environment, most of the cement plant machinery and equipment is working under negative pressure which requires the ventilation and cleaning of large volume of air or gases, respectively.

The following varieties of dust are generated in the operation of a cement plant :

1) Raw material dust, i.e. dust from limestone, marl, clay, iron ore, slag, etc.
2) Raw mix dust.
3) Exit dust from material dryers.
4) Exit dust from kilns (cement kiln dust).
5) Clinker dust.
6) Cement dust.
7) Raw gypsum dust.

With the exception of the cement kiln dust, the kinds of dust enumerated above, show the same chemical composition as the original material. The chemical analysis cited in Table (1) show the difference between the composition of the raw mix and the kiln exit dust origination from.

Table 1

Chemical composition of raw mix and rotary kiln dust.

Component	Raw mix %	Kiln dust %
SiO_2	11.39	12.29
Al_2O_3	5.3	3.45
Fe_2O_3	1.81	1.63
CaO	43.52	(40-43)
MgO	0.98	1.61
SO_3	0.72	5.02
K_2O	1.25	1.03
+ Na_2O	0.09	0.41
Loss on ignition	35.43	23.95

The kiln exit dust represents a mixture of cement raw mix and clinker; the chemical composition of the exit dust is among other factors also influenced by the size of particles carried a way by the kiln gases. The exit dust shows a considerable concentration of alkalies volatalized in the burning zone and subsequently condensed on the kiln dust particles.

Behaviour of Volatile Matter :

Some minor components in raw mix and fuel evaporate at burning zone temperature and condense when cooled. This repeated evaporation and condensation results in an increasing internal circulation until an equilibrium is reached. In many plants such problems are unknown because the kiln system is sufficiently open to allow the evaporated components to escape through the chimny, but in modern installations with efficient preheaters and filters it is a problem which has to be studied in each case.

The components we are talking about are mainly potassium, sodium, sulphur, and chloride. But other components such as Fluorine, Arsenic, although so far of less practical importance, follow a similar pattern.

Circulation Phenomena :

The term circulation phenomena has taken the place of the term alkali problems, which was frequently used until now. The designation was changed for two reasons;

On one hand it has become evident that in addition to alkalies (potassium and sodium), the elements sulfur and chlorine must also be included under this heading; these four elements are referred to as the circulating elements. On the other hand, the changing of term implies an expanding and shifting of the problem areas; originally, the term alkali problems was used almost exclusively in connection with cement quality.

As is well known, alkalies in cement can lead to flash setting, to a reduction of the strength and to undesired