Physical and Chemical Properties of Fly Ash based Portland Pozzolana Cement

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Abstract

This project is aimed to study the Physical and Chemical properties of fly ash based Portland pozzolana cement manufactured by Tokyo cement (lanka) PLC. Basics of cement, fly ash, pozzolana and physical and chemical properties of cement have been studied to proceed the project easily. The test methods available to find out Physical and Chemical properties of fly ash based Portland pozzolana cement have been studied. To identify the importance of this blended cement, comparison of Physical and Chemical properties of fly ash based Portland pozzolana cement with normal Ordinary Portland cement is proposed. From that it can be easily identified the importance of this locally manufactured special fly ash based Portland pozzolana cement in many applications in the construction industry.

1. Introduction[1]

Cement is a bonding material used with stones, sand, bricks, building blocks etc. consumed in the construction industry. It has a property of setting and hardening under by virtue of a chemical reaction.

Cement production is a significant source of global carbon dioxide (CO_2) emissions, making up approximately 5 per cent of global anthropogenic CO_2 emissions (Worrell *et al*. [1]). Pozzolan can be defined as a siliceous or alumino-siliceous material with very fine particles. In the presence of water, it reacts with calcium hydroxide released by the hydration of Portland cement at ordinary temperatures, to form compounds of possessing cementing properties. Supplementary cementing materials (SCM) are a class of mineral-based materials possessing pozzolanic reactivity such as coal fly ash (a residue from coal burning), blast furnace slag (a residue from iron making), or other pozzolanic materials (e.g., volcanic material). These products are blended with the ground clinker to produce a homogenous product: blended cement. Blended

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cement has different properties than Portland cement, e.g., setting takes longer but ultimate strength is higher.

The global potential for CO_2 emission reduction through producing blended cement is estimated to be at least 5 per cent of total CO_2 emissions from cement making (Worrell *et al*.,[1]).

2. Literature Review

A Number of researches have been carried out to find the properties of different types of cement. A survey of Portland cements marketed in North America was conducted in 1994 under the sponsorship of the American Society for Testing and Materials (ASTM) Committee C-1 on Cement (Gebhardt [2]). The primary purpose of the survey was to provide data on modern cement characteristics. The study reviewed 387 cements from 136 of 140 cement-producing facilities in the United States and Canada, plus several imported cements. The last survey of similar scope on cement characteristics was done on 203 cements procured in 1953 and 1954 by the National Bureau of Standards (presently called the National Institute of Standards and Technology) (Gebhardt [2]).

In April 2005, a survey of manufacturers of Portland and blended cements in the US and Canada was conducted to collect data on cements produced in 2004. The characteristics of interest include those required to meet specifications ASTM C 150, C 595, and C 1157: physical measurements such as strength and fineness, chemical composition, and performance characteristics such as setting time. It was also comparing and contrasting results on Portland and blended cements (Tennis *et al*., [3]).

Compressive strength, fineness, soundness, setting time, and specific gravity are some physical properties of cement. Loss on ignition, chloride content, and insoluble residue are some of chemical properties of cement. Also percentage of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, and K_2O of cement can be determined. Variation of physical and chemical properties of Ordinary Portland Cement (OPC) and blended pozzolana cement has been discussed in this paper.

3. Methodology

With the blended cement, OPC sample was also tested according to the standards. ASTM and SLS test methods were used to find out above physical properties and chemical properties. The test method used to find out each property is given in Table 1.

Table 1: Test Methods use to find out properties of Cement

Property	Test Method
Compressive Strength	ASTM 109/C 109M
Setting Time	ASTM C 191
Specific Gravity	ASTM C 188

Fineness	ASTM C 430
Soundness, Al_2O_3Content, MgO Content, CaOContent and Chloride Content	SLS 107
Loss on Ignition, Insoluble Residue, Total alkalis, SiO_2 Content, Fe_2O_3 Content and SO_3 Content	ASTM C 114

4. Results and Discussion

Results obtained for Physical properties and Chemical properties of Cements are as follows.

4.1 Summary of Results

Obtained values for physical properties and chemical properties are shown in Table 2 and Table 3 respectively.

Table 2: Physical properties of Blended Cement and OPC

Property	Results	
	Ordinary Portland Cement	Blended Cement
Compressive Strength (MPa)		
3 Day	11.3	10.7
7 Day	13.2	14.3
28 Day	16.9	21.2
Setting time (min)		
Initial	120	164
Final	166	203
Specific Gravity	3.107	2.936
Fineness %	85.4	86.2
Soundness (mm)	0.5	1.0

Table 3: Chemical Properties of Blended Cement and OPC

Property	Results	
	Ordinary Portland Cement (%)	Blended Cement (%)
Loss on Ignition	2.05	1.05
Insoluble Residue	4.1	20.0
Total alkalis	0.59	0.71
Chloride Content	0.07	0.01
SiO_2 Content	28.7	23.5
Al_2O_3 Content	13.5	12.9
CaO Content	53.6	47.0
MgO Content	2.21	1.74
Fe_2O_3 Content	2.27	2.04

SO_3 Content	2.9	2.21

4.2 Chemical and Physical Property Requirements of Cement

After finding of these properties it was checked whether they satisfy the requirements given in ASTM C 150 and SLS 1247. According to the results obtained, the cement certifies to be called 'Blended'.

4.3 Discussion

Considering about the results of compressive strength, Portland cement has higher early strength and Blended cement has higher latter strength. The setting of Blended cement takes longer than Portland cement. Because of fly ash fineness of Blended cement becomes higher. Blended cement has low amount of CaO compare with Portland cement, resulting less CO_2 emission to the environment.

5. Conclusions

According to the measured physical properties and chemical composition of fly ash based Portland pozzolana cement manufactured by Tokyo Cement PLC, it was found that the fly ash based blended cement has the properties as which required for a cement to be called 'blended cement'. As the blended Cement reduces CO2 emission, and improves strength, workability, and durability it will be very effective in green building construction.

References

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