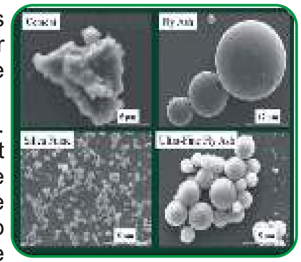
An Introduction to Pozzolana and Pozzolanic Cement



INTRODUCTION: Pozzolana, also known as pozzolanic ash, is a fine, sandy volcanic ash. Pozzolanic ash was first discovered and dug in Italy at Pozzuoli , in the region around Vesuvius. It was later discovered at a number of other sites as well. Vitruvius speaks of four types of pozzolana: black, white, grey, and red, all of which can be found in the volcanic areas of Italy, such as Naples.

Pozzolana is a siliceous and aluminous material which reacts with calcium hydroxide in the presence of water. This forms compounds possessing cementitious properties at room temperature which have the ability to set underwater. It transformed the possibilities for making concrete structures, although it took the Romans some time to discover its full potential. Typically it was mixed two-to-one with lime just prior to mixing with water. The Roman port at Cosa was built of Pozzolana that was poured underwater, apparently using a long tube to carefully lay it up without allowing sea water to mix with it. The three piers are still visible today, with the underwater portions in generally excellent condition even after more than 2100 years.

Portland Pozzolanic Cements are a mix of natural or industrial pozzolans and Portland cement. In addition to underwater use, the high alkalinity of pozzolana makes it especially resistant to common forms of corrosion from sulphates. Once fully hardened, the Portland Pozzolana Cement (PPC) will be stronger than Ordinary Portland Cement(OPC), due to its lower porosity, which also makes it more resistant to water absorption and spalling.

Some industrial sources of materials with pozzolanic properties are: Class F (silicious) fly ash from coal-fired power plants, silica fume from silicon production, rice husk ash from rice paddy-fields (agriculture), and meta kaolin from oil sand operations. Metakaolin, a powerful pozzolan, can also be manufactured, and is valued for making white concrete. **(some photographs of fly ashes are shown here :-)**

POZZOLANIC REACTION : At the basis of the Pozzolanic reaction stands a simple acid-base reaction between calcium hydroxide, also known as Portlandite, or ($Ca(OH)_2$), and silicic acid (H_4SiO_4, or $Si(OH)_4$). Simply, this reaction can be schematically represented as follows: $\mathbf{Ca(OH)_2 + H_4SiO_4 \rightarrow Ca^{2+} + H_2SiO_4^{2-} + 2H_2O \rightarrow CaH_2SiO_4 \cdot 2H_2O}$

or summarized in abbreviated notation of cement chemists: **CH + SH → CSH**

The product of general formula ($CaH_2SiO_4 \cdot 2H_2O$) formed is a calcium silicate hydrate, also abbreviated as CSH in cement chemist notation. The ratio Ca/Si, or C/S, and the number of water molecules can vary and the here above mentioned stoichiometry may differ.

QUALITY OF FLY ASH AS PER IS 3812 -2003 TO BE USED IN PPC:

S. No.	Parameters **Chemical**	Unit	Indian Standard: **3812 (Part 1) : 2003 Fly Ash^**		Indian Standard: **3812 (Par 2): 2003 Fly Ash^**	
			SPFA	**CPFA**	**SPFA**	**CPFA**
1.	$SiO_2 + Al_2O_3 + Fe_2O_3$	%	70	50	70	50
2.	Sio_2 Min	%	35	25	35	25
3.	Reactive SiO_2 Min (Optional)	%	20	20	-	-
4.	CaO, Max	%	-	-	-	-
5.	MgO, Max	%	5	5	5	5
6.	Total S as SO_3, Max	%	3	5	5	5
7.	Alkali as Na_2O, Max	%	1.5	1.5	1.5	1.5
8.	Total Cl, Max	%	0.05	0.05	0.05	0.05
9.	Loss on Ignition, Max	%	5	5	5	5
10.	Moisture content, Max	%	2	-	-	-
	Physical					
1.	Specific surface (Blaine), Min	M^2/kg	320		200	
2.	Sieve residue on 45 um sieve, Max	%	34 (Optional)		50 (Optional)	
4.	Lime reactivity** (Average compressive strength), Min	N/mm^2	4.5		-	
5.	Compressive strength at 28 days, Min	N/mm^2	Not less than 80% of the strength of corresponding plain cement mortar cubes		-	
6.	Drying shrinkage, Max	%	-		-	
7.	Soundness (Autoclave), Max	%	0.8		0.8	

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USAGES OF PORTLAND POZZOLANIC CEMENT: Portland Pozzolanic Cement is most widely used in concrete application as under:

- Concrete pavements
- Structures and foundations
- Mass concrete applications, such as dams
- Precast concrete, such as pipe and block
- Prestressed or post-tensioned concrete
- Concrete exposed to water and marine applications
- High-performance/high-strength concrete, used typically in high-rise building or bridges to give 100 year service life.

Hungary Horse Dam constructed by using Fly Ash

Metture Dam Mysore constructed by using Fly Ash

ADVANTAGES OF USING PORTLAND POZZOLANIC CEMENT : Following are the advantages of using Portland pozzolona Cement.

Portland Pozzolanic Cement improves the Properties of Fresh Concrete.

PPC improves the workability, placement and consolidation of concrete.

PPC is compatible with chemical admixtures in a similar manner to OPC concrete. Slight adjustments in admixture dosages may be necessary to achieve desired results.

Portland Pozzolanic Cement improves Concrete Strength and Elastic Modulus : PPC provides higher levels of compressive strength in concrete when compared with ordinary portland cement (OPC) concrete of equal cement content. Normally 15-35 % Fly ash addition is desirable to achieve optimum compressive strength. Concretes made with PPC will generally exhibit higher flexural strength for a given level of compressive strength. Modulus of elasticity follows the same relationship as OPC concrete, when based on compressive strength. Thus, with the higher compressive strengths achievable with PPC, structural stiffness can be enhanced, and load deflections minimized.

Portland Pozzolanic Cement reduce Permeability and Corrosion: Low permeability is essential for long-term durability, especially with regard to corrosion resistance of reinforcing steel. The additional Calcium Silicate Hydrate formed and denser cement paste in PPC concrete reduce pore size and reduced concrete permeability. Low permeability reduces the ingression of harmful substances (such as chlorides and sulfates) and the availability of water to catalyze harmful chemical reactions within concrete.

Portland Pozzolanic Cement Improves Resistance to Alkali-Aggregate Reaction: Alkali Aggregate Reaction occurs when the alkali in portland cement react with reactive Silica of aggregates to form an expandable gel that causes the concrete to crack, swell and prematurely deteriorate. PPC mitigates Alkali Aggregate Reactivity by reacting with the alkalis in portland cement and making them unavailable for reaction.

Portland Pozzolanic Cement Mitigate Sulfate Attack: Sulfate attack occurs when sulfates, found in seawater and some soils, react with the tricalcium aluminate in portland cement. This causes an expansive reaction and resulting deterioration of the concrete structure. Since Portland Pozzolanic Cement is containing less Tricalcium Aluminate , and thus lowers the total amount of Tricalcium Aluminate available for reaction.

Portland pozzolanic Cement Reduce Heat and Cracking in Mass Concrete: Mass concrete require low temperature differential between the surface and center of concrete to avoid thermal cracking. In cement Tricalcium Aluminate is one of the main source of heat of hydration. Since Tricalcium Aluminate is less in Portland Pozzolanic Cement resulting in lowering the heat of hydration and finally low temperature differential , which makes Portland Pozzolanic Cement most suitable for mass concrete.

Low life cycle cost of concrete: Longer durability of concrete made with Portland Pozzolanic Cement resulted into low life cycle cost.

Portland Pozzolanic Cement reduce the Global warming: Global warming is one of the Global issue and needs to be addressed by each and everyone on the earth. Usages of Flay Ash in Portland Pozzolanic Cement manufacturing is reducing the clinker consumption resulting in lowering the generation of Green House Gases(GHG) CO_2 in atmosphere.

Reducing energy consumption (Thermal & Electrical Energy), since a ton of Portland Pozzolanic Cement requires nearly 60 percent less energy to produce than a ton of Ordinary Portland Cement.

Thus in nut shell, we can say that using Portland Pozzolanic Cement is not only giving good quality of concrete but also helping in addressing the Global Warming issue as well as conserving natural resources, minimizing the pollution load on Environment.