Annex 18
Comparison of various Ultrafine Materials

Chemical Properties

Table-1

No.	Item	Silica fume	Ultrafine ggbs	Metakaolin	Ultrafine fly ash	Remarks
1	SiO_2 percent by mass (min)	85	-	-	35	Essentially there are two types of basic materials used in production of Ultrafine materials • Pozzolanic • Hydraulic Silica fume and Ultrafine fly ash fall in first category while Metakaolin and Ultrafine ggbs fall in second category. Chemical composition of both types of basic materials will be different. However, following parameters can be compared. a) Loads on ignition b) Moisture content c) Chloride d) Alkalies
2	Moisture content by mass (max)	3.0	3.0	-	2.0	
3	Loss on ignition percent by mass (max)	4.0	3.0	2.0	4.0	
4	Alkalies as Na_2O (equva) (max)	1.5	-	1.5	1.5	
5	$SiO_2 + Al_2O_3$ percent by mass (min)	-	-	94.0	-	
6	SiO_2/AlO_3 percent by mass (min)	-	-	1.15	-	
7	$Fc_2O_3+TiO_2$ percent by mass (max)	-	-	3.0	-	
8	Al_2O_3 percent by mass (min)	-	-	40.0	-	
9	Manganese Oxide (MnO) percent by (max)	-	5.5	-	-	
10	Magnesium Oxide (MgO) percent (max)	-	17	-	5.0	
11	Sulphide sulphur (max)	-	2.0	-	-	
12	Sulfide as SO_3	-	3.0	-	3.0	
13	Insoluble Residue (max)	-	3.0	-	-	
14	Chloride content (max)	-	0.1	-	0.05	
15	$CaO + MgO$ +1/3 Al2O3 (min) SiO2+2/3 Al2O3	-	-	-	-	
15	$\frac{CaO+MgO+⅓Al_2O_3}{SiO_2+⅔Al_2O_3}$(min)	-	1	-	-	
16	$\frac{CaO+MgO+Al_2O_3}{SiO_2}$(min)	-	1	-	-	
17	$SiO_2+Al_2O_3+Fc_2O_3$ (min)	-	-	-	70	

Physical properties of Ultrafine Materials

Table-2

No	Item	Silica fume	Ultrafine ggbs	Metakaolin	Ultrafine fly ash	Remarks
1	Surface area m^2/kg (BET method)	15000	1500	9000	1500	For Ultrafine fly ash replacement level is 10% while for other materials, it is 50%. Therefore the figures are different for activity index.
2	Oversize retained on 45-micron sieve (wet sieving)	10	1.5	-	5	
3	D_{50} (micron)	-	5	-	7	
4	D90 (micron)	-	-	-	15	
5	D95 (micron)	-	15	-	-	
6	Activity Index 7 days (%) 28 days (%)	 85 -	 60 75	 100 -	 95 110	

Dear Mr. Chaudhary,

Sub: Comparison of Ultrafine materials

Kindly recall P-1 meeting held on 09.07.2024. it was decided in the meeting that a comparison of physical and chemical characteristics of all Ultrafine materials will be made.

These are 3 Ultrafine materials of which IS Codes have already been made viz silica fume, Metakaolin and Ultrafine ggbs. The fourth material in line is Ultrafine fly ash.

I have compared the chemical and physical characteristics of all 4 Ultrafine materials as given in Table-1 and Table-2 respectively.

It will be seen that there are two types of basic materials from which Ultrafine materials are derived viz Pozzolanic and Hydroulic. Silica fume and Ultrafine fly ash are pozzolanic while Metakaolin and Ultrafine ggbs are hydraulic. The chemical properties therefore will differ, however following four items shall be comparable.

a) Loss on ignition
b) Moisture content
c) Total chlorides
d) Alkalis as Na_2O equivalent.

As regards physical properties, silica fume is industrial by-product (without any processing) therefore, its fineness is as per material generated as by-product. Metakaolin is basically derived from kaoline, a clayey material (softer in nature) and its fineness is specified accordingly. Ultrafine fly ash is produced through classification route and its fineness is comparable to Ultrafine slag.

The activity index of other materials (except Ultrafine fly ash) is done as per IS 1727 by 50% replacement of material with OPC, while in case of Ultrafine fly ash it is done by replacing 10% OPC.

In fact, Ultrafine materials are used in the range of 5% to 8% of cementitious material in concrete and 10% replacement is more logical for Ultrafine materials.