Appendix B

Specification for Fly Ash According to EIT 1014-46 (2003)

1. Classes and Types

Quality of fly ashes is classified by their chemical and physical properties into 3 classes as in the following.

1.1 First class is suitable for extremely high quality concrete.

1.2 Second class is suitable for conventional concrete and is divided in to 2 types.

1.2.1 Type A has low CaO content
1.2.2 Type B has high CaO content

1.3 Third class is fly ashes those have lower quality than the first and second class fly ashes. The third class fly ash is suitable for mass concrete, dam, and low quality concrete.

2. Required Properties

2.1 Chemical Properties

Fly ash must have chemical properties in accordance with Table B1. However, an additional item as in Table B2 may be added if specifically required by the purchasers. The test methods follow ASTM C 311.

2.2 Physical Properties

Fly ash must have physical properties in accordance with Table B3. However, additional items as in Table B4 may be added if specifically required by the purchasers. The test methods follow ASTM C 311.

Table B1 Chemical properties

Item	Properties	Requirement			
		First class	Second class		Third class
			Type a	Type b	
1	Silicon dioxide (SiO_2), min. %	30.0	30.0	30.0	30.0
2	Calcium oxide (CaO), %	-	Less than 10.0	Not less than 10.0	-
3	Sulfur trioxide (SiO_3), max. %	5.0	5.0	5.0	5.0
4	Moisture content, max. %	3.0	3.0	2.0	3.0
5	LOI content, % max. %	6.0 [1)]	6.0 [1)]	6.0 [1)]	12.0

Note: [1)] The use of fly ash with up to 12% LOI may be approved if either acceptable performance records or laboratory test results are made available.

Table B2 Chemical properties (addition)

Item	Properties	Requirement			
		First class	Second class		Third class
			Type a	Type b	
1	Alkali content ($Na_2O + 0.658K_2O$) [1], max. %				
	1.1 when SO_3 between 3.0 to 5.0 %	1.5	1.5	1.5	1.5
	1.2 when SO_3 less than 3.0 %	4.0	4.0	4.0	4.0

Note: [1] Fly ash with alkali content exceeding this limitation may be approved if the test results on control of alkali-silica reaction satisfy the requirement.

Table B3 Physical properties

Item	Properties	Requirement			
		First class	Second class		Third class
			Type a	Type b	
1	Fineness (alternative methods)				
	Retain on 45-μm-mesh sieve, max. %	10	50	55	65
	Or Blaine fineness, min. cm^2/g	6000	2300	2000	1600
2	Strength activity index [1] with OPC type 1				
	7-day, min. % control	85	70	70	60
	28-day, min. % control	95	75	75	70
	91-day, min. % control [2]	100	85	85	75
3	Water requirement, max. % control	102	105	105	108
4	Autoclave expansion [3], max. %	0.8	0.8	0.8	0.8

Note: [1] Strength activity index with OPC type 1 is not the specification for compressive strength of fly ash concrete. Besides, the fly ash content of 20% (by weight) of the total binder, which is indicated from the test method, is not the general recommendation for proportion of fly ash to be used in the actual mixture of concrete. The suitable proportion of fly ash in concrete must be designed to meet the required properties of concrete in each project. This test method is aimed to quantify the reaction between fly ash and cement. This recommended value may be changed according to the source of fly ash and type of cement.

[2] If Strength activity index at 7 and 28 days fail the requirement, Strength activity index at 91 days may be used as criterion.

[3] In case of proportioning of concrete containing fly ash more than 20% (by weight) of the total binder, the test specimens must be prepared to contain the same replacement percentage of fly ash.

Table B4 Physical properties (addition)

Item	Properties	Requirement			
		First class	Second class		Third class
			Type a	Type b	
1	Multiplication Multiplication of LOI and fineness (retain on 45-μm-mesh sieve) [1], max. %	225	225	225	225
2	Drying shrinkage Drying shrinkage of fly ash mortar bar at 28 days when compared with cement-only mortar bar at the same age, max. %	0.03	0.03	0.03	0.03
3	Consistency of air-entrained concrete measured by the amount of air-entrained agent for making 18% air-entrained mortar. Difference of each tested value from the average (less than 10 repeated test results), max. %	20	20	20	20
4	Effectiveness on control of alkali-silica reaction [2] Expansion of fly ash mortar bar at 14 days when compared with low alkali cement mortar bar at the same age, max %	100	100	100	100
5	Sulfate resistance [3] Method A, Expansion of fly ash mortar bar when submerged in sulfate solution for 6 months - Moderate sulfate exposure, max. % - Severe sulfate exposure, max. % Method B, Expansion of fly ash mortar bar when submerged in sulfate solution for 6 months compared with mortar bar using sulfate resisting cement, max %	 0.10 0.05 100	 0.10 0.05 100	 0.10 0.05 100	 0.10 0.05 100
6	Consistency Density Difference from the average (obtained from 5 – 10 repeated test results), max. % Or fineness (% retained on 45-μm-mesh sieve) Difference from the average (obtained from 5 – 10 repeated test results), max. % Or fineness (Blaine fineness) Difference from the average (obtained from 5 – 10 repeated test results), max. cm^2/g	 5 5 450	 5 5 450	 5 5 450	 5 5 450

Note: [1] Only required for concrete subjecting to freezing and thawing

[2] If fly ash passes this requirement, it can control the alkali-aggregate reaction as well as the use of low alkali cement. However, the content of fly ash must not be less than the tested content and the alkali content in cement must not be more than 0.05% of alkali content of the cement used in the test.

[3] The variation of fly ash content in practice must not be more than 2% from the tested content and cement must not contain higher content of tricalcium aluminate ($3CaO.Al_2O_3$) or C_3A than the tested cement.

The quality of fly ash concrete depends on type and content of fly ash, curing, and temperature. Therefore, the trial mix proportioning of fly ash concrete is required and the curing must be better and longer than the cement-only concrete, especially during the first few days. If high volume fly ash is used, the quality of concrete must be assured form tests.

These specifications for chemical and physical properties of fly ash only specify the minimum or maximum acceptable values in a similar way as the specification for cement. Unlike cement, which is an industrial product, fly ash is an industrial waste. The chemical and physical properties of fly ash are uncertain. If fly ash is used continuously in large amount or for a long period, there is an opportunity that the properties of fly ash concrete, i.e. workability or strength change during the construction. Routine quality assurance of chemical and physical properties of fly ash is recommended.