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Guide for the Use of Silica Fume in Concrete

Reported by ACI Committee 234

Per Fidjestøl, Chair
Anthony N. Kojundic, Secretary

James M. Aldred, Mark A. Bury, Rachel J. Detwiler, Fouad H. Fouad, William Halczak, Terence C. Holland, R. Doug Hooton, Tarif M. Jaber, Kamal H. Khayat, V. M. Malhotra, Dudley R. Morgan, Jan Olek, H. Celik Ozyildirim, Michael F. Pistilli, Jean-Claude Roumain, Della M. Roy, Marco J. Scali, Michael D. A. Thomas, John T. Wolsiefer, Min-Hong Zhang

This report describes the physical and chemical properties of silica fume; how silica fume interacts with portland cement; the effects of silica fume on the properties of fresh and hardened concrete; recent typical applications of silica-fume concrete; how silica-fume concrete is proportioned, specified, and handled in the field; and areas where additional research is needed.

Keywords: curing; durability; high-range water-reducing admixture; high-strength concrete; placing; plastic-shrinkage cracking; silica fume; time of setting; water-reducing admixture; workability.

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ACI 234R-06 supersedes ACI 234R-96 (Reapproved 2000) and became effective April 13, 2006.

CHAPTER 1—INTRODUCTION

1.1—General

Silica fume, a by-product of the ferrosilicon industry, is a highly pozzolanic material that is used to enhance mechanical and durability properties of concrete. It may be added directly to concrete as an individual ingredient or in a blend of portland cement and silica fume. ACI Committee 234 estimates that at least 120,000 metric tons (130,000 tons) of silica fume are used in concrete worldwide annually. Using this figure, more than 6 million cubic meters (nearly 8 million cubic yards) of silica-fume concrete are placed globally each year.

Interest in the use of silica fume resulted from the strict enforcement of air-pollution measures designed to stop release of the material into the atmosphere. Initial use of silica fume in concrete was mostly for cement replacement, along with water-reducing admixtures (WRAs). Eventually, the availability of high-range water-reducing admixtures (HRWRAs, often referred to as superplasticizers) allowed new possibilities for the use of silica fume to produce high levels of performance.

This document provides basic information on using silica fume in concrete. The document is organized as follows:

- Chapter 1 provides general information on silica fume;
- Chapter 2 describes the physical properties and chemical composition of silica fume;
- Chapter 3 describes the mechanisms by which silica fume modifies cement paste, mortar, and concrete;
- Chapter 4 describes the effects of silica fume on fresh concrete;
- Chapter 5 describes the effects of silica fume on hardened concrete;
- Chapter 6 shows how silica fume has been used on actual projects. This chapter covers only a very small number of applications because ACI Committee 234 is currently developing an additional document that will provide detailed case histories of many more projects;
- Chapter 7 discusses specifications for silica fume and silica-fume concrete;
- Chapter 8 presents a step-by-step methodology for proportioning silica-fume concrete for specific applications;
- Chapter 9 presents recommendations for working with silica fume in field concrete;
- Chapter 10 summarizes research needs for using silica fume in concrete; and
- Chapter 11 presents all of the references from the other chapters.

Note that the coverage in Chapters 7, 8, and 9 is somewhat brief. More details on working with silica-fume concrete in

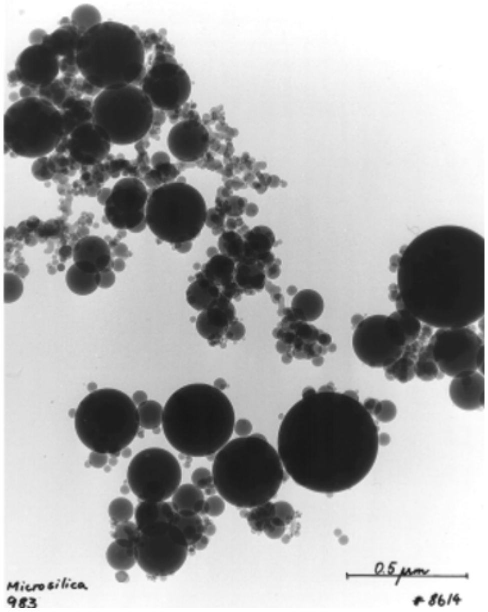

Fig. 1.1—Transmission electron microscope micrograph of silica fume. (Image courtesy of Elkem ASA materials.)

actual applications may be found in a guide published by the Silica Fume Association (Holland 2005).

As with other concrete constituent materials, potential users of silica fume should develop their own laboratory data for the particular type and brand of cement, aggregates, and chemical admixtures to be used with the silica fume. This testing may be supplemented by field observations of completed silica-fume concrete and by testing of cores taken from such concrete.

1.2—What is silica fume?

Silica fume, as defined in ACI 116R, is "very fine noncrystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon." The silica fume, which condenses from the gases escaping from the furnaces, has a very high content of amorphous silicon dioxide and consists of very fine spherical particles (Fig. 1.1 and 1.2) typically averaging 0.1 to 0.2 μm (4 to 8 × 10^{-6} in.) in diameter. Often, several individual spheres can be fused together to form small agglomerates.

The first mention of silica fume for use in concrete and mortar is found in a U.S. patent from 1946 (Sharp 1946) where the use of silica fume to improve the properties of fresh mortar is the main claim of the patent.

Silica fume was first collected in Kristiansand, Norway, in 1947. Investigations into the properties of the material and its uses began promptly, with the first paper being published by Bernhardt in 1952. Investigations of the performance of silica fume in concrete also followed in other Nordic countries: Iceland, Denmark, and Sweden. Additional early Scandinavian papers included those by Fiskaa et al. (1971), Traetteberg (1977), Jahr (1981), Asgeirsson and Gudmundsson (1979), Løland (1981), and Gjørv and Løland (1982). In 1976, a Norwegian standard permitted the use of silica fume in blended cement. Two years later, the direct addition of silica fume into concrete was permitted by a standard in Norway.

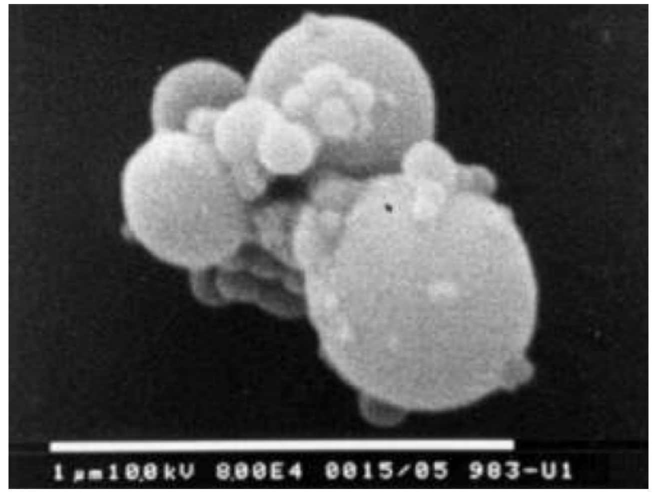

Fig. 1.2—Scanning electron microscope micrograph of silica fume. (Image courtesy of Elkem ASA materials.)

In South Africa, Oberholster and Westra published research results on using silica fume to control alkali-aggregate reaction in 1981.

In North America, the first paper was published in 1981 by Buck and Burkes of the U.S. Army Corps of Engineers Waterways Experiment Station (WES). Other early research was conducted by CANMET (Malhotra and Carette 1983; Carette and Malhotra 1983a), Sherbrooke University (Aïtcin 1983), Norchem (Wolsiefer 1984), and the U.S. Army Corps of Engineers WES (Holland 1983). In 1978, Norchem did the first major placement of ready mixed silica-fume concrete in the United States for resistance to chemical attack.* In late 1983, the U.S. Army Corps of Engineers did the first publicly bid project in the United States using silica-fume concrete (Holland et al. 1986).

The SiO_2 content of the silica fume is roughly related to the manufacture of silicon alloys as follows:

Alloy type	Typical SiO_2 content of silica fume
50% ferrosilicon	74 to 84%
75% ferrosilicon	84 to 91%
Silicon metal (98%)	87 to 98%

Ferrosilicon alloys are usually produced with nominal silicon contents of 50 to 98%. When the silicon content reaches 98%, the product is called silicon metal rather than ferrosilicon. As the silicon content increases in the alloy, the SiO_2 content increases in the silica fume. The majority of published data and field use of silica fume have been from alloys of 75% ferrosilicon or higher. Wolsiefer et al. (1995) and Morgan and Wolsiefer (1992), however, present information on using silica fume from production of alloys with

*Private communication from committee member.

50% iron in applications such as chemically resistant concrete, shotcrete, blended cement, and oil well cement grouts.

Silica fume is also collected as a by-product in the production of other silicon alloys. The use of these fumes should be avoided unless data on their favorable performance in concrete are available.

Silica fume has also been referred to as condensed silica fume, microsilica, and fumed silica (this last term is particularly incorrect—refer to Section 1.3). The most appropriate term is silica fume. In formal references related to health and safety regulations, the product is characterized as "Thermally Generated Silica Fume." The Chemical Abstracts Service (CAS) classifies silica fume by the number 69012-64-2. The corresponding European Index of Existing Chemical Substances (EINECS) number is 273-761-1. Other forms of silicon dioxide, including fumed silica, colloidal silica, diatomaceous earth, and quartz have differing chemical and physical properties, and thus have other classification numbers.

Silica fume is covered by several national and international standards. Chapter 7 provides a listing of the various standards in use and a discussion of some of the key provisions.

1.3—Silica fume versus other forms of silica

Other products with a high content of amorphous silica are marketed from time to time to the concrete industry. These can roughly be divided into two groups: synthetic silica and natural silica. None of these products should be confused with silica fume as defined in this document.

1.3.1 *Synthetic silica*—Synthetic silicas are amorphous products that are occasionally confused with silica fume. Unlike silica fume, they are purposefully made. While they offer the potential of performing well in concrete, they are typically too expensive for such use. These products are made through three processes:

- **Fumed silica.** Fumed silica is produced by a vapor-phase hydrolysis process using chlorosilanes, such as silicon tetrachloride, in a flame of hydrogen and oxygen. Fumed silica is supplied as a white, fluffy powder;
- **Precipitated silica.** Precipitated silica is produced in a finely divided form by precipitation from aqueous alkali-metal silicate solutions. Precipitated silica is supplied as a white powder or as beads or granules; and
- **Gel silica**. Gel silica is also prepared by a wet process in which an aqueous alkali-metal silicate solution is reacted with an acid so that an extensive three-dimensional hydrated silica structure or gel is formed. It is supplied as granules, beads, tablets, or as a white powder.

Colloidal silica is a stable suspension of discrete particles of amorphous silicon dioxide. The source of the silica particles may be one of the aforementioned processes. Colloidal silica may also be referred to as silica sol. Silica fume particles are too large to be colloidal.

Additional information on these synthetic types of silica may be found in the work of Iler (1979), Dunnom (1984), Ulrich (1984), Griffiths (1987), and Larbi and Bijen (1992). ASTM E 1156-87 contains additional descriptions of these synthetic amorphous silicas (note that this document has been withdrawn by its committee).

1.3.2 *Natural silica*—Natural silica is typically material with amorphous silica, and often reactive alumina, that is dug from the ground and then treated through grinding and classification. The origin of the raw materials can, for example, be volcanic ash, diatomaceous earth, or deposits from geothermal wells.

1.4—Using silica fume in concrete

Silica fume was initially viewed as a cement replacement material, but currently the most important reason for its use is the production of high-performance concrete, where adding silica fume provides enhancements in concrete properties. In this role, silica fume has been used to produce concrete with enhanced compressive strength and with very high levels of durability. Refer to Chapter 5 for a discussion of the effects of silica fume on the properties of hardened concrete.

In the U.S., silica fume is used predominantly to produce concrete with greater resistance to chloride penetration for applications such as parking structures, bridges, and bridge decks. A growing application area for silica fume is as an admixture for shotcrete, where silica fume typically reduces rebound loss, allows increased placement thickness, and generally improves the quality of the material placed (Norwegian Concrete Association 1999; Wolsiefer and Morgan 1993). Additional details of applications of silica-fume concrete are presented in Chapter 6.

Because of the fineness of the material, adding silica fume to concrete mixtures usually increases water demand. To produce high-performance, durable concrete, it is necessary to maintain (or decrease) the water-cementitious material ratio (*w/cm*). Consequently, HRWRAs, sometimes combined with WRAs, are used to obtain the required performance and workability. Silica-fume concrete will be more cohesive than ordinary concrete; consequently, a somewhat higher slump will normally be required to maintain the same apparent degree of workability.

1.5—Using silica fume in blended cements

The use of silica fume in blended cements has also attracted interest. Aïtcin (1983) reported that one Canadian cement manufacturer began making blended cement in 1982. At present, most Canadian cement companies are selling blended cement containing 7 to 12% silica fume, with 7.5% being the nominal amount most frequently used. The use of cement containing 6 to 7% silica fume to combat alkali-silica reaction (ASR) in Iceland was described by Asgeirsson and Gudmundsson (1979) and by Idorn (1988). Since 1979, all Icelandic cement has been blended with silica fume. Lessard et al. (1983) described the use of blended cement containing silica fume to reduce heat of hydration by reducing cement content. Typically, the properties of concrete made from cements containing silica fume as a blending material may be expected to be similar to those of concrete where silica fume was added separately, assuming the silica fume was properly mixed and dispersed in either case (Wolsiefer et al. 1995). As with any blended cement, there will be less flexibility in mixture proportioning with respect to the exact amount of silica fume in a given concrete mixture. Unless otherwise stated, the results and information presented in this document were derived from concrete made with separately added silica fume.

1.6—Worldwide availability of silica fume

Precise data on the annual output of silica fume in the world are not readily available because of the proprietary nature of the alloy industry. Estimates may be found in publications of the U.S. Bureau of Mines (1990) or in the work of RILEM Technical Committee 73-SBC (1988). ACI Committee 234 believes that approximately 900,000 metric tons (1,000,000 tons) of silica fume are produced annually worldwide.

Silica fume generation from silicon-alloy furnaces varies, but is typically about 30% by mass of alloy produced (Aïtcin 1983). Of the silica fume produced in the world, it is not known what percentage of the silica fume collected from silicon-alloy furnaces is actually used.

1.7—Types of silica fume products available

Silica fume is available commercially in several forms. All of the product forms have positive and negative aspects that may affect performance in concrete, material handling, efficiency, and product-addition rate. Material handling methods have been developed to use silica fume in its as-produced form, densified or compacted form, and as water-based slurry. The available forms are described in the following sections.

1.7.1 *As-produced silica fume*—Silica fume, as collected, is an extremely fine powder. For this report, this material is referred to as "as-produced silica fume." As-produced silica fume may be available in bulk or in bags, depending on the willingness of the producer to supply this form.

As-produced silica fume has been handled and transported like portland cement or fly ash. Because of its extreme fineness and low bulk density, however, as-produced silica fume may present serious handling problems. Some as-produced silica fumes will flow only with great difficulty. Clogging of pneumatic transport equipment, stickiness, and bridging in storage silos are other problems associated with as-produced silica fume. These problems can be partially overcome with properly designed loading, transport, storage, and batching systems.

Bagged, as-produced silica fume has been added to concrete by discharging the material directly into truck mixers. This approach, however, has not been popular because of the dust generated and the high labor costs. As-produced silica fume has not been used extensively in ready mixed concrete because of the handling difficulties and higher transportation costs than for other forms of silica fume (Holland 1989).

1.7.2 *Silica-fume slurry*—To overcome the difficulties associated with transporting and handling the as-produced silica fume, some suppliers have concentrated on supplying silica fume as a water-based slurry. Slurried silica fume typically contains 42 to 60% silica fume by mass. Slurry of 50% solids content will contain about 700 kg/m^3 (44 lb/ft^3) dry material versus 130 to 430 kg/m^3 (8 to 27 lb/ft^3) for as-produced material. Transportation of slurry will, despite the water content, often be more economical than transportation of the dry, as-produced silica fume.

The slurries are available with and without chemical admixtures such as WRAs, HRWRAs, and retarders. The actual amount of chemical admixture in the slurry will vary depending on the supplier. The admixture dosage typically ranges from that which offsets part of the increased water demand caused by the silica fume to that which provides significant water reduction to the concrete. Silica fume slurry offers an advantage of ease of use over the as-produced silica fume once the required dispensing equipment is available at the concrete plant. Slurry products are typically available in bulk, 55 gal. (208 L) drums, and 5 gal. (19 L) pails. If slurried silica fume is used on a project, the manufacturer's recommendations concerning storage and handling must be followed diligently.

1.7.3 *Densified (compacted) silica fume*—Dry, densified (or compacted) silica-fume products are also available. These products are dense enough to be transported economically. They may be handled like portland cement or fly ash at a concrete plant. The densification process greatly reduces the dust associated with the as-produced silica fume.

One method to produce the densified silica fume is to place as-produced silica fume in a silo. Compressed air is blown in from the bottom of the silo, causing the particles to tumble. As the particles tumble, they agglomerate. The heavier agglomerates fall to the bottom of the silo and are periodically removed. Because the agglomerates are held together relatively weakly, they break down with the mixing action during concrete production. The majority of published data and field use of densified silica fume have been from literature on the air-densification process. Unless otherwise stated, the air-densification process produced the densified silica fume referred to in this report.

Another method for producing densified silica fume is to compress the as-produced material mechanically. Although mechanically densified silica fume was commercially available in the U.S. at one time, ACI Committee 234 is not aware of any mechanically densified material currently available worldwide.

Densified (compacted) dry silica-fume products are available with and without dry chemical admixtures. These products are typically available in bulk, in bulk bags of 1300 to 2700 lb (600 to 1200 kg), and in small bags of 22 to 55 lb (10 to 25 kg).

1.7.4 *Pelletized silica fume*—As-produced silica fume may also be pelletized by mixing the silica fume with a small amount of water and often a little cement, typically on a disk pelletizer. This process forms pellets of various sizes that can be disposed of in landfills. In Norway, pellets have been used as fill behind retaining walls in private and public areas. Pelletizing is not a reversible process—the pellets are too hard to break down easily during concrete production. Pelletized silica fume is not being used as an admixture for concrete; however, a Canadian cement producer intergrinds pellets with portland-cement clinker to form a blended cement. Published data are available (Wolsiefer et al. 1995) comparing the performance of blended cement containing interground pelletized silica fume with that of directly added silica fume or blended cement made with as-produced or densified silica fume. They concluded that, regardless of the product form of the silica fume, the mechanical properties and durability characteristics of the silica-fume concretes were comparable.

1.8—Health hazards

ACI Committee 234 is not aware of any reported health-related problems associated with the use of silica fume in concrete. There are no references to the use of silica fume in the concrete industry in the publications of either the Occupational Safety and Health Administration (OSHA) or the American Conference of Governmental Industrial Hygienists (ACGIH).

Although silica fume is not known to cause cancer or silicosis, it is not entirely harmless. Because of the small size of silica fume particles, generally smaller than 1 μm (4×10^{-5} in.) with an average diameter of 0.1 to 0.2 μm (4 to 8×10^{-6} in.), all airborne silica fume should be considered respirable. As with other fine, respirable powders, adverse health effects can result from massive inhalation of silica fume (Davies 1974). Such dust levels are highly unlikely to be encountered in modern silicon metal or ferrosilicon alloy plants, let alone in a concrete production plant or at a construction site. No silica fume dust can be produced from in-place concrete, and thus, there is no exposure whatsoever.

Trace amounts (much less than 1%) of crystalline silica (such as quartz) may be present in silica fume; however, the detection limit of the procedures used to quantify crystalline SiO_2 mixed into amorphous SiO_2 is approximately 0.5%. Therefore, conformity to limits of 0.1% crystalline SiO_2 cannot be documented.

Papers from the *Symposium on Health Effects of Synthetic Silica Particulates* (Dunnom 1981) indicate that there is little health-hazard potential from the inhalation of amorphous silica fume due to the small particle size and noncrystalline structure. Jahr (1981) stated that experience in Norwegian ferrosilicon manufacturing plants indicated that if the threshold limit values (TLVs) of 2×10^{-6} oz/ft^3 (2 mg/m^3) are not exceeded, then the risk of silicosis is very small from exposure to this type of amorphous silica. Jahr concluded that "most of the reported cases of silicosis among workers exposed to amorphous silica in the ferrosilicon industry have either been transient lung changes or connected to exposure to crystalline silica. Workers exposed only to precipitated amorphous silica do not seem to be at any significant risk."

Members of the ACGIH (1991) reviewed the available literature on exposure to silica fume by inhalation to determine an appropriate threshold limit value. They noted that, based on the available data, it was not possible to identify an airborne concentration below which adverse health effects do not occur. It was also not possible to sort out the confounding effects of other lung irritants, such as crystalline silica, asbestos, and tobacco smoke, to which many of the workers examined were also exposed. Lacking definitive dose-response data, the ACGIH recommended a threshold limit value of 2×10^{-6} oz/ft^3 (2 mg/m^3).

Dalen and Fjelldal (1998) concluded that, when used properly, silica fume does not represent a hazard to health and environment and that, from an environmental point of view, silica fume is comparable to naturally occurring fine powders such as clay and river sediments.

In recognition of the importance of a safe working environment, the Committee wishes to emphasize that users should refer to the manufacturer's material safety data sheets for the products being used for specific health and safety information.

1.9—Environmental impact

Silica fume is a by-product of the ferrosilicon industry, and its use in concrete means that resources are used in a constructive manner. Because silica-fume concrete can be made to be very durable, the use of the material contributes to more efficient structures with less need for repair and maintenance and, therefore, reduced lifetime impact on the economy and on the environment.

CHAPTER 2—PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION OF SILICA FUME

This chapter describes the physical properties and chemical composition of silica fume. The limits that exist for these properties in U.S. and international standards are presented in Chapter 7.

2.1—Color

Most silica fumes range from light to dark gray. Because SiO_2 is colorless, the color is determined by the nonsilica components, which typically include carbon and iron oxide. In general, the higher the carbon content, the darker the silica fume. The carbon content of silica fume is affected by many factors relating to the manufacturing process, such as: use of wood chips versus coal, wood chip composition, furnace temperature, furnace exhaust temperature, and the type of product (metal alloy) being produced.

2.2—Specific gravity

The specific gravity of silica fume is approximately 2.2, as compared with about 3.1 for portland cement. Table 2.1 lists the specific gravity of silica fume from several sources. Variations in specific gravity are attributed to the nonsilica components of the various silica fumes.

2.3—Bulk density

2.3.1 *As-produced silica fume*—The bulk density of as-produced silica fume collected from silicon metal and ferrosilicon alloy production usually ranges from 8 to 27 lb/ft^3 (130 to 430 kg/m^3), although it is most common to see values near the middle of this range.

2.3.2 *Slurried silica fume*—Slurried silica fume will typically have a bulk density of approximately 11 to 12 lb/gal. or 83 to 90 lb/ft^3 (1.3 to 1.4 Mg/m^3). The nominal silica fume content of most slurries is approximately 50% by mass. The actual silica fume content may vary, depending on the particular source and whether chemical admixtures have been added to the slurry.

Table 2.1—Silica fume specific gravity versus alloy type

Silicon alloy type	Silica fume specific gravity	Reference
Si	2.23	Aïtcin et al. (1984)
Si and FeSi-75% blend	2.27; 2.26	Pistilli et al. (1984a,b)
FeSi-75%	2.21 to 2.33	Aïtcin et al. (1984)
FeSi-50%	2.30	Aïtcin et al. (1984)

2.3.3 *Densified (compacted) silica fume*—Densification from an initial bulk density of 13 lb/ft^3 (200 kg/m^3) to a densified value of 31 lb/ft^3 (500 kg/m^3) has been reported (Elkem 1980; Popovic et al. 1984). The bulk density of commercially available densified silica fume ranges from approximately 25 to 45 lb/ft^3 (400 to 720 kg/m^3).* At higher bulk densities, it may become increasingly difficult to disperse densified silica fume particles within concrete. Concrete made with a silica fume with a bulk density of 50 lb/ft^3 (810 kg/m^3) showed decreased performance in both strength and frost resistance (Fidjestøl 1992).

2.4—Fineness, particle shape, and oversize material

Silica fume consists primarily of very fine smooth spherical glassy particles with a surface area of approximately 98,000 ft^2/lb (20,000 m^2/kg) when measured by the nitrogen-adsorption method. The extreme fineness of silica fume is illustrated by the following comparison with other fine materials (note that the values derived from the different measuring techniques are not directly comparable):

- Silica fume: 63,000 to 150,000 ft^2/lb (13,000 to 30,000 m^2/kg), nitrogen adsorption
- Fly ash: 1400 to 3400 ft^2/lb (280 to 700 m^2/kg), Blaine air permeability
- Ground-granulated blast-furnace slag:1700 to 2900 ft^2/lb (350 to 600 m^2/kg), Blaine air permeability
- Portland cement: 1500 to 2000 ft^2/lb (300 to 400 m^2/kg), Blaine air permeability

The nitrogen-adsorption method is currently the most frequently used test to determine the surface area of silica fume. The Blaine air permeability apparatus is not appropriate for measuring the surface area of silica fume because of difficulties in obtaining the necessary 0.50 porosity to conduct the test. Nitrogen-adsorption surface area results for various silica fumes range from 63,000 to 150,000 ft^2/lb (13,000 to 30,000 m^2/kg) (Malhotra et al. 1987b). One study of Si and FeSi-75% silica fumes reported results between 88,000 and 110,000 ft^2/lb (18,000 and 22,000 m^2/kg) (Elkem 1980). Another study (Nebesar and Carette 1986) reported average surface area values of 98,000 and 84,000 ft^2/lb (20,000 and 17,200 m^2/kg) for Si and FeSi-75% silica fumes, respectively.

Individual silica fume particles have a diameter of less than 1 μm (4 × 10^{-5} in.), which is approximately 1/100 of the size of an average cement particle. The individual particles, however, are usually found in agglomerations that may range in size from 1 to 100 μm (4 to 400 × 10^{-5} in.) (Dingsoyr et al. 1992). The degree and extent of agglomeration will vary depending on the fume type and the furnace gas exhaust temperature.

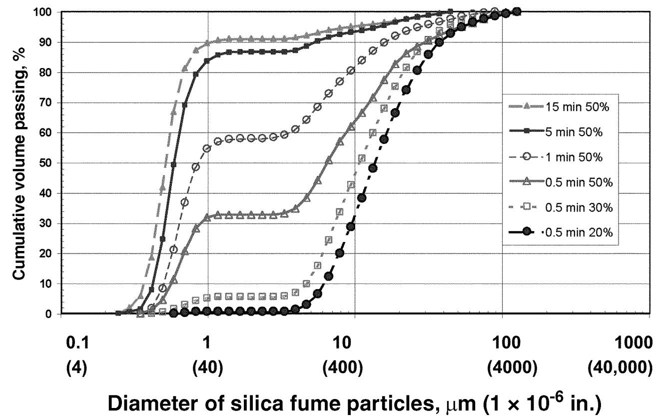

Fig. 2.1—Particle-size distribution of silica fume subjected to varying amounts of dispersion. The set of curves shows the importance of the amount of dispersion on the measured distribution. Varying the intensity and duration of ultrasonic dispersion gives very different results for the same silica fume. The values shown are percentages of full stroke in a Microtrac apparatus; higher percentages indicate increased dispersion effort. (Figure courtesy of Elkem ASA Materials.)

Any attempt to show particle-size distribution of silica fume must take the agglomeration tendency into account. Figure 2.1 shows several particle-size distributions from the same as-produced silica fume subjected to differing degrees of dispersion. ACI Committee 234 is not aware of data showing that different degrees of agglomeration of as-produced silica fume affect its performance in concrete.

One of the most common tests conducted on silica fume is the residue (oversize) on the 45 μm (No. 325) sieve. In this test, a sample of silica fume is washed through the sieve, and the mass and composition (wood, quartz, carbon, coal, rust, and relatively large silica fume agglomerates) of the oversize particles are reported.

The amount of oversize material is strongly influenced by the silica-fume collection system, and the amount of oversize material may vary considerably from one system to another. Various values have been reported for the amount of oversize: 0.3 to 3.5% (Elkem 1980), 3.7 to 5.6% (Pistilli et al. 1984a), and 1.8 and 5.4% for Si and FeSi-75%, respectively (Nebesar and Carette 1986).

Because many nonsilica components of silica fume are associated with the larger particles, some silica fume suppliers routinely remove oversize particles from the silica fume. Some oversize removal (beneficiating) processes work with the dry fume using various kinds of cyclones or classifiers. Other systems run slurried silica fume through sieves, usually after the silica fume has been passed through one or more of the dry beneficiating processes.

2.5—Chemical composition

Table 2.2 gives the chemical composition of typical silica fumes from silicon furnaces in Norway and North America.

*Private communications from producer members to ACI Committee 234.