Admixtures

Admixtures

admixture (*n*.) any material other than water, aggregates, hydraulic cement and fiber reinforcement, used as an ingredient of concrete or mortar, and added to the batch immediately before or during mixing.

Types of Admixtures

1. Air-entraining admixtures
   added to improve freeze-thaw durability
2. Chemical admixtures
   water-soluble compounds used to improve the properties of the fresh concrete
3. Mineral admixtures
   finely divided solids usually added to improve the strength of the hardened concrete

Designation: C260/C260M – 10a (Reapproved 2016)

Standard Specification for Air-Entraining Admixtures for Concrete[1]

This standard is issued under the fixed designation C260/C260M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers materials proposed for use as air-entraining admixtures to be added to concrete mixtures in the field.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

use in the work is essentially identical in concentration, composition, and performance to the air-entraining admixture tested under this specification.

NOTE 1—It is recommended that, whenever practicable, tests with the air-entraining admixture be made using all of the ingredients of the concrete proposed for the specific work, because the effect produced by the air-entraining admixture may vary with the properties of the other ingredients of the concrete.

4.2 Requirements for establishing compositional or chemical equivalence of a subsequent lot relative to a previous lot that was subjected to quality tests and found to comply with the requirements of 5.1 shall be determined if agreed upon by the purchaser and the manufacturer. At the request of the purchaser, the manufacturer shall recommend appropriate test procedures, such as infrared spectrophotometry (I.R.), pH value and solids content, for establishing the equivalence of materials from different lots or different portions of the same lot.

Air Entrainment Goals

tiny air bubbles, uniform in size

uniform dispersion in cement paste

air content = 9% of mortar volume

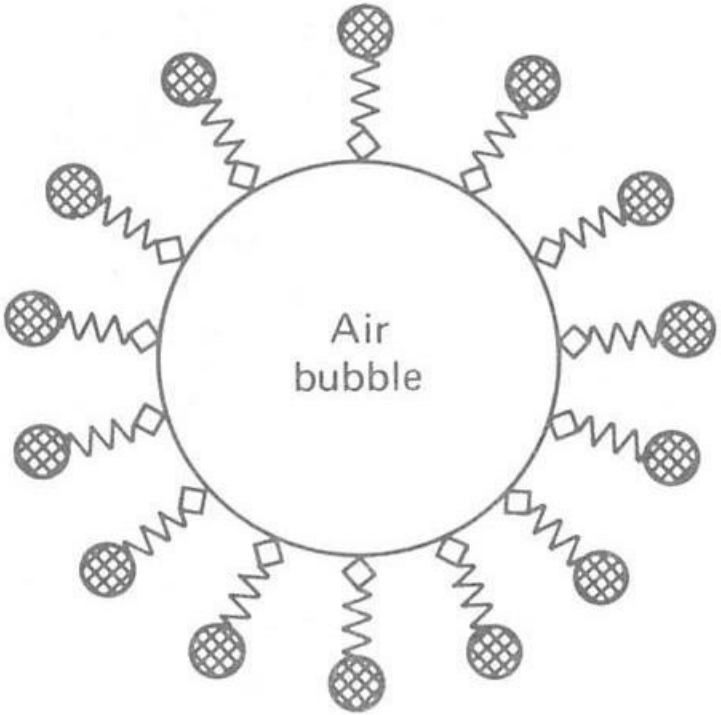
one billion bubbles per cubic yard

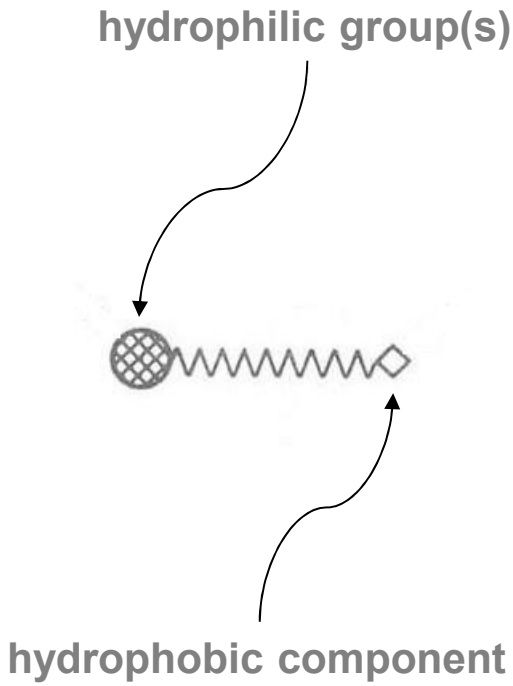
Air Entrainment

In Roman times, ox blood was used to improve durability (though I'm not sure they knew why).

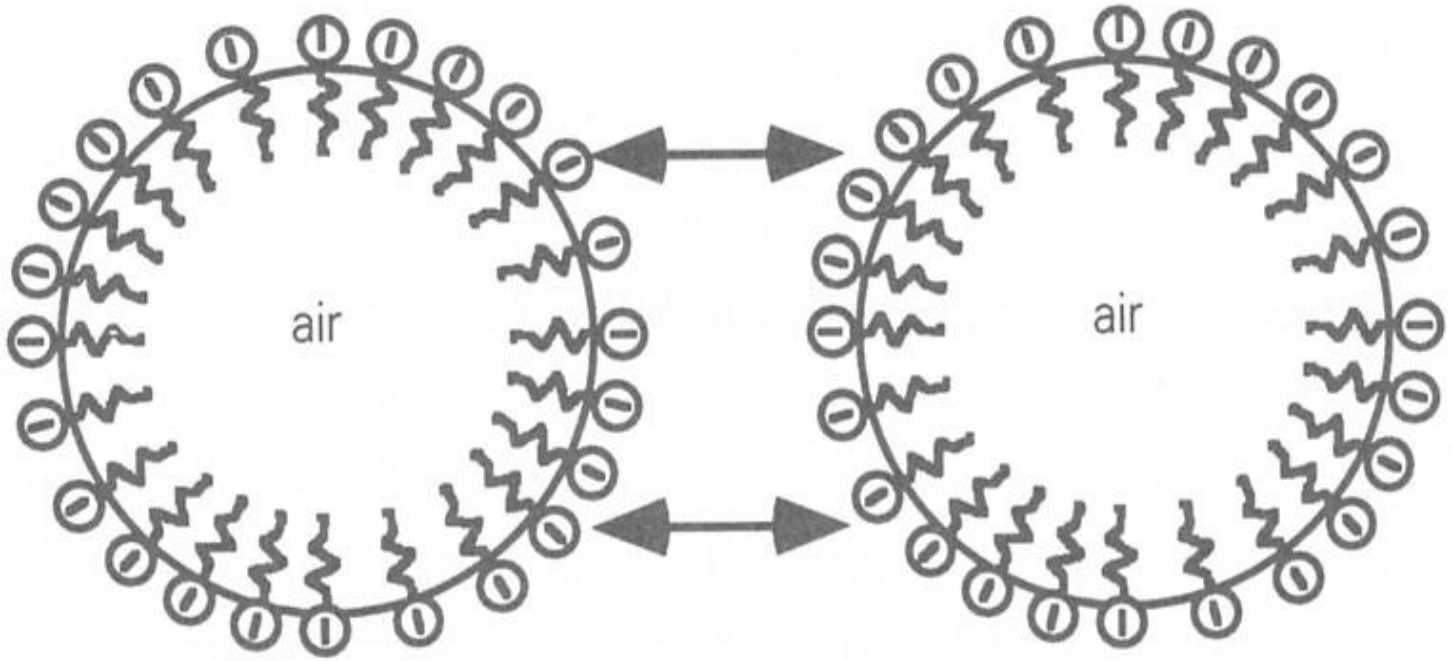
Rediscovery in modern times due to accidental observation that freeze-thaw resistant sections of some roads had been made with cement that had been contaminated with beef tallow added as a grinding aid.

Air Entrainment



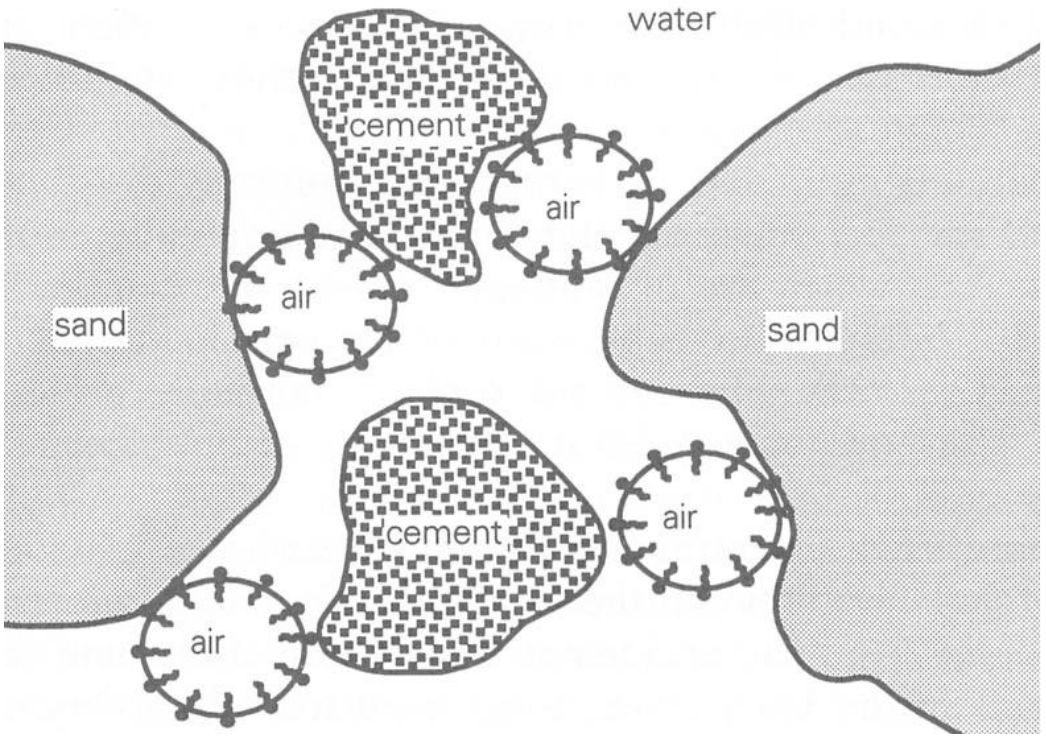


Air Entrainment



Repulsion between negative surface charges prevents coalescence

Air Entrainment



Chemical Admixtures

set accelerators

set retarders

water reducers

stabilizers

Designation: C494/C494M – 17

Standard Specification for Chemical Admixtures for Concrete[1]

This standard is issued under the fixed designation C494/C494M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers materials for use as chemical admixtures to be added to hydraulic-cement concrete mixtures in the field for the purpose or purposes indicated for the eight types as follows:

1.1.1 *Type A*—Water-reducing admixtures,

1.1.2 *Type B*—Retarding admixtures,

1.1.3 *Type C*—Accelerating admixtures,

1.1.4 *Type D*—Water-reducing and retarding admixtures,

1.1.5 *Type E*—Water-reducing and accelerating admixtures,

1.1.6 *Type F*—Water-reducing, high range admixtures,

1.1.7 *Type G*—Water-reducing, high range, and retarding admixtures, and

1.1.8 *Type S*—Specific performance admixtures.

1.2 This specification stipulates tests of an admixture with suitable concreting materials as described in 11.1 – 11.3 or with cement, pozzolan, aggregates, and an air-entraining admixture proposed for specific work (11.4). Unless specified otherwise

NOTE 3—Admixtures that contain relatively large amounts of chloride may accelerate corrosion of prestressing steel. Compliance with the requirements of this specification does not constitute assurance of acceptability of the admixture for use in prestressed concrete.

1.3 This specification provides for three levels of testing.

1.3.1 *Level 1*—During the initial approval stage, proof of compliance with the performance requirements defined in Table 1 demonstrates that the admixture meets the requirements of this specification. Admixtures (except for Types B, C, E, and S) shall qualify for provisional compliance when the physical requirements and any of the alternative compressive strength requirements in Table 1 are met. If subsequent test results at six months or one year fail to meet the standard requirement of 100 % of reference strength, the compliance of the admixture to this standard is withdrawn and all users of the admixture shall be notified immediately. Uniformity and equivalence tests of Section 6 shall be carried out to provide results against which later comparisons can be made (see Note 4).

Chemical Admixtures

- Type A – water reducing
- Type B – retarding
- Type C – accelerating
- Type D – water reducing and retarding
- Type E – water reducing and accelerating
- Type F – high-range water reducing (HRWR)
- Type G – HRWR and retarding
- Type S – specific performance admixtures

Set Accelerators

Typically used in cold weather to reduce setting and curing times; also used to speed removal of formwork

Salts (calcium chloride, sodium chloride) are cheap set accelerators but can corrode rebar and reduce resistance to sulfate attack

Nitrates and nitrites are less effective and more expensive but are also non-corrosive

Set Retarders

Typically used in hot weather to slow setting and curing so concrete can be finished; also used in mass pours to eliminate cold joints

Sugars, starches, and cellulose derivatives are absorbed onto the surface of cement particles to delay hydration of the calcium silicates

As little as 0.05% by mass will delay setting for four hours; 1% prevents setting completely

Stabilizers

Lets leftover concrete be returned to plant and reused the next day

Forms protective barrier around cement grains to prevent hydration of both calcium silicates and calcium aluminates for up to 72 hours

Activator dissolves the protective barrier and lets setting proceed in a normal manner with no harm to the concrete

Water Reducers

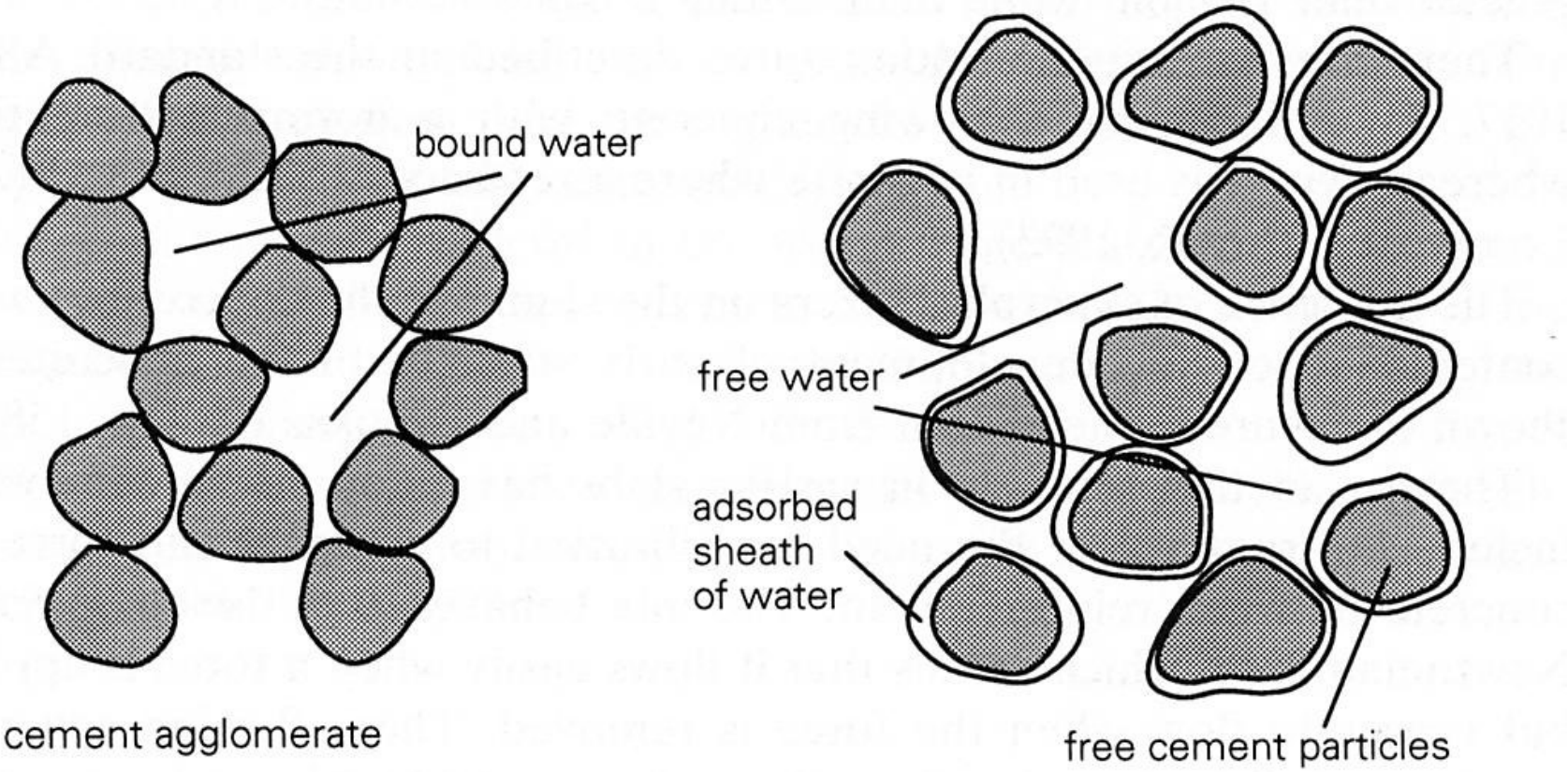
low-range (5-10% reduction)

mid-range (10-15% reduction)

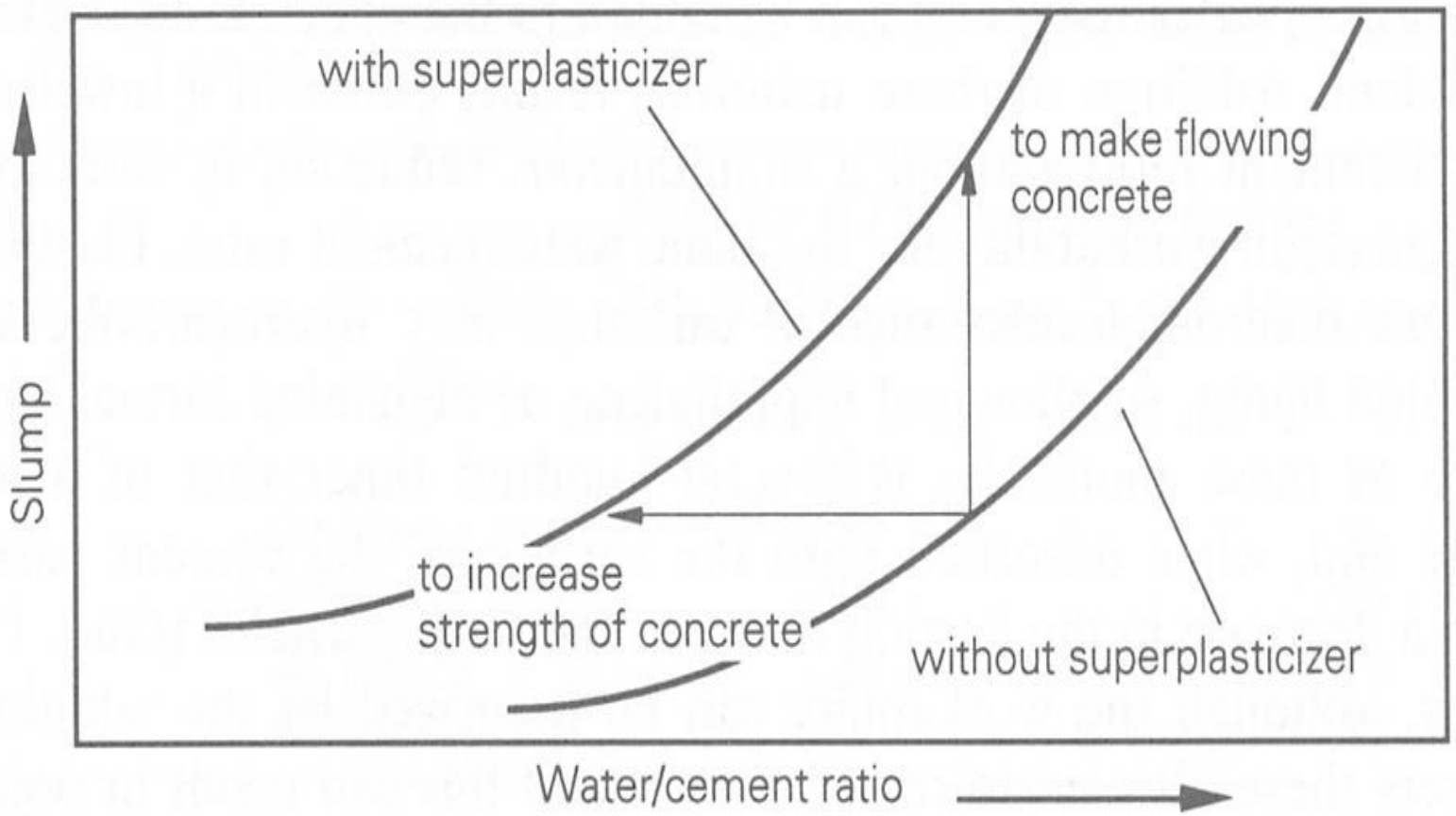
high-range (15-30% reduction)

"superplasticizers"

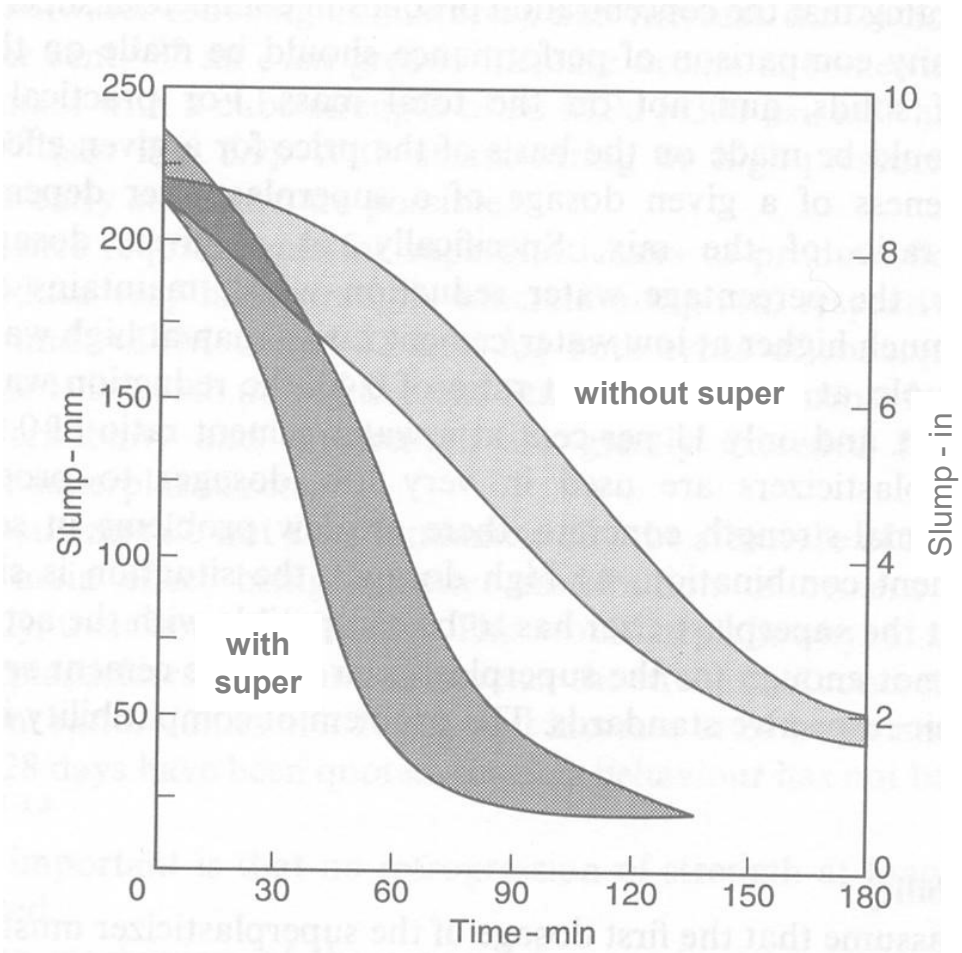
How Water Reducers Work



Using Superplasticizers



Drawback: Slump Loss



Supplementary Cementitious Materials

(Mineral Admixtures)

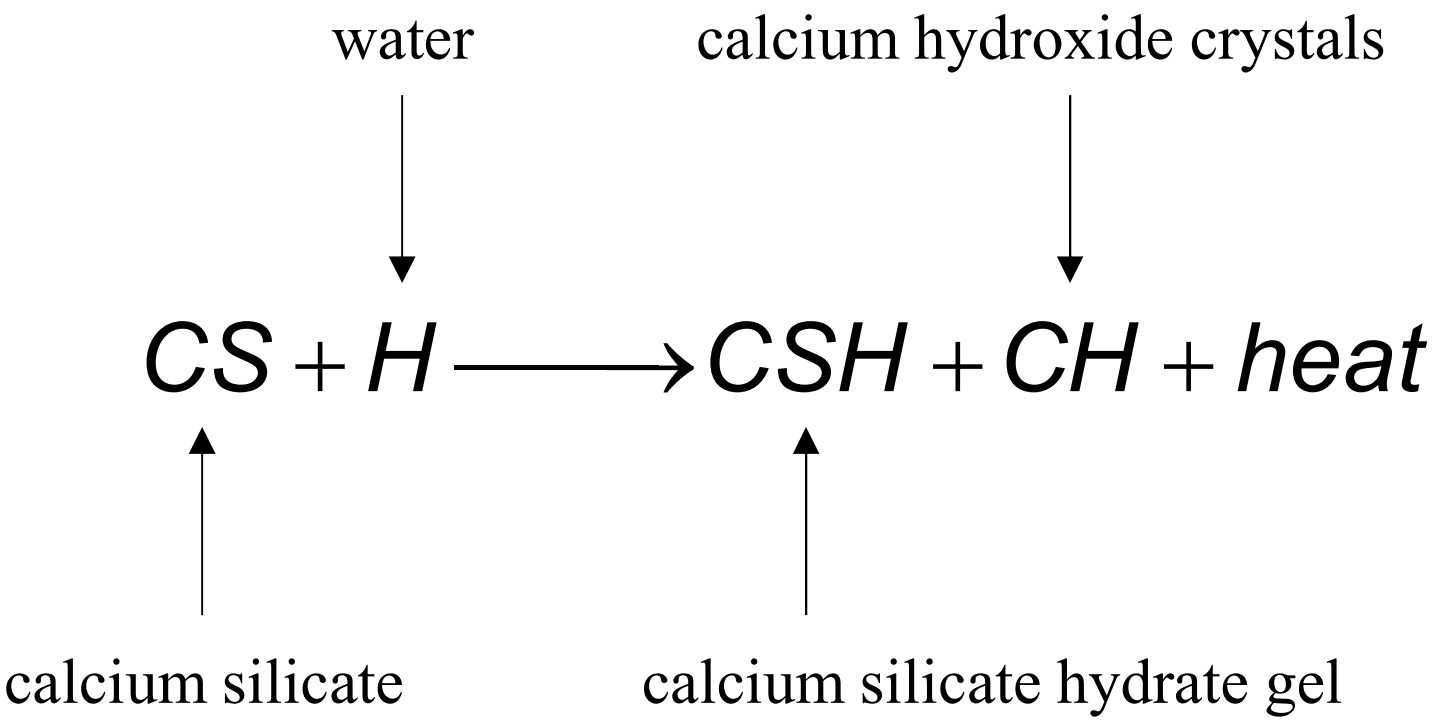
Mineral Admixtures

Natural Pozzalans	Artificial Pozzalans
volcanic ash	fly ash
diatomaceous earth	silica fume
rice husk ash	blast furnace slag
calcined clays (metakaolin)	

Pozzalans

pozzalan (*n*.) siliceous materials which by themselves have little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide (CH) at ordinary temperatures to form compounds (CSH) that have cementing properties.

Hydration Chemistry



True Pozzalans

silicates

(high in SiO_2)

high specific surface

(fine powder)

usually glassy

(no crystals)

usually spherical

Natural Pozzolans

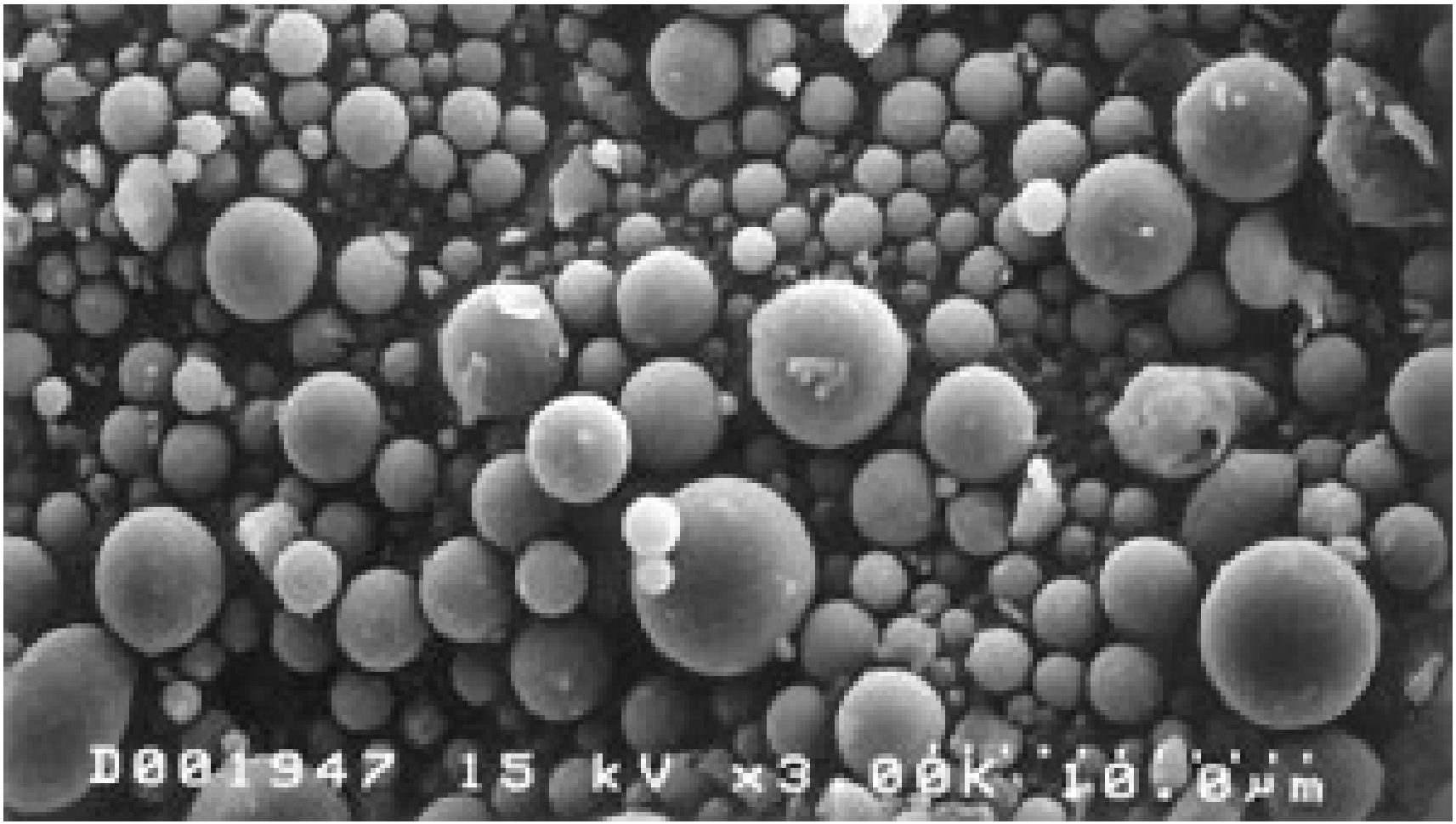
volcanic ash

diatomaceous earth

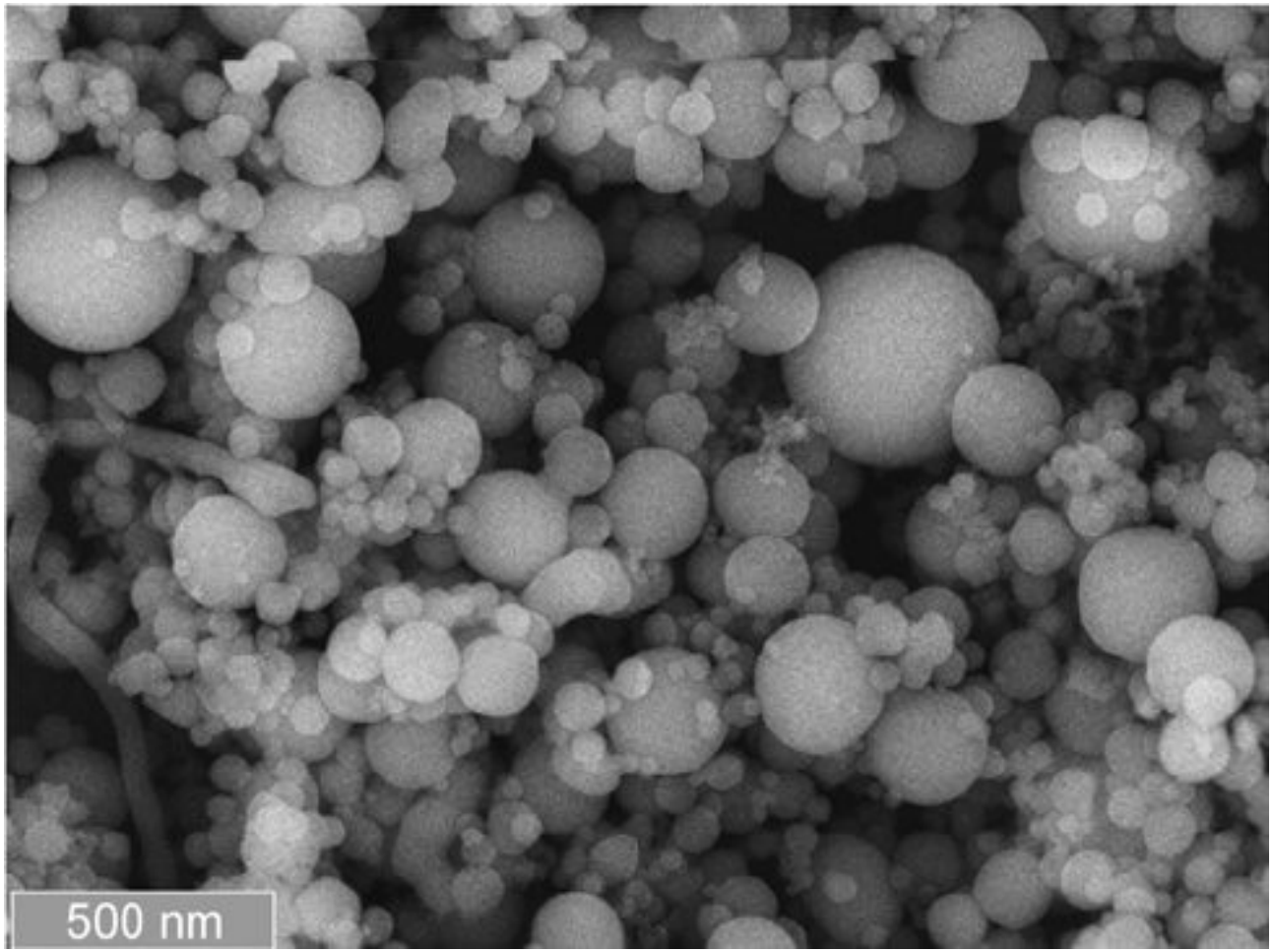
rice husk ash

calcined clay (metakaolin)

Fly Ash



Silica Fume



Uses of Pozzalans

Save money by replacing expensive cement

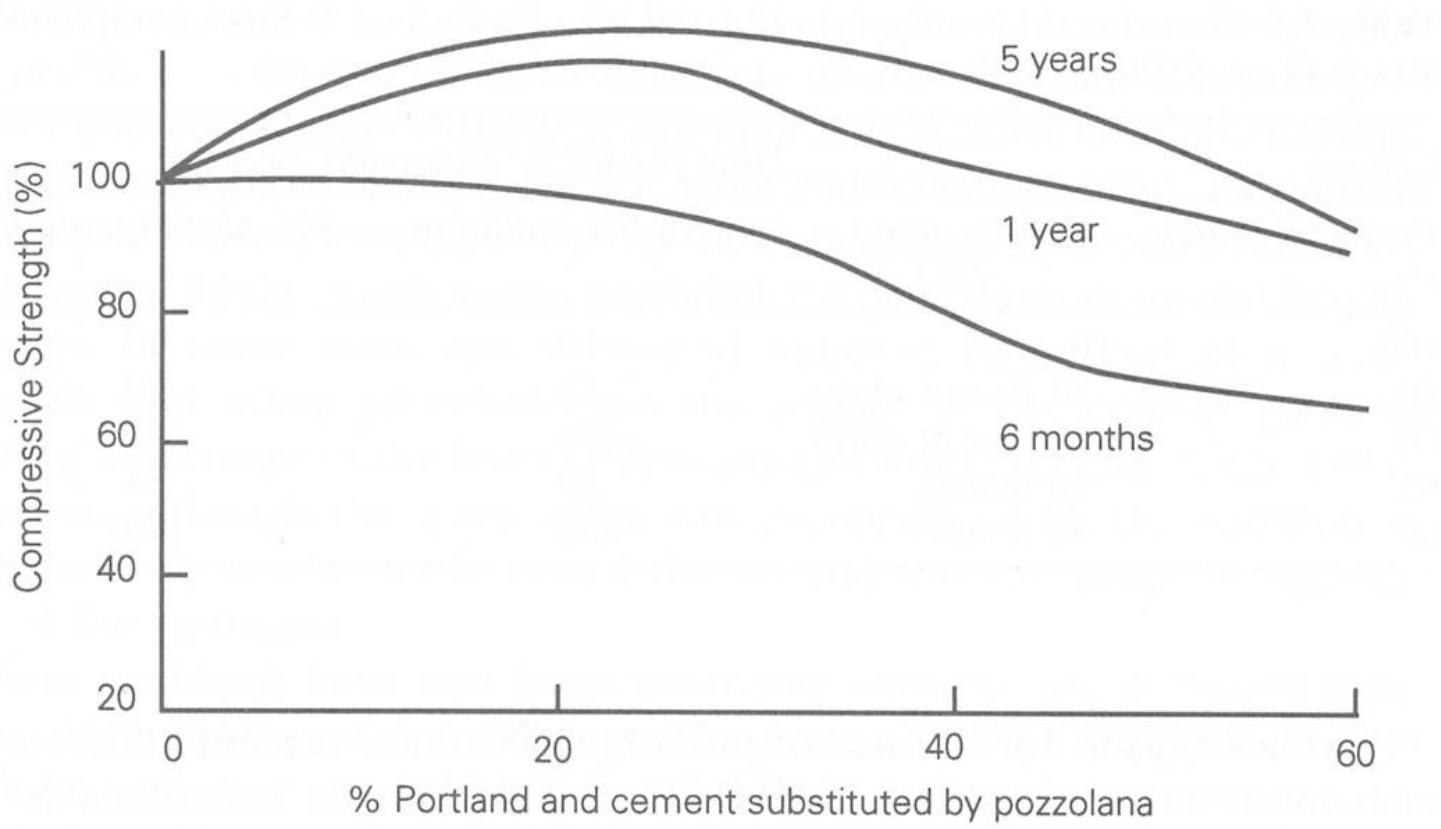
Lower heat of hydration due to slow strength gain

Increase sulfate resistance if low in alumina

Improve workability due to spherical shape

Increase strength by converting CH to CSH

Effects on Strength



Fly Ash

Tiny spheres of glassy silica and alumina that are electrostatically precipitated from exhaust gases given off by coal-fired power plants

Anthracite = Class F fly ash

Lignite = Class C fly ash

Fly Ash

The primary difference between Class C and Class F fly ash is the chemical composition of the ash itself.

Class F fly ash is highly pozzolanic, meaning that it reacts with calcium hydroxide during hydration of the portland cement to form calcium-silicate-hydrate.

Class C fly ash is pozzolanic but also has cementitious properties all by itself.

Blast Furnace Slag

Formed when iron ore, coke and a flux (either limestone or dolomite) are melted together in a blast furnace to produce molten iron

Air cooled slag

Pelletized slag

Granulated slag

Granulated Slag

Granulated slag is rapidly cooled by large quantities of water to produce a sand-like granule that is primarily ground into a cement known as Ground Granulated Blast Furnace Slag (GGBS), or Type S slag cement. It is also mixed with Portland cement clinker to make a blended Type 1S cement.

Granulated Blast Furnace Slag

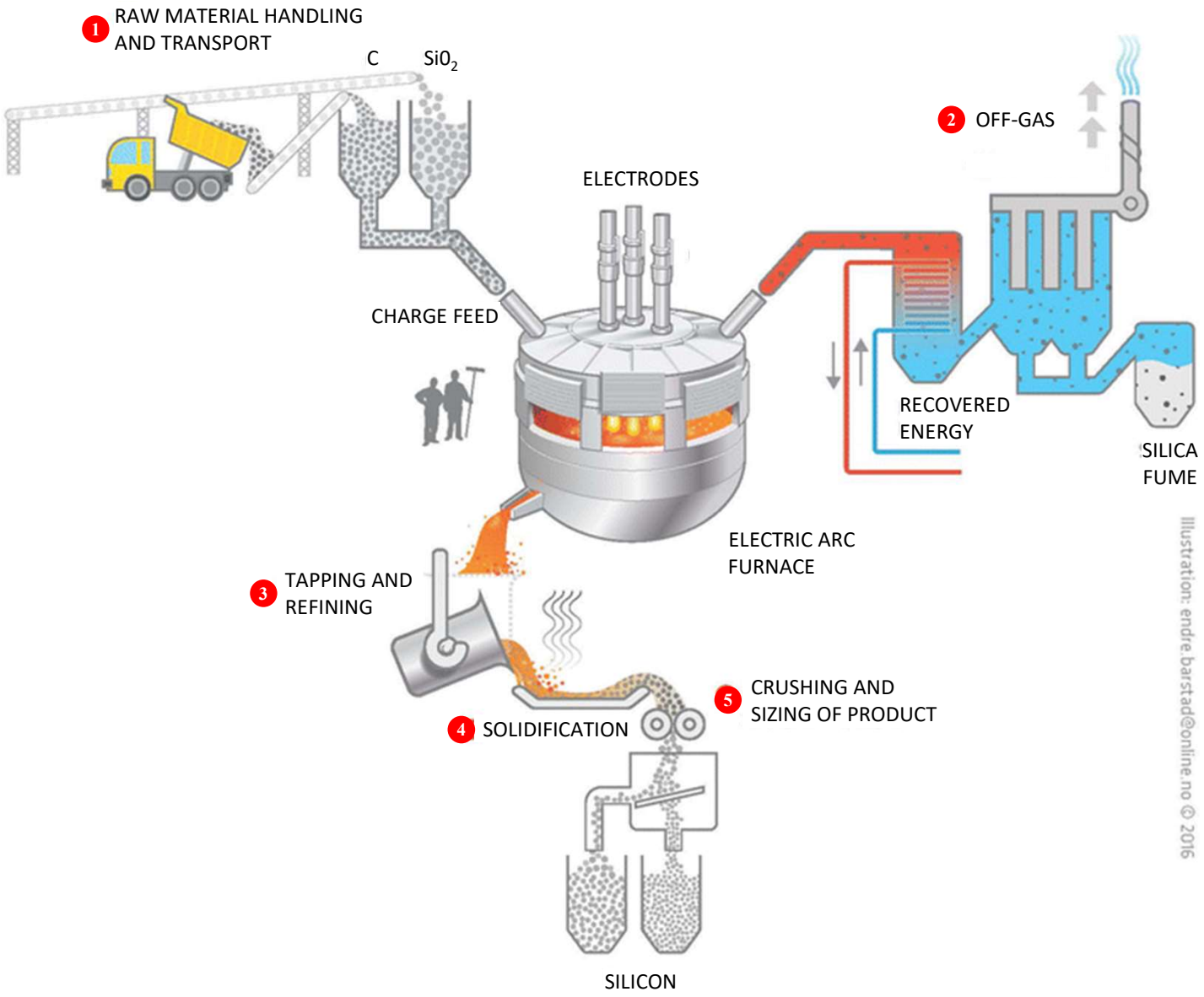
GGBFS

Silica Fume

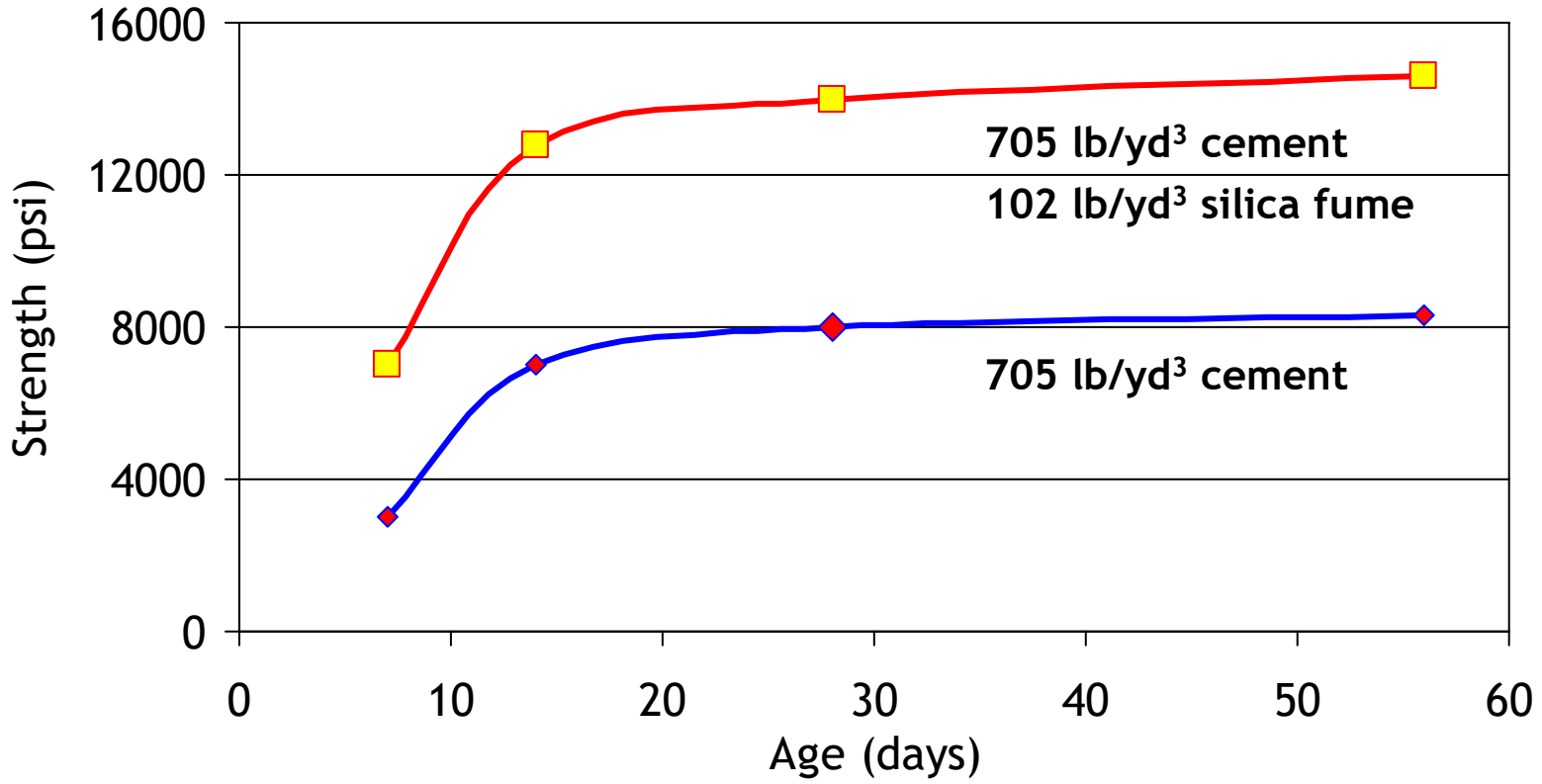
Tiny spheres of glassy silica electrostatically precipitated from exhaust gases given off by electric arc furnaces used to make silicon

Carbon-free = white silica fume

Carbonaceous = black silica fume


1 RAW MATERIAL HANDLING AND TRANSPORT
C
SiO_2
2 OFF-GAS
ELECTRODES
CHARGE FEED
RECOVERED ENERGY
SILICA FUME
ELECTRIC ARC FURNACE
3 TAPPING AND REFINING
5 CRUSHING AND SIZING OF PRODUCT
4 SOLIDIFICATION
SILICON
Illustration: endre.barstad@online.no © 2016

Silica Fume


16000
12000
8000
4000
0
Strength (psi)
0
10
20
30
40
50
60
Age (days)
705 lb/yd³ cement
102 lb/yd³ silica fume
705 lb/yd³ cement