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
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

Air bubble

hydrophilic group(s)

hydrophobic component
Air Entrainment

Repulsion between negative surface charges prevents coalescence
Air Entrainment
Air Entrainment
Chemical Admixtures

set accelerators
set retarders
stabilizers
water reducers
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
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%)
mid-range (10-15%)
high-range (15-30%)
“superplasticizers”
Water Reducers

- Bound water
- Free water
- Adsorbed sheath of water
- Free cement particles

Cement agglomerate
Superplasticizers

- With superplasticizer:
  - To increase strength of concrete
  - To make flowing concrete

- Without superplasticizer:

Slump vs. Water/cement ratio graph.
Slump Loss

![Graph showing slump loss over time for concrete with and without superplasticizer]
Supplementary Cementitious Materials
## Mineral Admixtures

<table>
<thead>
<tr>
<th>Natural Pozzalans</th>
<th>Artificial Pozzalans</th>
</tr>
</thead>
<tbody>
<tr>
<td>volcanic ash</td>
<td>fly ash</td>
</tr>
<tr>
<td>diatomaceous earth</td>
<td>silica fume</td>
</tr>
<tr>
<td>burnt clays</td>
<td>blast furnace slag</td>
</tr>
<tr>
<td></td>
<td>burnt rice hulls</td>
</tr>
</tbody>
</table>
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

\[ \text{water} \rightarrow \text{calcium hydroxide crystals} \]

\[ \text{calcium silicate} \rightarrow \text{calcium silicate hydrate gel} \]

\[ CS + H \rightarrow CSH + CH + heat \]
True Pozzalans

silicates

high specific surface

usually spherical

usually glassy
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

![Graph showing the effects on strength over time with curves for 5 years, 1 year, and 6 months. The x-axis represents the percentage of Portland and cement substituted by pozzolana, and the y-axis represents compressive strength in percentage.]
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
Blast Furnaces
Blast Furnace Slag

Diagram of slag production with water jets and rotating drum producing granules and pellets.
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
Silica Fume

Strength (psi) vs. Age (days)

- 705 lb/yd³ cement
- 102 lb/yd³ silica fume
- 705 lb/yd³ cement