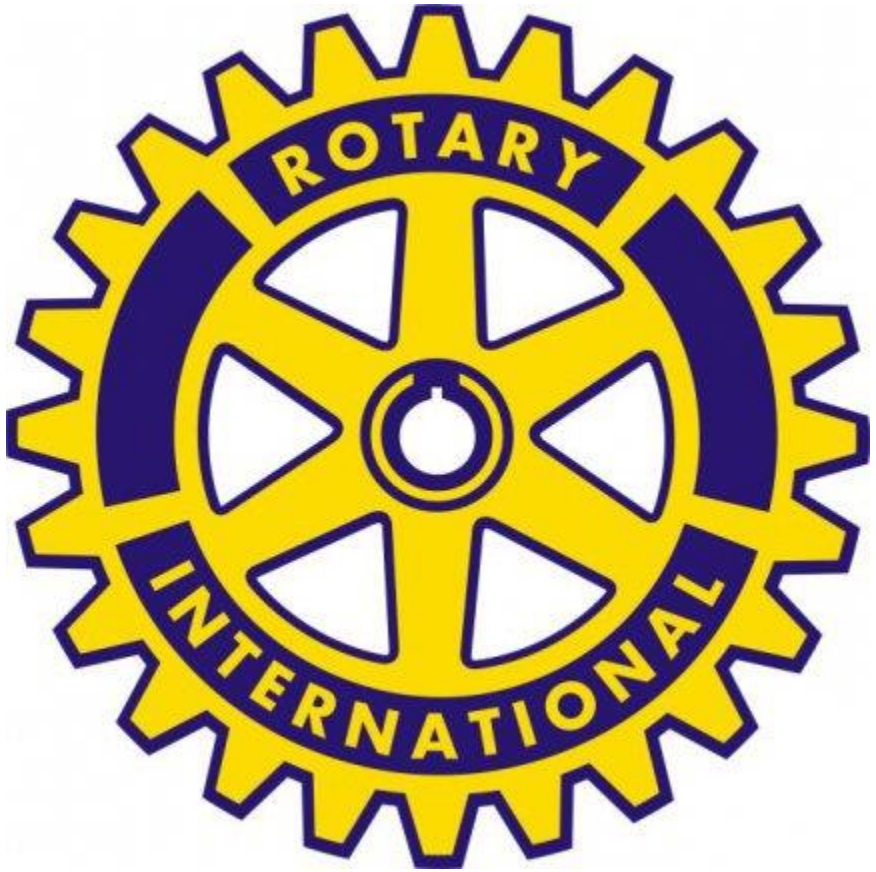
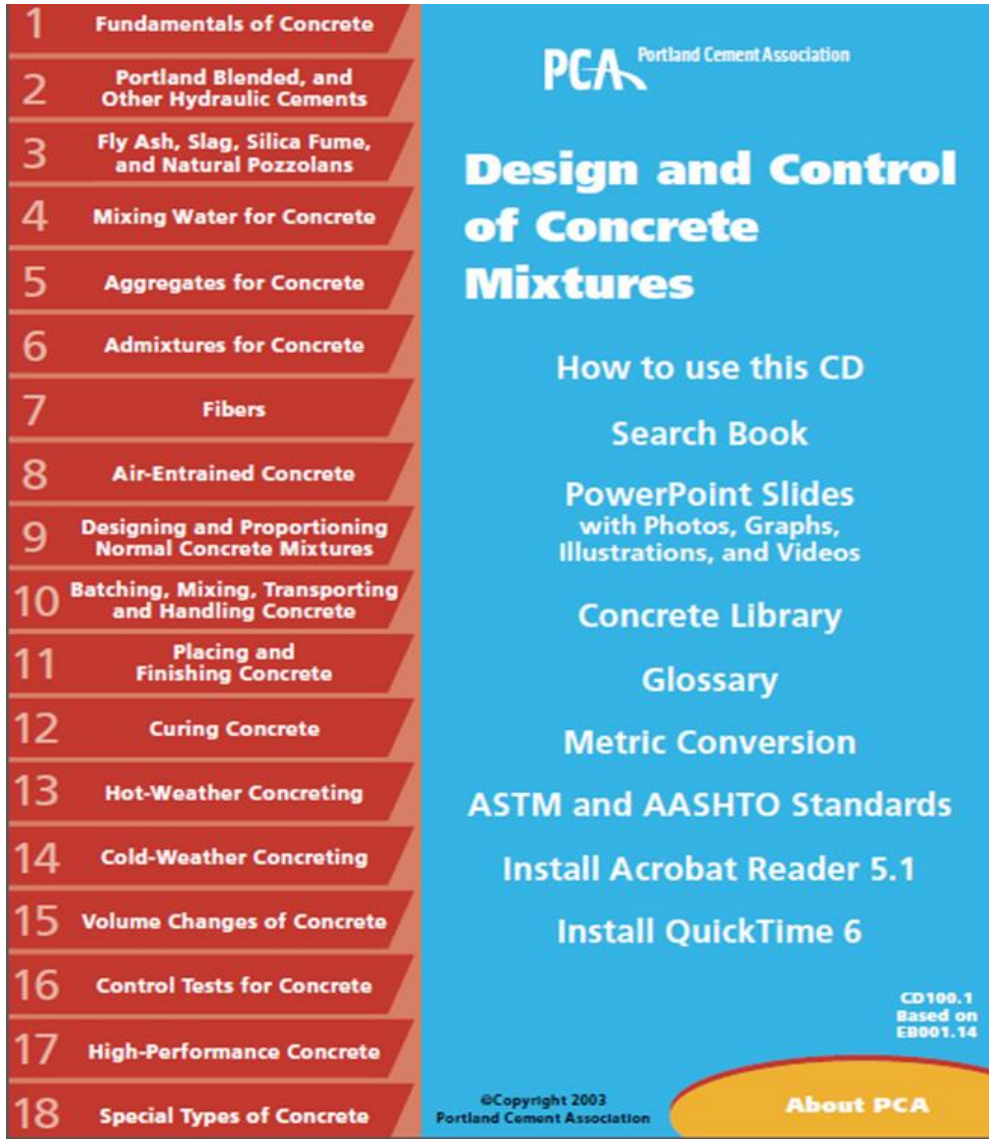

ROTARY
INTERNATIONAL



PCA

Portland Cement Association

Rotary

Club Rotario de
Lomas de Cocoyoc

Tecnología de Concreto:
Academia del Concreto

www.concretovirtual.com

- Cemento
  - Otros cementantes
- Agua
- Agregados finos
- Agregados gruesos

- Aire
- Aditivos
  - Otros materiales suplementarios

- Tecnología de Concreto 101
  - Cemento
  - Agregados
  - Concretos
- Interacciones de los Aditivos en el Concreto
  - Retardantes / Acelerantes / Inclusores de Aire
  - Reductores de Agua / Superplastificantes / Polifuncionales
  - Impermeabilización / Inhibidores de Corrosión / Nuevas Tecnologías
- Formulación de Aditivos para Concreto
  - Acido Glucónico / Glucosa / Melaza
  - Trietanolamina / Tiocianato de Sodio / Nitrato de Calcio / Cloruro de Calcio
  - Resina de Vinsol / Agentes Espumantes
  - Gluconato de Sodio / Lignosulfonatos / Melaminas / Naftalenos
  - Nitrito de Calcio / Metil Celulosa / Policarboxilatos
- Diseño de Mezclas de Concreto

Rotary Club Rotario de Lomas de Cocoyoc

Tecnología de Concreto:
Manufactura del cemento

www.concretovirtual.com

Table 2-1. Sources of Raw Materials Used in Manufacture of Portland Cement

Calcium	Iron	Silica	Alumina	Sulfate
Alkali waste	Blast-furnace flue dust	Calcium silicate	Aluminum-ore refuse*	Anhydrite
Aragonite*	Clay*	Cement rock	Bauxite	Calcium sulfate
Calcite*	Iron ore*	Clay*	Cement rock	Gypsum*
Cement-kiln dust	Mill scale*	Fly ash	Clay*	
Cement rock	Ore washings	Fuller's earth	Copper slag	
Chalk	Pyrite cinders	Limestone	Fly ash*	
Clay	Shale	Loess	Fuller's earth	
Fuller's earth		Marl*	Granodiorite	
Limestone*		Ore washings	Limestone	
Marble		Quartzite	Loess	
Marl*		Rice-hull ash	Ore washings	
Seashells		Sand*	Shale*	
Shale*		Sandstone	Slag	
Slag		Shale*	Staurolite	
		Slag		
		Traprock		

Note: Many industrial byproducts have potential as raw materials for the manufacture of portland cement.
*Most common sources.

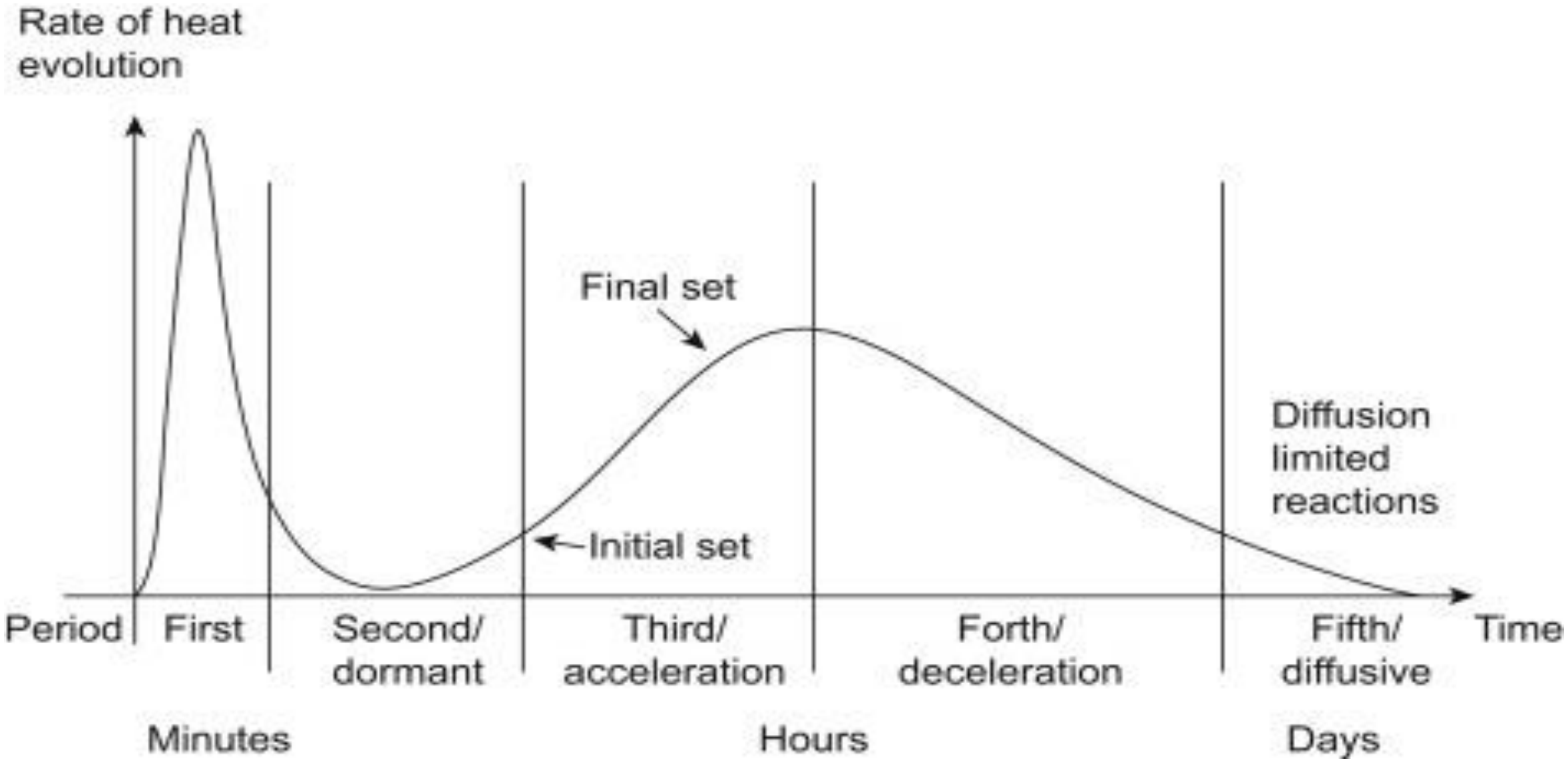

Rate of heat evolution
Final set
Initial set
Diffusion limited reactions
Period
First
Second/ dormant
Third/ acceleration
Forth/ deceleration
Fifth/ diffusive
Time
Minutes
Hours
Days

Table 2-3. Applications for Commonly Used Cements

Cement specification	Applications*						
	General purpose	Moderate heat of hydration	High early strength	Low heat of hydration	Moderate sulfate resistance	High sulfate resistance	Resistance to alkali-silica reactivity (ASR)**
ASTM C 150 (AASHTO M 85) portland cements	I	II (moderate heat option)	III	IV	II	V	Low alkali option
ASTM C 595 (AASHTO M 240) blended hydraulic cements	IS IP I(PM) I(SM) S, P	IS(MH) IP(MH) I(PM)(MH) I(SM)(MH)		P(LH)	IS(MS) IP(MS) P(MS) I(PM)(MS) I(SM)(MS)		Low reactivity option
ASTM C 1157 hydraulic cements***	GU	MH	HE	LH	MS	HS	Option R

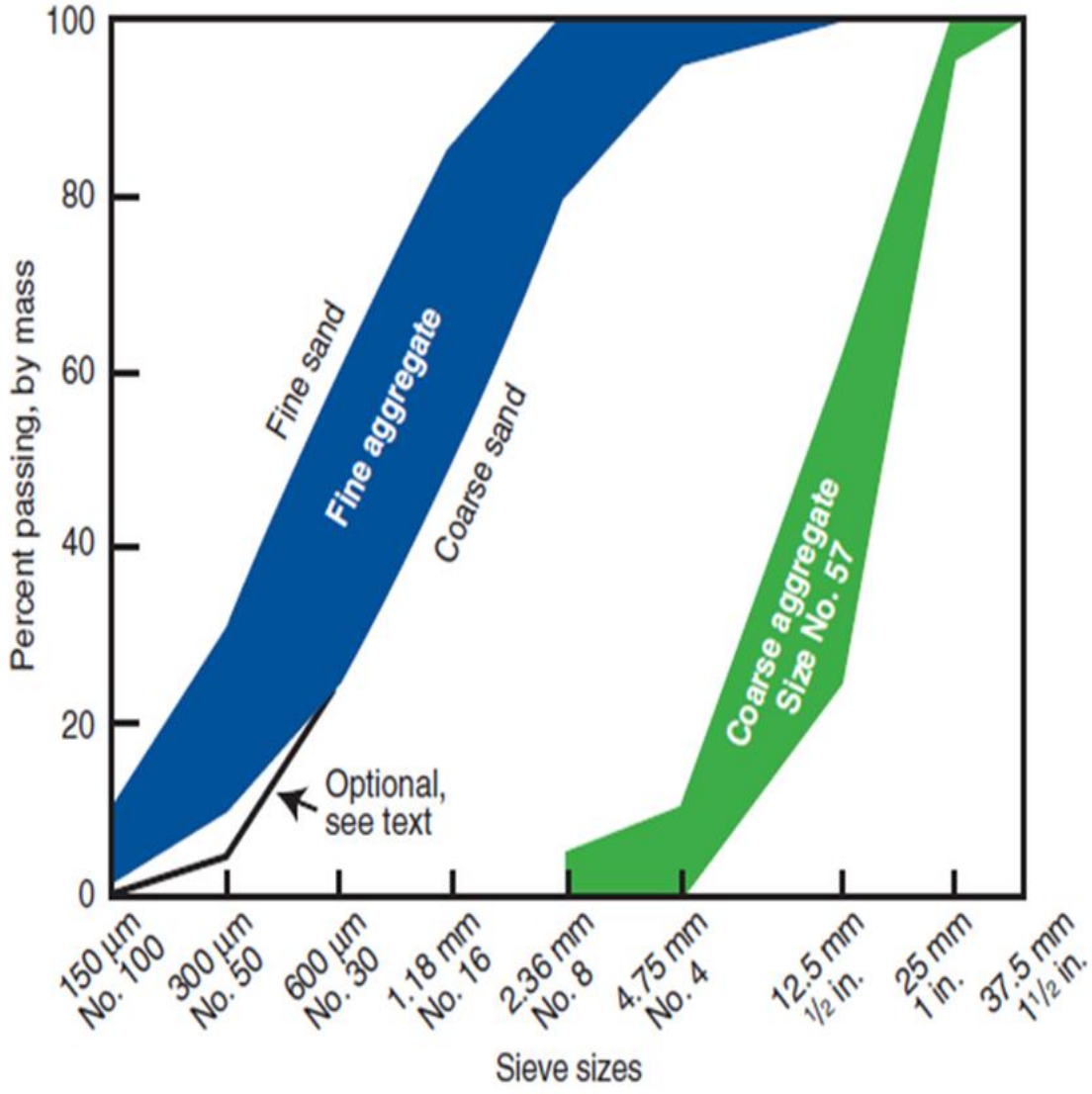
Table 2-5. Portland Cement Compound Hydration Reactions (Oxide Notation)

$2\ (3CaO{\bullet}SiO_2)$ Tricalcium silicate	$+\ 11\ H_2O$ Water	$=\ 3CaO{\bullet}2SiO_2{\bullet}8H_2O$ Calcium silicate hydrate (C-S-H)	$+\ 3\ (CaO{\bullet}H_2O)$ Calcium hydroxide
$2\ (2CaO{\bullet}SiO_2)$ Dicalcium silicate	$+\ 9\ H_2O$ Water	$=\ 3CaO{\bullet}2SiO_2{\bullet}8H_2O$ Calcium silicate hydrate (C-S-H)	$+\ CaO{\bullet}H_2O$ Calcium hydroxide
$3CaO{\bullet}Al_2O_3$ Tricalcium aluminate	$+\ 3\ (CaO{\bullet}SO_3{\bullet}2H_2O)$ Gypsum	$+\ 26\ H_2O$ Water	$=\ 6CaO{\bullet}Al_2O_3{\bullet}3SO_3{\bullet}32H_2O$ Ettringite
$2\ (3CaO{\bullet}Al_2O_3)$ Tricalcium aluminate	$+\ 6CaO{\bullet}Al_2O_3{\bullet}3SO_3{\bullet}32H_2O$ Ettringite	$+\ 4\ H_2O$ Water	$=\ 3\ (4CaO{\bullet}Al_2O_3{\bullet}SO_3{\bullet}12H_2O)$ Calcium monosulfoaluminate
$3CaO{\bullet}Al_2O_3$ Tricalcium aluminate	$+\ CaO{\bullet}H_2O$ Calcium hydroxide	$+\ 12\ H_2O$ Water	$=\ 4CaO{\bullet}Al_2O_3{\bullet}13H_2O$ Tetracalcium aluminate hydrate
$4CaO{\bullet}\ Al_2O_3{\bullet}Fe_2O_3$ Tetracalcium aluminoferrite	$+\ 10\ H_2O$ Water	$+\ 2\ (CaO{\bullet}H_2O)$ Calcium hydroxide	$=\ 6CaO{\bullet}Al_2O_3{\bullet}Fe_2O_3{\bullet}12H_2O$ Calcium aluminoferrite hydrate

Table 2-6. Chemical and Compound Composition and Fineness of Cements*

Type of portland cement	Chemical composition, %							Potential compound composition,%				Blaine fineness, m^2/kg
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O eq	C_3S	C_2S	C_3A	C_4AF	
I (min-max)	18.7-22.0	4.7-6.3	1.6-4.4	60.6-66.3	0.7-4.2	1.8-4.6	0.11-1.20	40-63	9-31	6-14	5-13	300-421
I (mean)	20.5	5.4	2.6	63.9	2.1	3.0	0.61	54	18	10	8	369
II** (min-max)	20.0-23.2	3.4-5.5	2.4-4.8	60.2-65.9	0.6-4.8	2.1-4.0	0.05-1.12	37-68	6-32	2-8	7-15	318-480
II** (mean)	21.2	4.6	3.5	63.8	2.1	2.7	0.51	55	19	6	11	377
III (min-max)	18.6-22.2	2.8-6.3	1.3-4.9	60.6-65.9	0.6-4.6	2.5-4.6	0.14-1.20	46-71	4-27	0-13	4-14	390-644
III (mean)	20.6	4.9	2.8	63.4	2.2	3.5	0.56	55	17	9	8	548
IV (min-max)	21.5-22.8	3.5-5.3	3.7-5.9	62.0-63.4	1.0-3.8	1.7-2.5	0.29-0.42	37-49	27-36	3-4	11-18	319-362
IV (mean)	22.2	4.6	5.0	62.5	1.9	2.2	0.36	42	32	4	15	340
V (min-max)	20.3-23.4	2.4-5.5	3.2-6.1	61.8-66.3	0.6-4.6	1.8-3.6	0.24-0.76	43-70	11-31	0-5	10-19	275-430
V (mean)	21.9	3.9	4.2	63.8	2.2	2.3	0.48	54	22	4	13	373
White (min-max)	22.0-24.4	2.2-5.0	0.2-0.6	63.9-68.7	0.3-1.4	2.3-3.1	0.09-0.38	51-72	9-25	5-13	1-2	384-564
White (mean)	22.7	4.1	0.3	66.7	0.9	2.7	0.18	63	18	10	1	482


State
Ovendry
Air dry
Saturated, surface dry
Damp or wet
Total moisture:
None
Less than potential absorption
Equal to potential absorption
Greater than absorption


Percent passing, by mass
100
80
60
40
20
0
Fine sand
Fine aggregate
Coarse sand
Coarse aggregate Size No. 57
Optional, see text
150 µm No. 100
300 µm No. 50
600 µm No. 30
1.18 mm No. 16
2.36 mm No. 8
4.75 mm No. 4
12.5 mm ½ in.
25 mm 1 in.
37.5 mm 1½ in.
Sieve sizes

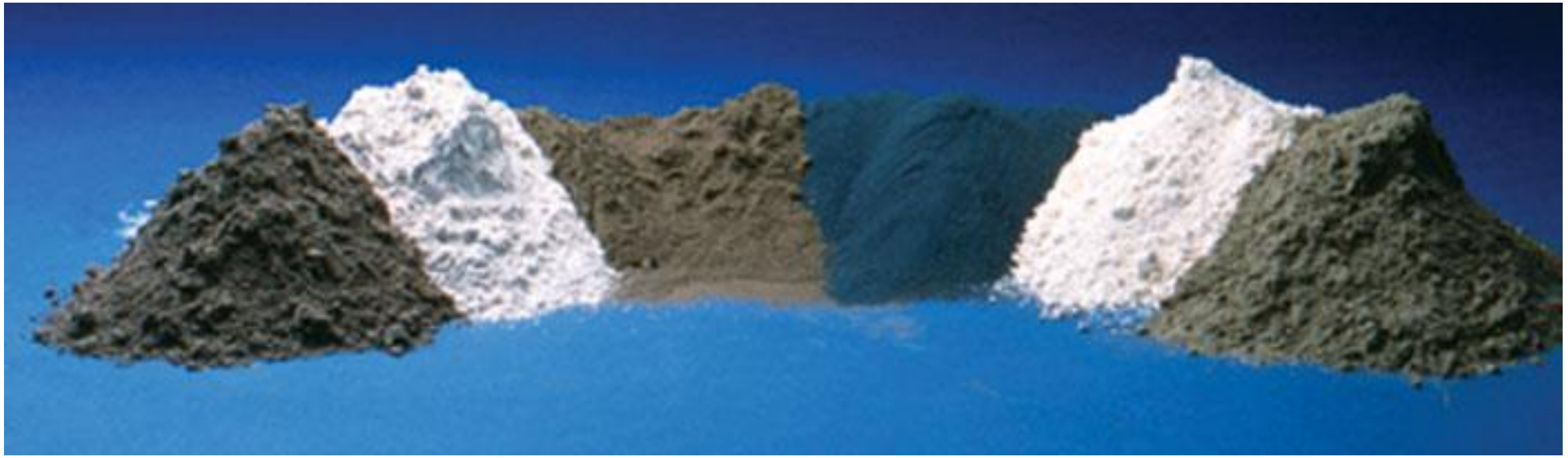


Table 6-1. Concrete Admixtures by Classification

Type of admixture	Desired effect	Material
Accelerators (ASTM C 494 and AASHTO M 194, Type C)	Accelerate setting and early-strength development	Calcium chloride (ASTM D 98 and AASHTO M 144) Triethanolamine, sodium thiocyanate, calcium formate, calcium nitrite, calcium nitrate
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, octyl alcohol, water-insoluble esters of carbonic and boric acid, silicones
Air-entraining admixtures (ASTM C 260 and AASHTO M 154)	Improve durability in freeze-thaw, deicer, sulfate, and alkali-reactive environments Improve workability	Salts of wood resins (Vinsol resin), some synthetic detergents, salts of sulfonated lignin, salts of petroleum acids, salts of proteinaceous material, fatty and resinous acids and their salts, alkylbenzene sulfonates, salts of sulfonated hydrocarbons
Alkali-aggregate reactivity inhibitors	Reduce alkali-aggregate reactivity expansion	Barium salts, lithium nitrate, lithium carbonate, lithium hydroxide
Antiwashout admixtures	Cohesive concrete for underwater placements	Cellulose, acrylic polymer
Bonding admixtures	Increase bond strength	Polyvinyl chloride, polyvinyl acetate, acrylics, butadiene-styrene copolymers
Coloring admixtures (ASTM C 979)	Colored concrete	Modified carbon black, iron oxide, phthalocyanine, umber, chromium oxide, titanium oxide, cobalt blue
Corrosion inhibitors	Reduce steel corrosion activity in a chloride-laden environment	Calcium nitrite, sodium nitrite, sodium benzoate, certain phosphates or fluosilicates, fluoaluminates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium or ammonium stearate or oleate Butyl stearate Petroleum products
Foaming agents	Produce lightweight, foamed concrete with low density	Cationic and anionic surfactants Hydrolized protein
Fungicides, germicides, and insecticides	Inhibit or control bacterial and fungal growth	Polyhalogenated phenols Dieldrin emulsions Copper compounds
Gas formers	Cause expansion before setting	Aluminum powder
Grouting admixtures	Adjust grout properties for specific applications	See Air-entraining admixtures, Accelerators, Retarders, and Water reducers
Hydration control admixtures	Suspend and reactivate cement hydration with stabilizer and activator	Carboxylic acids Phosphorus-containing organic acid salts
Permeability reducers	Decrease permeability	Latex Calcium stearate
Pumping aids	Improve pumpability	Organic and synthetic polymers Organic flocculents Organic emulsions of paraffin, coal tar, asphalt, acrylics Bentonite and pyrogenic silicas Hydrated lime (ASTM C 141)
Retarders (ASTM C 494 and AASHTO M 194, Type B)	Retard setting time	Lignin Borax Sugars Tartaric acid and salts
Shrinkage reducers	Reduce drying shrinkage	Polyoxyalkylene alkyl ether Propylene glycol
Superplasticizers* (ASTM C 1017, Type 1)	Increase flowability of concrete Reduce water-cement ratio	Sulfonated melamine formaldehyde condensates Sulfonated naphthalene formaldehyde condensates Lignosulfonates Polycarboxylates

Table 6-1. Concrete Admixtures by Classification (Continued)

Type of admixture	Desired effect	Material
Superplasticizer* and retarder (ASTM C 1017, Type 2)	Increase flowability with retarded set Reduce water–cement ratio	See superplasticizers and also water reducers
Water reducer (ASTM C 494 and AASHTO M 194, Type A)	Reduce water content at least 5%	Lignosulfonates Hydroxylated carboxylic acids Carbohydrates (Also tend to retard set so accelerator is often added)
Water reducer and accelerator (ASTM C 494 and AASHTO M 194, Type E)	Reduce water content (minimum 5%) and accelerate set	See water reducer, Type A (accelerator is added)
Water reducer and retarder (ASTM C 494 and AASHTO M 194, Type D)	Reduce water content (minimum 5%) and retard set	See water reducer, Type A (retarder is added)
Water reducer—high range (ASTM C 494 and AASHTO M 194, Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer—high range—and retarder (ASTM C 494 and AASHTO M 194, Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and also water reducers
Water reducer—mid range	Reduce water content (between 6 and 12%) without retarding	Lignosulfonates Polycarboxylates

Table 18-1. Some Special Types of Concrete

Special types of concrete made with portland cement		
Architectural concrete	Heavyweight concrete	Recycled concrete
Autoclaved cellular concrete	High-early-strength concrete	Roller-compacted concrete
Centrifugally cast concrete	High-performance concrete	Sawdust concrete
Colloidal concrete	High-strength concrete	Self-compacting concrete
Colored concrete	Insulating concrete	Shielding concrete
Controlled-density fill	Latex-modified concrete	Shotcrete
Cyclopean (rubble) concrete	Low-density concrete	Shrinkage-compensating concrete
Dry-packed concrete	Mass concrete	Silica-fume concrete
Epoxy-modified concrete	Moderate-strength lightweight concrete	Soil-cement
Exposed-aggregate concrete	Nailable concrete	Stamped concrete
Ferrocement	No-slump concrete	Structural lightweight concrete
Fiber concrete	Polymer-modified concrete	Superplasticized concrete
Fill concrete	Pervious (porous) concrete	Terrazzo
Flowable fill	Pozzolan concrete	Tremie concrete
Flowing concrete	Precast concrete	Vacuum-treated concrete
Fly-ash concrete	Prepacked concrete	Vermiculite concrete
Gap-graded concrete	Preplaced aggregate concrete	White concrete
Geopolymer concrete	Reactive-powder concrete	Zero-slump concrete
Special types of concrete not using portland cement		
Acrylic concrete	Furan concrete	Polyester concrete
Aluminum phosphate concrete	Gypsum concrete	Polymer concrete
Asphalt concrete	Latex concrete	Potassium silicate concrete
Calcium aluminate concrete	Magnesium phosphate concrete	Sodium silicate concrete
Epoxy concrete	Methyl methacrylate (MMA) concrete	Sulfur concrete