



Admixtures for Concrete

An Online Continuing Education Course for Engineers

Course Number: C-1031

Credit: 1 Hour / 1 PDH / 1 CPD

ADMIXTURES FOR CONCRETE

1. Definition

Concrete is essentially made from five materials.

1. Air
2. Water
3. Cement 1+2+3=paste
4. Fine aggregate 1+2+3+4=grout or mortar
5. Course aggregate 1+2+3+4+5=concrete

An *admixture* is a material added to the batch of concrete before or during its mixing to modify its freshly mixed, setting, or hardened properties. About 80% of concrete produced in North America has one or more admixtures. About 40% of ready-mix producers use fly ash. About 70% of concrete produced contains a water-reducer admixture. One or more admixtures can be added to a mix to achieve the desired results.

2. History

We don't know exactly when the use of admixtures began. We do know that certain civilizations used admixtures.

1. Romans
 - a. Milk, lard, blood
2. Europe – middle ages
 - a. Eggs
3. Chinese
 - a. Rice paste, lacquer, tung oil, molasses, boiled bananas
4. Mesoamerica and Peru
 - a. Cactus juice, latex
5. Mayans
 - a. Bark extracts

3. Standards

There are two main standards from three different organizations.

Air-Entraining Admixtures	ASTM C 260
Standard Specification for Air-Entraining Admixture for Concrete	AASHTO M 154
Standard Specification for Air-Entraining Admixture for Concrete	CRD-C 13
Chemical Admixtures	ASTM C 494
Standard Specification for Chemical Admixture for Concrete	AASHTO M 194
Standard Specification for Chemical Admixture for Concrete	CRD-C 87

4. Functions

The reasons to use admixtures are:

- Increase slump and workability;
- Retard or accelerate initial setting;
- Reduce or prevent shrinkage;
- Modify the rate or capacity for bleeding;
- Reduce segregation;
- Improve pumpability and finish ability;
- Retard or reduce heat evolution during early hardening;
- Accelerate the rate of strength development at early ages;
- Increase strength (compressive, tensile, or flexural);
- Increase durability or resistance to severe conditions of exposure, including application of deicing salts and other chemicals (air-entraining);
- Decrease permeability of concrete;
- Control expansion caused by the reaction of alkalis with potentially reactive aggregate constituents;
- Increase bond of concrete to steel reinforcement (bonding);
- Increase bond between existing and new concrete;
- Improve impact and abrasion resistance (hardness);
- Inhibit corrosion of embedded metal;
- Gas-forming;
- Anti-washout;
- Foaming; and
- Produce colored concrete.

5. Groups

There are two main groups of admixtures.

1. *Chemical*
2. *Mineral*

5.1 Chemical admixtures

Chemical admixtures reduce the cost of construction, modify the properties of concrete and improve the quality of concrete during mixing, transportation, placing and curing.

1. Air-entrainment
2. Water-reducing
3. Set-retarding
4. Accelerating
5. Super-plasticizers
6. Corrosion-inhibitors
7. Shrinkage-reducers
8. Alkali-silica reactivity reducers

5.1.1 Air-entrainment

Air-entrainment introduces tiny air bubbles in concrete during the mixing process. It helps protect against damage caused by repeated freezing and thawing cycles. It also imparts better workability, improved homogeneity, decreased segregation and decreased bleeding. More than 80% of Portland-cement concrete pavements in the United States contain air-entrained admixtures. Entrapped air, is large air voids, while entrained air, is tiny voids between 10 to 1000 micrometers. The admixture may be a liquid added during batching or a powder blended with the cement.

Some of the most commonly used air-entrainment chemicals are:

- Salts of wood resins
- Synthetic detergents
- Salts of petroleum acids
- Fatty and resinous acids and their salts

Air-entrainment admixtures should be required to conform to ASTM C 260. Air voids should not have a *spacing factor* larger than 0.2 mm. (0.008 in.). The *spacing factor* represents the maximum distance that water would have to move before reaching the air void. The *specific surface* should be greater than 24 mm²/mm³ (600 in.²/in.³). The *specific surface* represents the surface area of the air voids in concrete per unit volume of air. When you increase the air content of concrete by about 1%, you decrease the compressive strength by about 5%.

Dosage rates generally range from 15 to 130 ml per 100 kg (¼ to 2 fl oz. per 100 lb) of cement material. Typical air entrainment ranges from about 5% to 8% of the volume of concrete (see table below). A test for entrained air content should be performed before placing the concrete in the forms. The test for air-content should be performed per ASTM C 231 and ASTM C 173. The Standard Test Method for Air-entrained Admixtures is ASTM C 233.

Recommended air contents for concrete exposed to freezing and thawing (ACI 201.2R)

Normal maximum aggregate size, mm (in.)	Average air content, percent*	
	Severe exposure†	Moderate exposure‡
9.5 (3/8)	7-1/2	6
12.5 (1/2)	7	5-1/2
19 (3/4)	6	5
25 (1)	6	4-1/2
37.5 (1-1/2)	5-1/2	4-1/2

* A reasonable tolerance for air content if field construction is $\pm 1-1/2\%$.

† Severe exposure—Outdoor exposure in a cold climate where the concrete may be in almost continuous contact with moisture before freezing and where deicing compounds are used. Examples are pavements, bridge decks, and sidewalks.

‡ Moderate exposure—Outdoor exposure in a cold climate where the concrete will be only occasionally exposed to moisture before freezing and where no deicing compounds will be used. Examples are certain exterior walls, beams, bridge decks, and slabs not in direct contact with soil.

Steel troweling of air-entrained slabs can result in surface scaling. The maximum total air-content for interior steel-troweled slabs should be 3%.

Air content will increase as cement alkali levels increase. The more median sand there is in the total aggregate, the greater the air content. Median sand ranging from the No. 30 sieve to the No. 100 is the most effective at entraining air. Excessive fines below No. 100 sieve cause a reduction in air content. Adding calcium chloride will slightly increase air content. Some super-plasticizers or high-range water reducers (HRWR) interact with cement and air-entraining admixtures. The result is a reduction in *specific surfaces* and an increase in *spacing factor*. *Mineral admixtures* have some effect on the use of air-entrainment admixtures. In mixes containing fly ash, you may need more air-entrainment admixtures to produce the same air content in a mix without fly ash. Silica fume seems to have no detrimental effect on the air-void system. Air entrainment varies inversely with temperature. When the temperature goes up, the air entrained goes down.

Air-entraining admixtures should be specified when concrete is exposed to freezing and thawing conditions, deicing salts, or sulfate attack. Air-entraining admixtures are compatible with most other admixtures.

Euclid Chemical Company

- AEA-92
- Air Mix 200

Fox Industries

- FX-340

BASF

- Micro Air 905
- Micro Air 940

5.1.2 Water reducing

Water-reducing admixtures are added to obtain certain workability (slump) at a lower water-cement ratio (w/c). The slump can be reduced by about 1 to 2 inches without the addition of water. For a given air content, concrete strength is inversely proportional to the water-cement ratio. The reduction in water needed to obtain the desired slump will increase the strength. These admixtures can reduce the amount of water required by 20% to 30%. The compressive strength may increase as much as 25%, and the flexural strength may increase as much as 10%. They are used to improve the quality of the concrete and to obtain certain strength at lower cement content. Water reducers are so important in concrete that they could be considered as one of its ingredients. Water reducers are mostly used for hot weather concrete placing and to aid pumping. Water reducers usually cost \$3 to \$5 per cubic yard of concrete. Proper design of the mix is important in the use of this admixture.

ASTM C 494, —Standard Specification for Chemical Admixtures for Concrete, II classifies admixtures into seven types as follows:

Type A Water-reducing admixtures;

Type B Retarding admixtures;

Type C Accelerating admixtures;

Type D Water-reducing and retarding admixture;

Type E Water-reducing and accelerating admixtures;

Type F Water-reducing, high-range admixtures; and

Type G Water-reducing, high-range, and retarding admixtures.

To be classified as a Type A admixture, a minimum water reduction of 5% must be obtained. Other requirements for all types are setting times, compressive and flexural strengths, drying shrinkage, and freezing-and-thawing resistance.

The basic ingredients in all types are:

1. Lignosulfonic acids and their salts;
2. Hydroxylated polymers;
3. Hydroxylated carboxylic acids (HC) and their salts;
4. Sulfonated melamine or naphthalene formaldehyde condensates; and
5. Polyether-polycarboxylates.

Salts of lignosulfonic acids-based admixtures:

- Provide excellent water reduction;
- Produce good concrete mixture;
- Tend to entrain air (1-2%); and
- Can produce sticky, hard-to-finish concrete.

Hydroxylated polymer admixtures:

- Improved mobility of the concrete,
- Improved workability;
- Easier placement;
- May reduce segregation;
- May improve the finished appearance and reduce stickiness; Does not entrain air; and
- May improve pumpability.

Hydroxylated carboxylic acid-based admixtures (HC):

- Some promote rapid bleeding; and
- Benefits are the same as hydroxylated polymers.

Type A, water-reducing admixtures

Type A admixtures reduce the amount of water required in the mix for a given slump, produce a higher strength, obtain a specified strength at lower cement content and increase the slump without an increase in water content. They may also improve the properties of concrete containing aggregates that are harsh or poorly graded, or both. Type A admixtures, may be used for concrete that is placed under difficult conditions. They are also useful for concrete placed by means of a pump or tremie.

Type A admixtures will reduce the mixing water content by 5% to 12%. The typical *dosage rate* is from 130 to 390 ml per 100 kg (2 to 6 fl oz. per 100 lb) of cement material.

Euclid Chemical Company

- Eucon A+
- Eucon WR 89

BASF

- Pozzolith 370M
- Pozzolith 370C
- Pozzolith370 PC
- Pozzolith 80
- Pozzolith 322 Ni

Type D, water-reducing and retarding admixtures

The purpose of this admixture is to not only reduce the required water but to offset the unwanted effects of high temperature. As the temperature goes up, the setting time is reduced. Another purpose is to keep the concrete workable during the entire placing and consolidation period.

The benefits of retarding admixtures are:

- Greater flexibility in extending the setting time;
- Prevention of cold joints;
- Aid in finishing in hot weather; and
- Permitting full form deflection before the initial set.

Euclid Chemical Company

- Eucon 91

BASF

- Pozzolith 122Ri
- Pozzolith 300 Ri
- Pozzolith 400 Ri

Type E, water-reducing and accelerating admixtures

Accelerating admixtures are added to shorten the setting time and accelerate early strength development. Some widely used and effective chemicals that accelerate the rate of hardening of concrete mixtures, including calcium chloride, other chlorides, triethanolamine (TEA), silicates, fluorides, alkali hydroxide, nitrites, nitrates, formates, bromides, and thiocyanates.

Calcium chloride is one of the most effective and economical accelerators but causes corrosion of reinforcing steel. There are many limits and guidelines on the use of calcium chloride.

Non-chloride accelerating admixtures containing salts of formates, nitrates, nitrites, and thiocyanates are available. These non-chloride accelerators can be used in cool weather and for sub-freezing protection.

Euclid Chemical Company

- Accleguard 80
- Accelguard 90
- Accelguard NCA
- Acclguard DSA

BASF

- Polyheed 850
- Polyheed 861HE

5.1.3 Set-retarding

Retarding admixtures delays the hydration of cement. They are used to offset high-temperature effects, which decrease setting times. Set retarders are used where a delay in setting time is required to ensure sufficient placement, vibration, or compaction time. Set retarders are used in hot conditions or on very large pours. Set retarders permit the application of higher-temperature curing of precast/prestressed concrete without negatively affecting the ultimate strength. Set-retarding admixtures are the second most commonly used admixture in highway and bridge construction. ASTM-ASTM C 494, type B is simply a retarding admixture, while type D is both retarding and water-reducing.

Retarding admixtures consists of both organic and inorganic agents. Organic retardants include unrefined calcium, sodium, NH₄, salts of lignosulfonic acids, hydrocarboxylic acids, and carbohydrates. Inorganic retardants include oxides of lead and zinc, phosphates, magnesium salts, fluorates and borates. As an example of a retardant's effects on concrete properties, lignosulfate acids, and hydroxylated carboxylic acids slow the initial setting time by at least an hour and no more than three hours when used at 65 to 100 degrees Fahrenheit.

The use of set-retarding admixtures:

- Enables farther hauling, thus eliminating the cost of relocating central mixing plants;
- Allows more time for texturing or plastic grooving of concrete pavements;
- Allows more time for hand finishing around the headers at the start and end of the production day;
- Helps eliminate cold joints in two-course paving and in the event of equipment breakdown;
- Resist cracking due to form deflection that can occur when horizontal slabs are placed in sections;
- Some retarders entrain air;
- Slump loss may increase;
- Ultimate strength is improved;
- Rates of drying shrinkage and creep could increase;
- Good for hot-weather concreting;
- Slow pour rate; and
- Higher temperature curing of precast/prestressed concrete.

When a set retarder may not be required:

- Short hauls with quick placement;
- Cool moist interior location;
- Residential or commercial basement; and
- Fast pour rate.

Euclid Chemical Company

- Eucon Retarder 75

Edecon

- 700

5.1.4 Accelerators

Type C, accelerating

Accelerating admixtures are added to concrete to shorten the setting time and accelerate the early strength development of concrete. These are used in cold weather conditions (below 5°C or 41°F). There is also ASTM C 494 Type E, water-reducing and accelerating admixtures.

Some widely used and effective chemicals that accelerate the rate of hardening of concrete mixtures include calcium chloride, other chlorides, triethanolamine, silicates, fluorides, alkali hydroxide, nitrites, nitrates, formates, bromides, and thiocyanates.

The benefits of accelerating admixtures are:

- Reduced bleeding,
- Earlier finishing,
- Improved protection against early exposure to freezing and thawing,
- Earlier use of structure,
- Reduction of protection time to achieve a given quality,
- Early removal of form, and
- In some cases, early load application.

Accelerators do not act as anti-freeze agents; therefore, protection of the concrete at early ages is required when freezing temperatures are expected.

Although calcium chloride is the most effective and economical accelerator for concrete, its potential to cause corrosion of reinforcing steel limits its use. Corrosion has been associated with spalling, cracking, and loss of bond. At one time, calcium chloride was the predominant accelerating admixture. In Europe, the use of calcium chloride is banned from some applications. ACI Committee 318 suggests that the water-soluble chloride-ion content should be limited to the following levels.

Maximum Chloride-ion Content for Corrosion Protection of Reinforcement*	
Type of member	Maximum water-soluble chloride-ion (Cl ⁻) in concrete, percent by mass of cement
Pre-stressed concrete	0.06
Reinforced concrete exposed to chloride in service	0.15
Reinforced concrete that will be dry or protected from moisture in service	1.00
Other reinforced concrete construction	0.30

*Requirements from ACI 318 tested per ASTM C 1218

Proper proportioning, proper consolidation, and adequate cover can reduce or eliminate problems related to corrosion. Calcium chloride has been used in concrete since 1885. Compressive and flexural strength may be increased. The compressive strength may be increased as much as 400 to 1000 psi in the first few days. The long-term strength is usually unaffected and is sometimes reduced. Calcium chloride should meet the requirements of ASTM D 98.

Non-chloride-accelerating admixtures containing salts of formates, nitrates, nitrites, and thiocyanates are available from admixture manufacturers. These non-chloride accelerating admixtures offer year-round versatility because they can be used for acceleration purposes in cool weather and for sub-freezing protection.

Fox Industries

- FX-332

Edecon

- Blokast
- 606

BASF

- Pozzoloth NC534
- Pozzoloth 555
- Pozzoloth 102
- Pozzoloth 599

5.1.5 Super-plasticizers

High-range water-reducing admixtures (HRWR) ASTM C 494 Type F or Type G

HRWR admixtures may reduce the water requirement by 12-40%. They are used to produce normal workability at a lower w/c ratio. They may be used to produce a highly flowable concrete (slumps of 8 to 11 inches). When used to produce a flowable concrete the admixtures should also meet the requirements of ASTM C 1017 Type 1 or Type 2.

The types of ingredients used fall in three groups:

- Sulfonated melamine-formaldehyde condensate (SMF);
- Sulfonated naphthalene-formaldehyde condensate (SNF);
- Modified lignosulfonates (MLS); and
- Polyether-polycarboxylates.

HRWR admixtures are very efficient at dispersing fine grained particles like cement, fly ash, ground granulated blast-furnace slag and silica fume. HRWR admixtures may have adequate resistance to freezing and thawing. HRWR admixtures based on polyether-polycarboxylates are more effective and are gaining widespread acceptance.

HRWR Type F admixtures have a slump-increasing effect that is retained for 30-60 minutes, after which the concrete reverts to its original slump. That means they can make a low-to-normal slump concrete into a high-slump concrete which can be placed with little or no vibration in a short period of time. Because of the limited workability time, HRWR Type F admixtures are usually added at the job site. Type G can be added either during batching or at the job site. This admixture will delay setting, but cause the concrete to be flowable for a longer period of time. Re-dosing is also possible with this type. The strength of HRWR concrete is normally higher than predicted by w/c ratio alone. Because the w/c ratio is normally low, shrinkage and permeability may be reduced and overall durability may be increased.

POTENTIAL ADVANTAGES OF HRWR:

- Significant water reduction;
- Reduced cement contents;
- Increased workability;
- Reduced effort required for placement;
- More effective use of cement;
- More rapid rate of early strength development;
- Increased long-term strength; and
- Reduced permeability.

POTENTIAL DISADVANTAGES OF HRWR:

- Additional admixture cost (the concrete in-place cost may be reduced);
- Slump loss greater than conventional concrete;
- Modification of air-entraining admixture dosage;
- Less responsive with some cement;
- Mild discoloration of light-colored concrete; and
- Air-void and color blemishes on exposed and formed finishes.

Euclid Chemical Company

- Eucon 37
- Eucon 1037
- Plastol 5000

Fox Industries

- FX-330

Edecon

- Chemwet
- Powermix
- Slumpmix

BASF

- Rheobuild 561
- Rheobuild 716LR
- Rheobuild 1000
- Rheobuild 1023
- Rheobuild 3020

There are also *mid-range water-reducing* admixtures that provide moderate water reduction without a significantly delaying the setting time. These admixtures can reduce stickiness, improve finishability and pumpability. These admixtures are usually used in slumps ranging from 125 to 200 mm (5 to 8 in.) and may entrain air. These admixtures can reduce water content by 8-15%. These admixtures tend to be more stable over a wide range of temperatures and provide more consistent setting times.

Mid-range water-reducing admixtures are:

- Particularly useful in hot weather concreting by counteracting the accelerating effect of high ambient and concrete temperatures;
- Slow the setting rate of concrete;
- Delay initial set of concrete; and
- Keep concrete workable during placement.

Euclid Chemical Company

- Plastol 341

BASF

- Polyheed 819
- Polyheed 916N
- Rheoplus 44

5.1.6 Corrosion-inhibitors

Reinforcing steel corrosion is a major concern with regard to the durability of reinforced concrete structures. Chlorides are one of the causes of corrosion of steel in concrete. They can be introduced into concrete from deicing salts that are used in the winter months to melt snow or ice, from sea-water, or from concrete admixtures.

One way of combating chlorine-induced corrosion is to use a corrosion inhibiting admixture. These admixtures are added to concrete during batching and they protect embedded reinforcement by delaying the onset of corrosion and also reducing the rate of corrosion after initiation. These admixtures work for many years after the concrete has set. Corrosion-inhibitors are very expensive and sell for about \$30 per cubic yard of concrete.

There are inorganic formulation that contains calcium nitrite as the active ingredient and organic formulations consisting of amines and esters.

Euclid Chemical Company

- Eucon CIA

Fox Industries

- FX-346

Edecon

- CoolSet

BASF

- Rheocrete CNI
- MCI 2006NS Grenade

Build Core Chemicals

- Coreplast CR

5.1.7 Shrinkage-reducers

Dry shrinkage is the loss of moisture from the concrete as it dries, resulting in a volume contraction.

Dry shrinkage tends to:

- Lead to cracking,
- Curling of floor slabs, and
- Excessive loss of pre-stress in prestressed concrete.

The magnitude of dry shrinkage can be reduced by:

- Minimizing the unit water content,
- Using good quality aggregates, and
- Using the largest size coarse aggregate possible.

Drying shrinkage can also be reduced significantly by using shrinkage-reducing admixtures. These are organic-based formulations that reduce the surface tension of water in the capillary pores of the concrete, thereby reducing the tension forces within the concrete matrix that lead to drying shrinkage.

BASF

- Tetraguard AS21

Sika

- Sika Control 40

5.1.8 Alkali-silica reactivity reducers

Alkali-silica reactivity (ASR) is a reaction between soluble alkalis in concrete and reactive silica in certain types of aggregate that results in the formation of a water-absorptive gel that expands and fractures the concrete.

The reaction is:

- Typically slow,
- Dependent on the total amount of alkali present in the concrete,
- The reactivity of the aggregates, and
- The availability of moisture.

ASR can be mitigated by:

- Using low-alkali cement,
- Using sufficient amounts of pozzolans or ground granulated blast-furnace slag,
- Using non-reactive aggregates or
- Using lithium-based additives.

Lithium compounds are effective in reducing ASR because they form a non-absorptive gel with reactive silica in the aggregates. The high cost of lithium-based admixtures, however, has greatly limited their use.

Sika

- Sika Control ASR

5.2 Mineral admixtures

Mineral admixtures reduce cost, reduce permeability, increase strength and change other concrete properties. There are three main *mineral admixtures*.

1. Fly ash ;Supplementary Cementitious Materials (SCM),
2. Silica fume, and
3. Ground granulated blast furnace slag; also SCM.

5.2.1 Fly ash

Fly ash is a byproduct of electrical coal-fired power plants and can vary widely depending on the source. It should meet the requirements of ASTM C 618. Fly ash particles are usually finer than cement and are mainly made of glassy-spherical particles. Use of fly ash started in the United States about early 1930's. Tests have shown that high-strength concrete can be made by using high volumes of Class C fly ash (about 1/3 of total cement material). Strength levels were obtained in the range of 14,000 psi (100 MPa) at one year of age and beyond. Because of the carbon content of fly ash, air-entraining admixtures may be required. Fly ash inhibits alkali-silica reaction (ASR) in hardened concrete. Fly ash is used in about 40% of ready-mix concrete.

The two main classes of fly ash specified in ASTM C 618 are Class F and Class C. All fly ash used in the United States before 1975 were Class F. The Class C fly ash content of concrete generally ranges from 15 to 40 % of the total cementitious material. Class F content usually ranges from 15 to 25%. There is also a Class N; Natural pozzolans from volcanic ash or other materials.

Class F usually from burning anthracite or bituminous coal

- Reduces bleeding,
- Increase the time of setting,
- Improve workability,
- Reduces segregation in plastic concrete,
- Increases ultimate strength,
- Reduces drying shrinkage and permeability,
- Lowers the heat of hydration, and
- Reduces creep.

Class C usually from burning sub-bituminous coal and lignite,

Provides self-hardening characteristics,

- Increase the time of setting for most Class C,
- Improves permeability,
- Useful in pre-stressed concrete and
- Has high early strength.

5.2.2 Silica fume

Silica fume admixtures are used to meet high strength and low permeability requirements. They have been used to produce concrete with compressive strengths as high as 20,000 psi. They are added in slurry or in dry form at the batching plant. Silica fume is extremely fine. The particles are about 100 times smaller than cement particles. It should meet the requirements of ASTM C 1240

Benefits are:

- Reduced permeability,
- Improves bonding within the concrete,
- Improves resistance to corrosion,
- Can reduce alkali-silica reactivity (ASR),
- Increased compressive and flexural strengths, and Increased durability.

Applications are:

- High-strength structural columns,
- Low permeable parking garage decks, and
- Abrasion resistant hydraulic structures.

Silica fume dosage is about 8-15% by weight of cement which is added to and not a replacement for the amount of cement.

Dosage:

- High durability / low permeability of bridge decks or parking structures (8-10%)
- High strength structural columns (10-15%)
- Flatwork (10% max.)

The higher the percentage of silica fume used, the higher the amount of superplasticizer needed. The mix may become sticky. Replace 1/3 of the superplasticizer with a mid-range water reducer to improve workability. Silica fume increases water demand often requiring one pound of water for every pound of silica fume. Silica fume is very expensive and sells for as much as \$40 per cubic yard of concrete.

Elkem Chemicals

- EMS 960
- EMS 970S

Master Builders

- MS-SF

Simcala, Inc.

- Simcala Microsilica

W.R. Grace

- Force 10,000 D

Burgess Pigment Company

- Optopozz

Sika Corporation

- Sikacrete 950DP

Fox Industries

- FX-32 SF

BASF

- Rheomac AS 180

5.2.3 Ground granulated blast-furnace slag (GGBFS)

Ground granulated blast-furnace slag is the granular material formed when molten iron blast furnace slag is rapidly chilled (quenched) by immersion in water. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, hydrates like portland cement. Since it is a cementitious material, it can be substituted for some of the cement. The optimum is typically 50% of the cement if not exposed to deicing salts and 25% if exposed to deicing salts.

It should meet the requirements of ASTM C 989. The three grades are 80, 100 and 120. The use of grade 80 should be avoided unless warranted in special circumstances. It should not be used in cold conditions.

Effects of slag additives:

- Usually improves workability and decreases water demand,
- Increases setting times,
- Reduces bleeding,
- Increases the air entrainment required,
- Usually improves flexural strength,
- Reduces permeability, and
- Prevent damage due to ASR.

Holcim, Inc

- Grancem, Grade 100

Lone Star Ind.

- Aucem, Grade 120

6 Other Admixtures

6.1 Anti-washout / underwater admixtures

When concrete is placed under water it may be subject to wash-out during placing and before hardening. These admixtures are used to stabilize the mix, increase cohesion and reduce wash-out.

Fox Industries

- FX-Segnot

BASF

- Rheomac UW450

Sika

- Sikament 100 SC

Build Core Chemicals

- Coreplast AWA

6.2 Truck wash-water admixtures

These allow the reuse of water and washings used to clean out the ready-mix trucks at the end of the day. The washings are treated with the admixture and then used in the following days concrete mix.

General Resource Technology, Inc.

- Polychem Renu

6.3 Foaming admixtures for Controlled low strength material (CLSM)

These admixtures, allow for very large amounts of air to be foamed in the concrete. This type of concrete is typically used as a low-strength, light weight material, suitable for filling large voids where strength is not an issue. It provides a fluid backfill material that flows easily and is self leveling. It does not need to be placed in lifts, spread, and compacted after each lift. It is great for places where future excavation might be required. The typical 28-day compressive strength is 50 to 200 psi and densities from 115 to 145 lb/cu-ft.

BASF

- Rheocell Rheofill

6.4 Water resisting (waterproofing) admixtures

These block or impede the flow of water through the natural capillaries in hardened concrete and are used in structures below the water table or in water retaining structures like swimming pools or reservoirs.

Aquafin

- Aquafin-IC Admix
- Integramix-WP

6.5 Pumping admixtures

These are used to reduce pump pressure in long pump lines or where difficult aggregates are being used. They are especially effective with lightweight aggregates.

BASF

- Rheomac 614

6.6 Coloring admixtures

These are to change the color of the concrete. They should meet the requirements of ASTM C 979.

Materials used:

- Modified carbon black,
- Iron oxide,
- Phthalocyanine,
- Umber,
- Chromium oxide,
- Titanium oxide, and
- Cobalt blue.

REFERENCE:

ACI E4, *Chemical Admixtures for Concrete*, ACI Education Bulletin E4-03, American Concrete Institute, Farmington Hills. Michigan, 2003, 12 pages.

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