

Course: Concrete Technology

Lecture 5: Water, Admixtures, and Supplementary Materials

Mauricio Javier León Tejada

mjleon@ucsp.edu.pe

Session Objectives

- Understand physical and chemical properties of water in concrete
- Analyze its role from mixing to curing processes
- Review standards, quality control, and acceptance criteria
- Compare water, admixtures, and mineral additions in mix design

Content

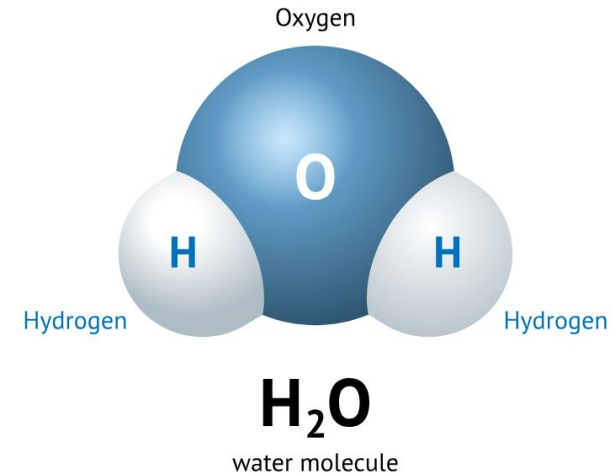
- General Overview
- Mixing (Batching) Water
- Curing Water
- Negative Effects
- Water Quality



General Overview

Physicochemical Properties of Water

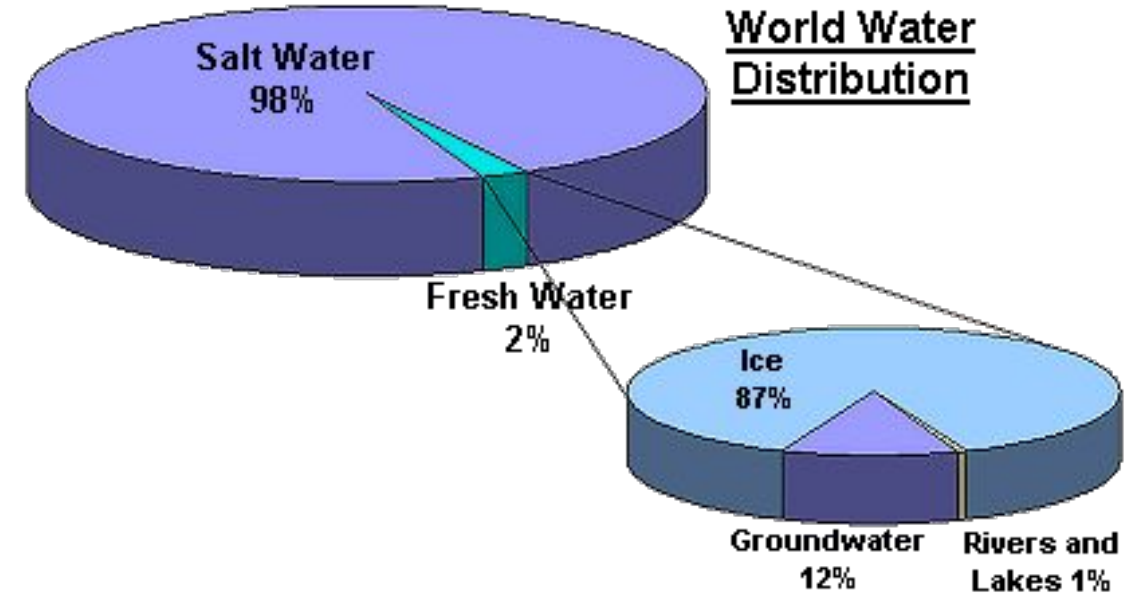
- Polar molecule enabling dissolution of substances
- Interaction with hydrophilic and hydrophobic materials
- Acts as reaction and transport medium in hydration
- Influences formation of C-S-H and microstructure



Source: Energy Encyclopedia. (n.d.)

Global Water Distribution and Resource Management

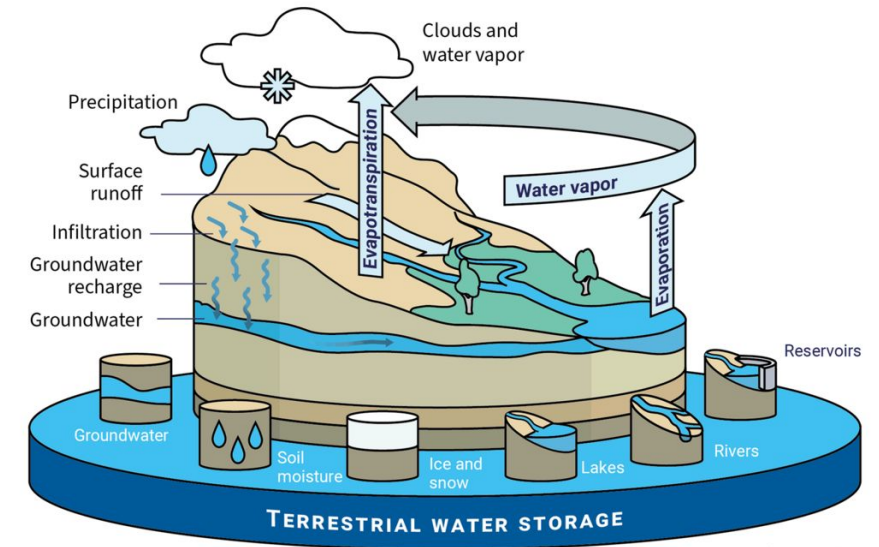
- Water circulates through the hydrological cycle
- Availability depends on climate, geology, and land use
- Essential for agriculture, industry, and construction
- Scarcity impacts costs and sustainability of projects



Source: UNL School of Natural Resources. (n.d.)

Water Resources and Storage Systems

- Snow and ice act as natural reservoirs, regulating river flow.
- Ice affects hydraulic structures, requiring data for safe design.
- Surface water is essential but variable, needing regulation (e.g., dams).
- Groundwater and alternatives (reuse, desalination) are key under scarcity.



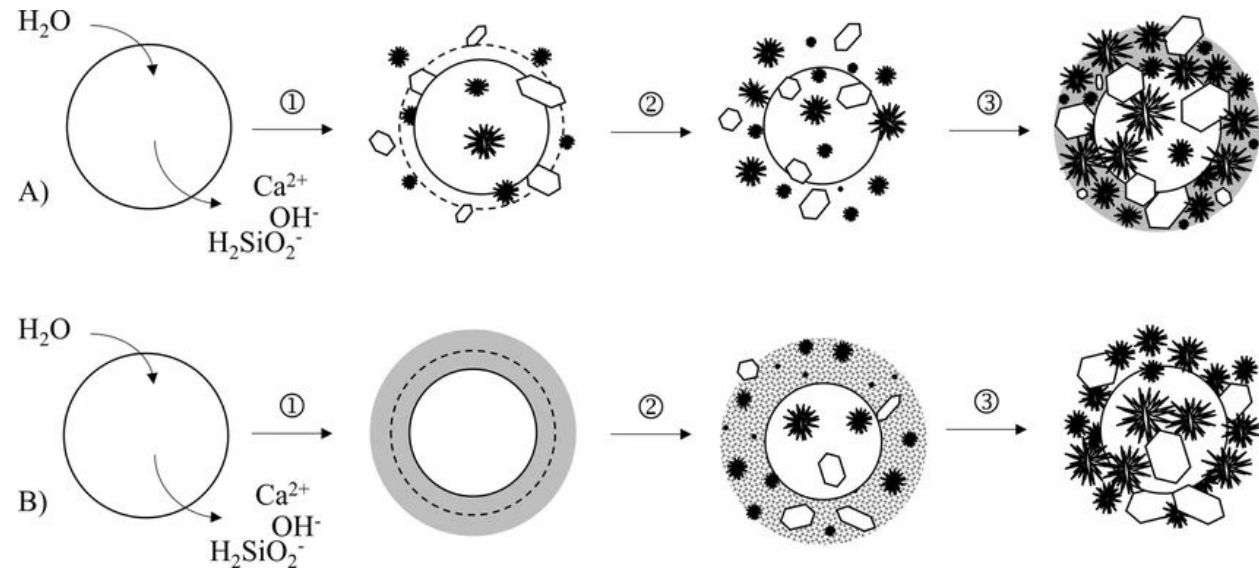
Source: Global Water Storage Information Project. (n.d.)



Mixing (Batching) Water

Water as a key Component in Concrete

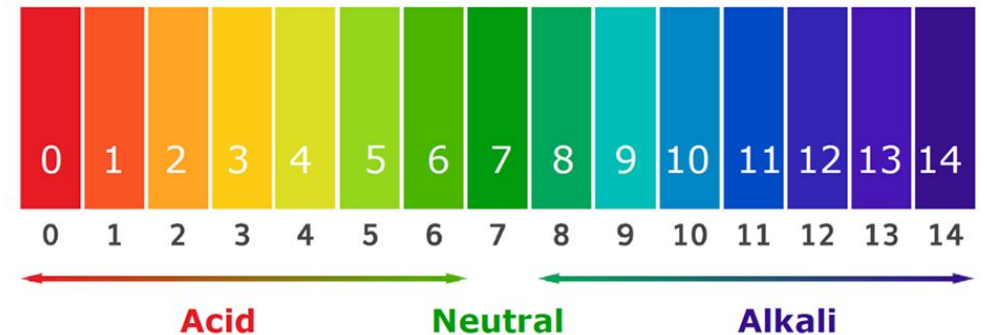
- Essential for cement hydration reactions
- Acts as dispersion medium for particles
- Dual role: hydration and workability
- Critical for constructability and long-term performance



Source: John, E., & Lothenbach, B. (2023)

Chemical Properties of Water (ASTM D1129)

- Key parameters: pH, acidity, alkalinity, hardness
- Presence of dissolved solids and suspended particles
- Chlorine, turbidity, and sedimentation considerations
- Essential for evaluating water suitability



Source: Water Quality Solutions. (n.d.)

Water Quality Requirements

- Must be free from harmful impurities
- Contaminants affect setting and strength
- Potable water is generally acceptable (with caution)
- Quality control is essential for durability



Source: The Constructor. (n.d.)

Functions of Mixing Water

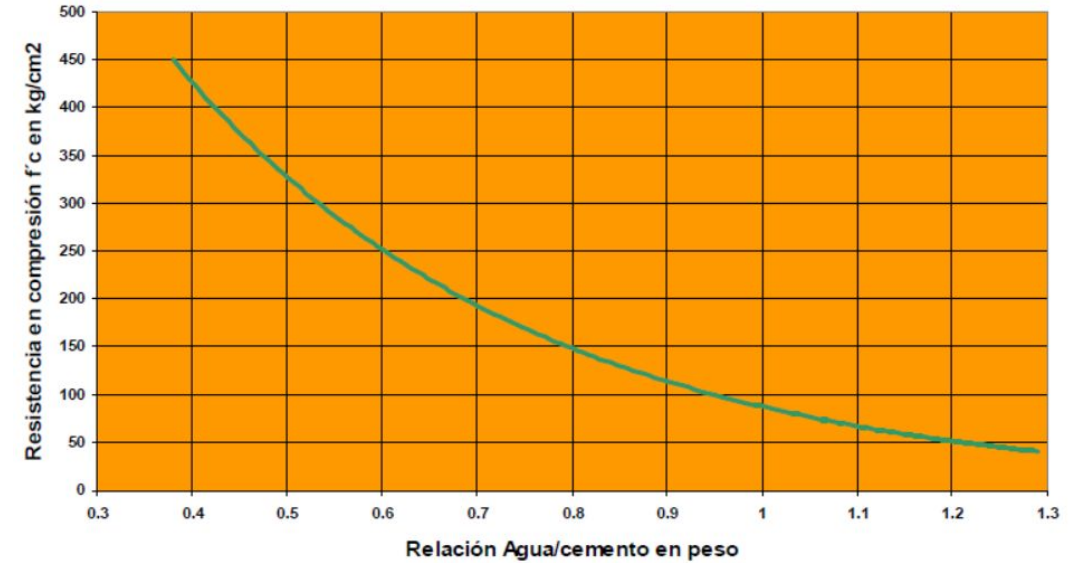
- Enables cement hydration and strength development
- Provides workability and plasticity
- Influences pore structure formation
- Excess water increases porosity and reduces durability



Source: Madmix. (n.d.)

Water–Cement Ratio Effects

- Optimal hydration occurs near $w/c \approx 0.42$
- Excess water increases capillary porosity
- Higher w/c reduces strength and increases permeability
- Fundamental principle in mix design



Source: Pasquel (1998)

Regulatory Limits for Water Quality

- Control of chlorides and sulfates is critical
- Stricter limits for reinforced concrete
- pH should be neutral to slightly alkaline
- Standards ensure durability and structural performance

Parámetro	ASTM	NTP	Límite (ppm)
Acidez y alcalinidad	D1067	-	1000 máximo
Calcio y magnesio	D511	-	150
Cloruros			
* Concreto pretensado, tableros de puentes	D512	339.076	500 máximo
* Concretos reforzados en ambientes húmedos			1000 máximo
Definición de términos relativos al agua	D1129	-	-
Partículas y materia disuelta en el agua	D1888	339.071	5000 máximo
pH	D1293	339.073	6 - 8
Sulfatos	D516	339.074	3000 máximo
Materia orgánica	-	-	3 a 10

Source: Author's own elaboration

Seawater in Concrete: Composition and Effects

- High salt content compared to potable water (chlorides and sulfates)
- Modifies setting and may increase early strength
- Reduces long-term strength and durability
- Promotes corrosion, efflorescence, and surface deterioration

Compuesto	ppm
Cloruro de sodio (NaCl)	27000
Cloruro de magnesio (MgCl ₂)	3200
Sulfato de magnesio (MgSO ₄)	2200
Sulfato de calcio (CaSO ₄)	1100
Cloruro de calcio (CaCl ₂)	500
Total de sales disueltas	34000

Source: Author's own elaboration

Guidelines for Using Seawater

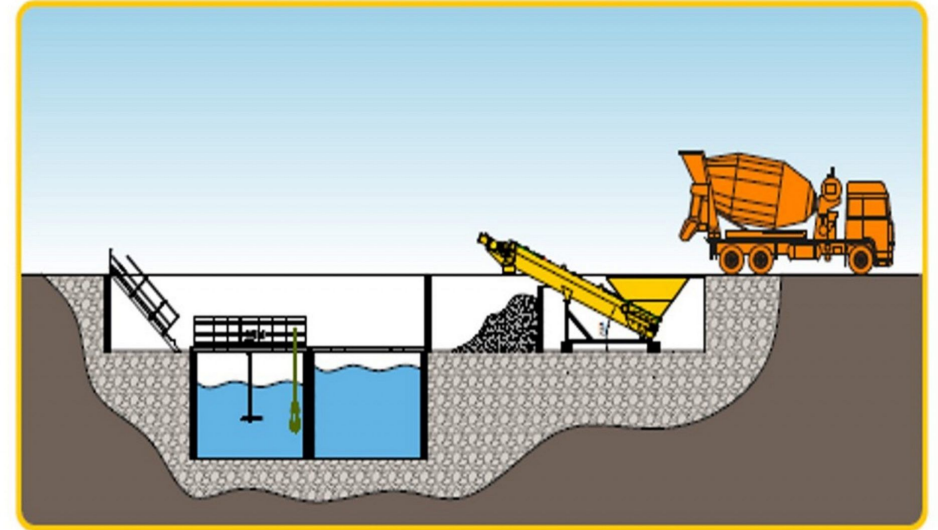
- Acceptable only for plain (non-reinforced) concrete
- Not suitable for reinforced or prestressed concrete
- Requires strength compensation (increase by 10–20%)
- Not recommended for high-strength concrete applications



Source: Tech-Dry. (n.d.)

Water Use in Mixer Truck Washing

- Cleaning prevents contamination and hardened buildup
- High water consumption managed with reuse systems
- Settling ponds remove solids through sedimentation stages
- Recycled water must meet quality standards before reuse



Source: Lintec & Linnhoff. (n.d.)

Aggregate Washing in Concrete Production

- Removes dust, clays, and unwanted fine materials
- Improves bond between aggregates and cement paste
- Water must meet minimum quality standards
- Contamination negatively affects concrete properties



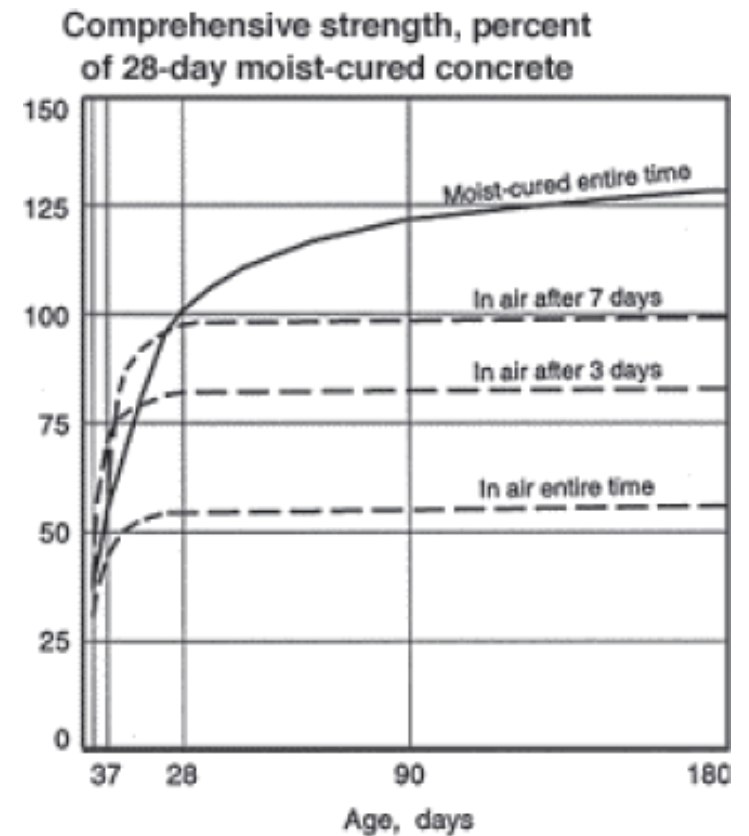
Source: GreenSpec. (n.d.)



Curing Water

Importance of Curing Water

- Ensures continuous cement hydration after setting
- Reduces porosity and improves strength and durability
- Maintains near-saturated conditions in concrete
- Quality affects surface appearance and performance



Source: Jaybird Manufacturing. (n.d.)

Methods of Water Curing

- Direct application using hoses or water jets
- Use of wet coverings (burlap, geotextiles)
- Spraying systems, curing compounds, or ponding
- Requires planning and quality control of materials



Source: Home Improvement & Decor. (n.d.)



Negative Effects

Negative Effects of Impurities in Water

- Interferes with hydration and alters setting times
- May cause corrosion, staining, and weak bonding
- High suspended solids increase shrinkage and demand
- Dissolved solids can reduce strength up to 30%



Source: Water Filter Cyprus. (n.d.)

Effects of Organic Matter and Algae

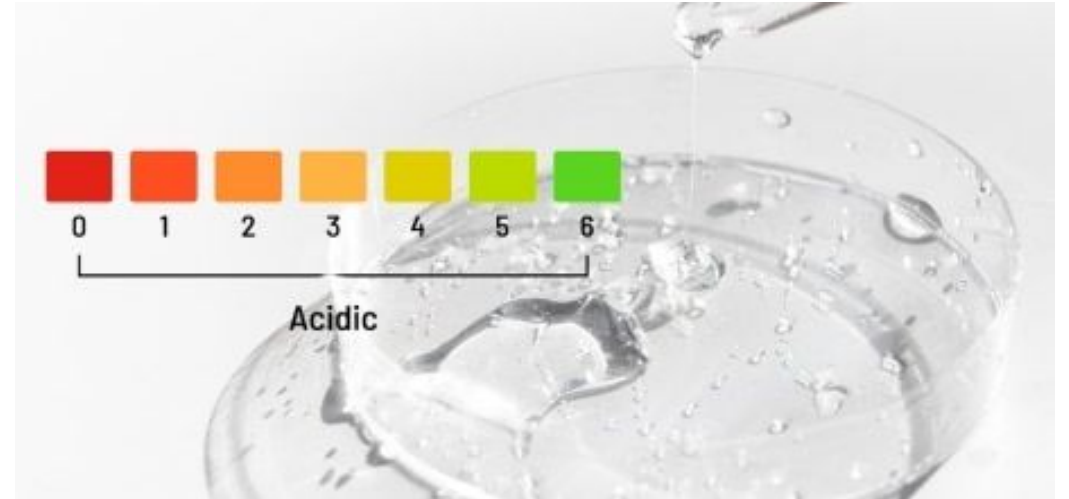
- Causes discoloration and air entrainment
- Generates interconnected voids in concrete
- Reduces strength and durability
- Decomposition leads to internal void formation



Source: Stantec. (n.d.)

Effects of Sugars, Acids, and Alkalis

- Sugars alter setting depending on concentration
- Organic acids are harmful to hardening
- Low pH water should be avoided
- High alkalinity may accelerate setting and reduce strength



Source: Apure. (2024)



Water Quality

Laboratory Testing for Water Quality

- Determines chemical composition of water
- Verifies compliance with technical standards
- Uses reference limits for impurities
- Essential for durability-focused projects

Element		Units	Tap water	Seawater
Calcium	Ca	ppm	90	389
Chloride	Cl	ppm	44	18,759
Iron	Fe	ppm	-	0.5121
Potassium	K	ppm	6	329
Magnesium	Mg	ppm	6	1,323
Sodium	Na	ppm	26	9,585
Sulfate	SO ₄ ²⁻	ppm	8	831
Nitrate	NO ₃	ppm	1	0.1345
Salinity		ppt	<0.5	35

Chemical composition of tap water and seawater used in concrete mixtures
Source: Elshami, A. A. (2023)

Field Tests for Water Suitability

- Mortar strength compared to control samples
- $\geq 90\%$ strength indicates acceptable water
- Setting time evaluated using Vicat test
- ASTM standards used for verification



Source: Construction How. (n.d.)

Conclusions on Water in Concrete

- Water is a key active component of concrete, directly influencing its fresh and hardened properties.
- Its composition (e.g., pH, salts, impurities) must be controlled to ensure proper hydration and durability.
- Variability in water quality can significantly impact strength development and long-term performance.
- Water that does not fully meet standards may still be used if validated through testing and performance criteria.
- Using recycled water (e.g., from mixer washout) promotes sustainability and efficient resource management.



Admixtures and Additions

Content

- General Overview
- Types of Admixtures
- Mineral Additions
- Quality Control of Admixtures



General Overview

Definition and Role of Chemical Admixtures

- Materials added to modify concrete properties
- Act on fresh, setting, and hardened states
- Improve workability, strength, and durability
- Essential for performance under challenging conditions



Source: Grupo Mathiesen. (n.d.)

Historical Development of Admixtures

- Ancient use of organic materials (Romans)
- Scientific development began with Portland cement
- 1930s: first synthetic admixtures introduced
- Modern innovations include superplasticizers and PCEs



Source: Dmitrii Maslov (iStock)

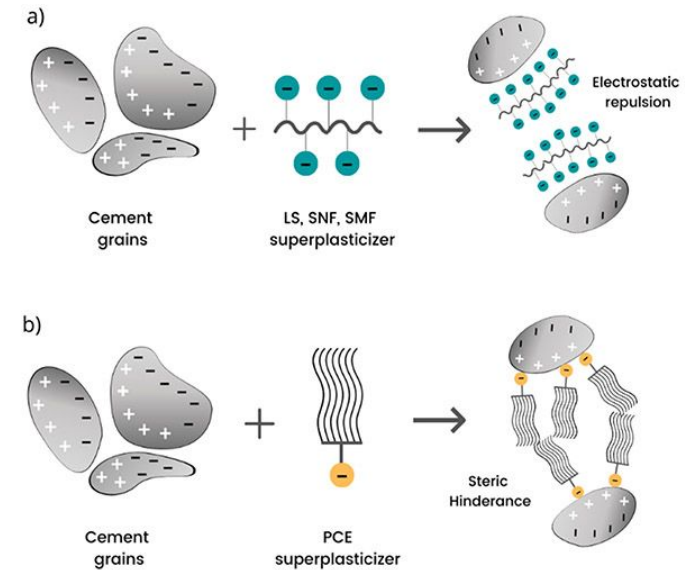
ASTM C 494 Classification of Admixtures

S. No.	Type	Description
01.	Type A	Water-Reducing Admixtures
02.	Type B	Retarding Admixtures
03.	Type C	Accelerating Admixtures
04.	Type D	Water Reducing and Retarding Admixtures
05.	Type E	Water Reducing and Accelerating Admixtures
06.	Type F	Water Reducing, High Range Admixtures
07.	Type G	Water Reducing, High Range and Retarding Admixtures

Source: Khan, J. S. (n.d.)

Third-Generation Admixtures (PCE)

- Solve slump loss issues
- Enable very low water–cement ratios
- Improve durability and mechanical strength
- Provide precise rheology control



Source: Sure Chemical. (n.d.)

Applications of Admixtures

- Improve workability and reduce water demand
- Control setting time and hydration heat
- Enhance strength and durability
- Reduce permeability and chemical reactions



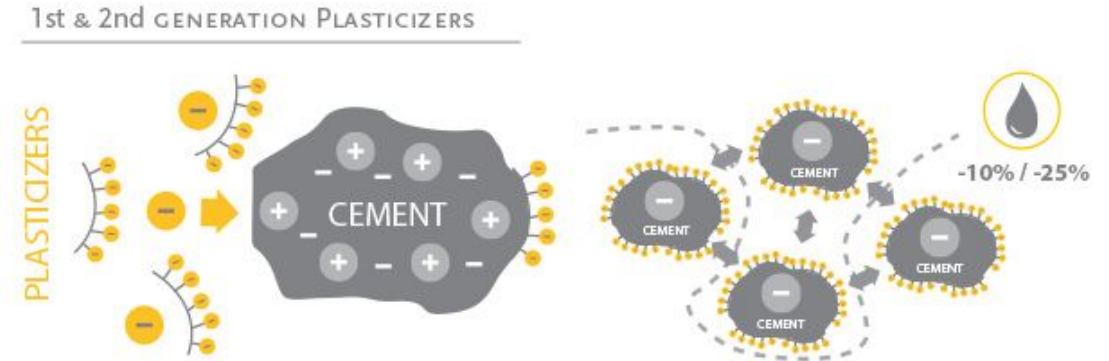
Source: Aboelkasem, Y. (n.d.)



Types of Admixtures

Plasticizers (Type A)

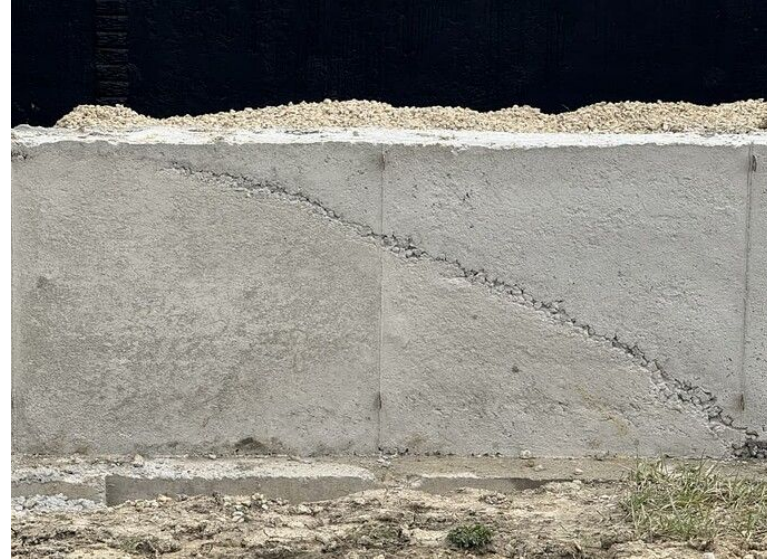
- Reduce water content while maintaining workability
- Disperse cement particles to improve hydration
- Increase strength and reduce permeability
- Require dosage control to avoid shrinkage



Source: Best Support Underground. (n.d.)

Retarding Admixtures (Type B)

- Delay setting in hot climates
- Extend workability time
- Prevent cold joints in large pours
- May reduce early-age strength



Source: Gonzalez, G. (2025)

Accelerating Admixtures (Type C)

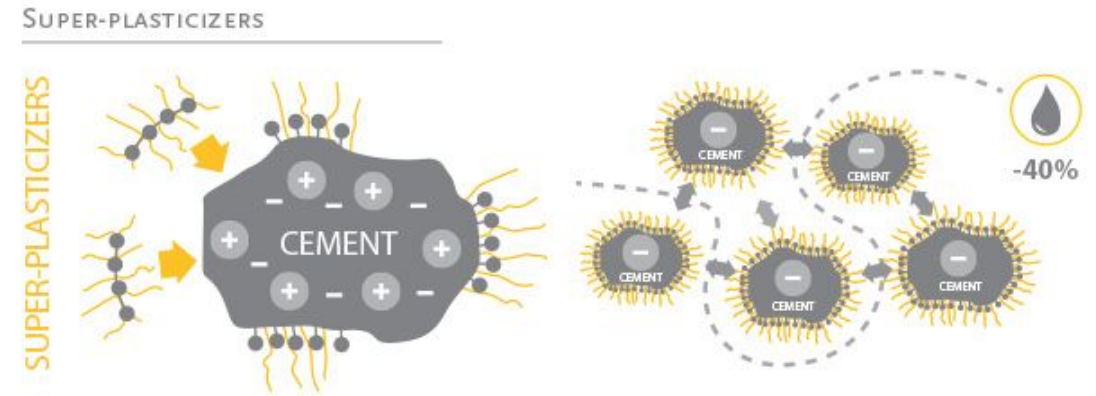
- Speed up setting and early strength gain
- Useful in cold climates
- Calcium chloride limited due to corrosion risk
- Must be used carefully to avoid cracking



Shotcrete as final tunnel lining Source: Thompson, A. (n.d.)

Combined Admixtures & Superplasticizers

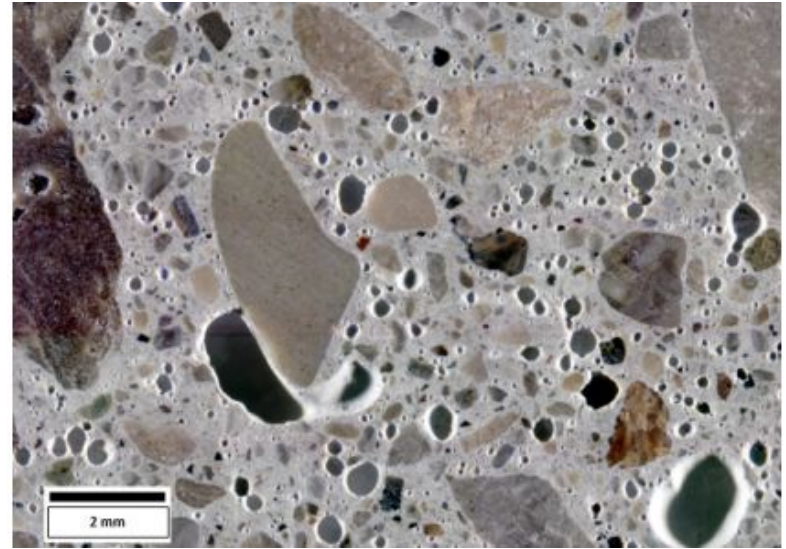
- Combine water reduction with set control
- Superplasticizers reduce water up to 30%
- Enable self-compacting and high-performance concrete
- May cause rapid slump loss if not controlled



Source: Best Support Underground. (n.d.)

Air-Entraining Admixtures

- Introduce controlled air bubbles
- Improve freeze–thaw resistance
- Reduce segregation and bleeding
- Slightly reduce mechanical strength



Source: Karl Peterson. (2019)



Mineral Additions

Introduction to Mineral Additions

- Finely ground natural or industrial materials
- Improve performance and sustainability
- Classified as cementitious, pozzolanic, or inert
- Include slag, natural cement, and lime



Fly ash



GGBS



RHA



Silica Fume



Metakaolin



POFA

Source: Kanamarlapudi, L., et al. (2020)

Pozzolanic and Inert Materials

- React with calcium hydroxide to form C-S-H
- Fly ash improves durability and workability
- Silica fume refines microstructure
- Inert materials enhance particle distribution



Fly ash



GGBS



RHA



Silica Fume



Metakaolin



POFA

Source: Kanamarlapudi, L., et al. (2020)

Specialized Admixtures

- Gas-forming for expansion applications
- Waterproofing reduces permeability
- Pumping aids improve flow and cohesion
- Corrosion inhibitors and colorants for durability/design



Source: Firth Industries. (n.d.)



Quality Control of Admixtures

Quality Control of Admixtures

- Must meet standards and manufacturer specs
- Tests include pH, density, solids content
- Chemical and spectroscopic analysis used
- Performance verified through comparative testing



Source: Construction How. (n.d.)

Conclusions on Admixtures

- Admixture selection must rely on a technical cost–benefit analysis, as improving one property may negatively affect another.
- Environmental and operational conditions can significantly influence admixture performance and must be considered.
- The water content of liquid admixtures must be included in the total mixing water to maintain the water–cement ratio.
- Powdered admixtures require proper storage and have limited shelf life due to sensitivity to moisture.
- Concrete quality depends on the interaction of all components and requires comprehensive control and testing.

References

- ❖ Pasquel, E. (1998). *Tópicos de Tecnología de Concreto en el Perú*. Lima: Colegio de Ingenieros del Perú - Consejo Nacional
- ❖ Energy Encyclopedia. (n.d.). Water. <https://www.energyencyclopedia.com/en/glossary/water>
- ❖ University of Nebraska–Lincoln, School of Natural Resources. (n.d.). World water distribution. <https://snr.unl.edu/data/water/groundwater/realtime/waterdistribution.aspx>
- ❖ Global Water Storage Information Project. (n.d.). Terrestrial water storage. Retrieved April 18, 2026, from <https://www.globalwaterstorage.info/en/anwendungen/terrestrial-water-storage>
- ❖ John, E., & Lothenbach, B. (2023). A: The mechanism of cement hydration according to the thin film theory by Rosenhain. In Cement hydration mechanisms through time – a review. *Journal of Materials Science*, 58, 9805–9833. <https://doi.org/10.1007/s10853-023-08651-9>
- ❖ Water Quality Solutions. (n.d.). What is water pH and why is it important? Retrieved April 18, 2026, from <https://waterqualitysolutions.com.au/what-is-water-ph-and-why-is-it-important/>
- ❖ The Constructor. (n.d.). Quality of water for concrete construction and its specification. Retrieved April 18, 2026, from <https://theconstructor.org/practical-guide/construction-water-qualityspecification/6012/>
- ❖ Madmix. (n.d.). The workability of concrete – Why is it important? Retrieved April 18, 2026, from <https://www.madmix.co.uk/blog/the-workability-of-concrete-why-is-it-important/>

References

- ❖ Tech-Dry. (n.d.). How to avoid saltwater corrosion within reinforced concrete. Retrieved April 18, 2026, from <https://www.techdry.com.au/how-to-avoid-salt-water-corrosion-within-reinforced-concrete/>
- ❖ Lintec & Linnhoff. (n.d.). Concrete recycling system. Retrieved April 18, 2026, from <https://lintec-linnhoff.com/product/concrete-recycling-system/>
- ❖ GreenSpec. (n.d.). Aggregates for concrete. Retrieved April 18, 2026, from <https://www.greenspec.co.uk/building-design/aggregates-for-concrete/>
- ❖ Jaybird Manufacturing. (n.d.). Concrete curing. Retrieved April 18, 2026, from <https://jaybird-mfg.com/applications/concrete/concrete-curing/>
- ❖ Home Improvement & Decor. (n.d.). What is curing of cement? Methods and its importance explained. Retrieved April 18, 2026, from <https://www.homeimprovementanddecor.com/curing-of-cement/>
- ❖ Water Filter Cyprus. (n.d.). A guide to identifying and filtering common impurities. Retrieved April 18, 2026, from <https://waterfiltercyprus.com/a-guide-to-identifying-and-filtering-common-impurities/>
- ❖ Stantec. (n.d.). Stopping algae in its tracks before it disrupts your water treatment plant. Retrieved April 18, 2026, from <https://www.stantec.com/en/ideas/stopping-algae-in-its-tracks-before-it-disrupts-your-water-treatment-plant>

References

- ❖ Apure. (2024, December 27). Acidic water. Retrieved April 18, 2026, from <https://apureinstrument.com/blogs/acidic-water/>
- ❖ Elshami, A. A. (2023). Chemical composition of tap water and seawater used in concrete mixtures [Figure]. In Effects of five sources of mixing water on durability of concrete. ResearchGate. Retrieved April 18, 2026, from https://www.researchgate.net/figure/Chemical-composition-of-tap-water-and-seawater-used-in-concrete-mixtures_tbl2_317350352
- ❖ Construction How. (n.d.). Physical properties of cement. Retrieved April 18, 2026, from <https://constructionhow.com/physical-properties-of-cement/>
- ❖ Grupo Mathiesen. (n.d.). Essential chemical admixtures to improve concrete performance. <https://www.grupomathiesen.com/application/los-aditivos-quimicos-esenciales-para-mejorar-el-rendimiento-del-concreto/>
- ❖ Lab Manager. (2023, January 6). Why was Roman concrete so durable? <https://www.labmanager.com/why-was-roman-concrete-so-durable-29552>
- ❖ Khan, J. S. (n.d.). Classification of admixtures according to ASTM C-494 [Table]. In Effectiveness of locally available superplasticizers on the workability and strength of concrete. ResearchGate. Retrieved April 18, 2026, from https://www.researchgate.net/figure/Classification-of-admixtures-according-to-ASTM-C-494_tbl1_329892744

References

- ❖ Sure Chemical. (n.d.). Unlocking the secrets of polycarboxylate superplasticizers: Synthesis and advanced dispersing mechanisms demystified. Retrieved April 18, 2026, from <https://www.surechemical.com/aboutus/RP20240509-Unlocking-the-Secrets-of-Polycarboxylate-Superplasticizers.html>
- ❖ Aboelkasem, Y. (n.d.). Slump-flow test: Slump diameter with varying PET content [Figure]. In Effect of PET on fresh and hardened properties of concrete. ResearchGate. Retrieved April 18, 2026, from https://www.researchgate.net/figure/Slump-flow-test-Figure-2-Slump-diameter-with-varying-of-PET-fig3_36571156
- ❖ Gonzalez, G., & contributors. (2025, April 17). Foundation cold joints: What's your opinion? InterNACHI Forum. Retrieved April 18, 2026, from <https://forum.nachi.org/t/foundation-cold-joints-whats-your-opinion/254998>
- ❖ Federal Highway Administration. (2017, April). Office of Operations: Guide to promote successful products (FHWA-HOP-17-009). U.S. Department of Transportation. Retrieved April 18, 2026, from <https://www.fhwa.dot.gov/pavement/pubs/hif17009.pdf>
- ❖ Kanamarlapudi, L., Jonalagadda, K. B., Jagarapu, D. C. K., & Eluru, A. (2020). Different mineral admixtures in concrete: A review. SN Applied Sciences, 2, Article 760. <https://doi.org/10.1007/s42452-020-2533-6>
- ❖ Firth Industries. (n.d.). Standard pumped concrete. Retrieved April 18, 2026, from <https://www.firth.co.nz/concrete/certified-concrete/standard-pumped>

Course: Concrete Technology

Lecture 5: Water, Admixtures, and Supplementary Materials

Mauricio Javier León Tejada

mjleon@ucsp.edu.pe