PCA

Concrete Technology and Codes

Mixing Water for Concrete

Objectives

- Introduce mixing water standards
- Common mixing water sources
- Overview of impurities and their impact

ASTM C1602

Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

- Potable water – no testing needed
- Non-potable or combined mixing water – testing required
- Recycled water – solids content tested daily

Sources of Mixing Water

At the Batch Plant

- Municipal water supply
- Municipal reclaimed water
- Recycled water from concrete production operations

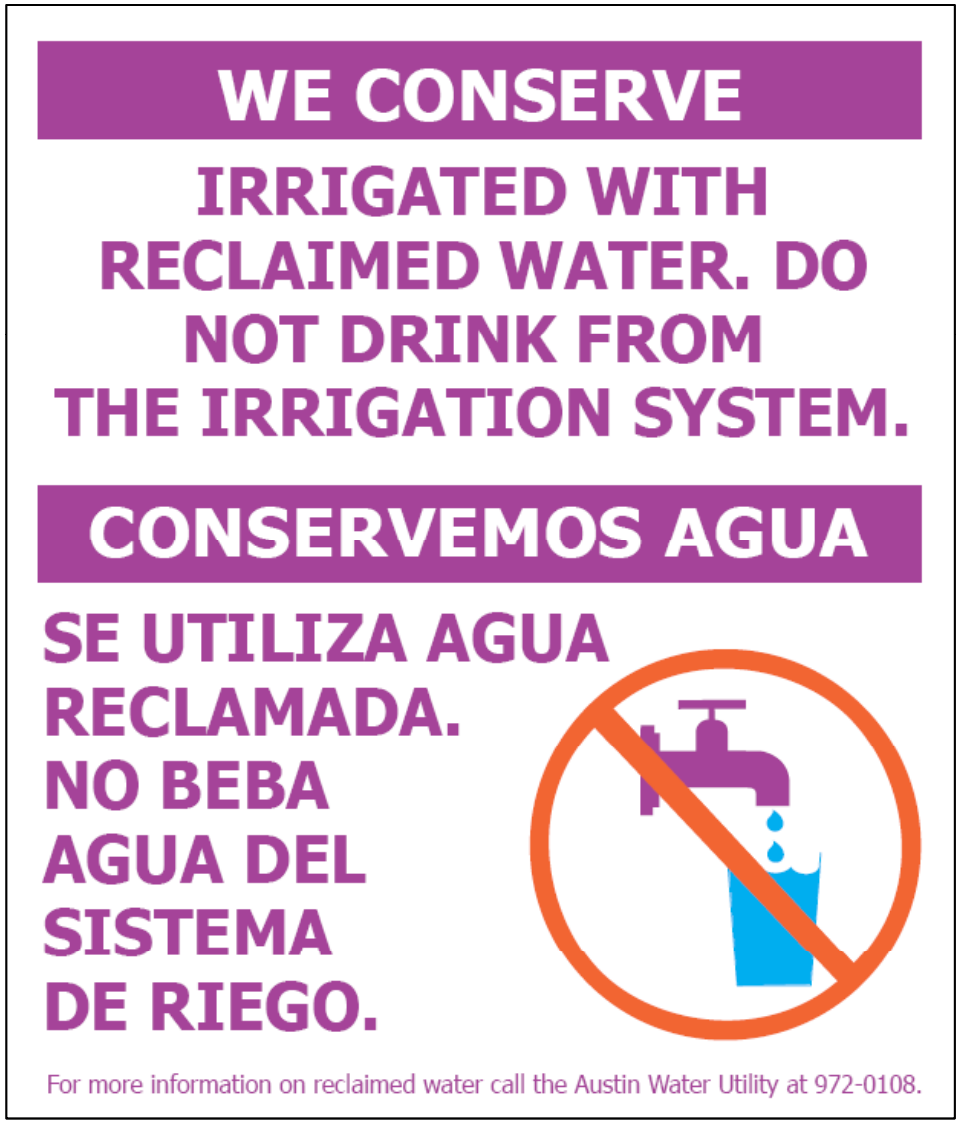
Municipal Water

Typical Analyses of City Water Supplies and Seawater (parts per million)

Chemicals	Analysis No. 1	2	3	4	5	6	Seawater*
Silica (SiO_2)	2.4	0.0	6.5	9.4	22.0	3.0	—
Iron (Fe)	0.1	0.0	0.0	0.2	0.1	0.0	—
Calcium (Ca)	5.8	15.3	29.5	96.0	3.0	1.3	50 to 480
Magnesium (Mg)	1.4	5.5	7.6	27.0	2.4	0.3	260 to 1410
Sodium (Na)	1.7	16.1	2.3	183.0	215.0	1.4	2190 to 12,200
Potassium (K)	0.7	0.0	1.6	18.0	9.8	0.2	70 to 550
Bicarbonate (HCO_3)	14.0	35.8	122.0	334.0	549.0	4.1	—
Sulfate (SO_4)	9.7	59.9	5.3	121.0	11.0	2.6	580 to 2810
Chloride (Cl)	2.0	3.0	1.4	280.0	22.0	1.0	3960 to 20,000
Nitrate (NO_3)	0.5	0.0	1.6	0.2	0.5	0.0	—
Total dissolved solids	31.0	250.0	125.0	983.0	564.0	19.0	35,000

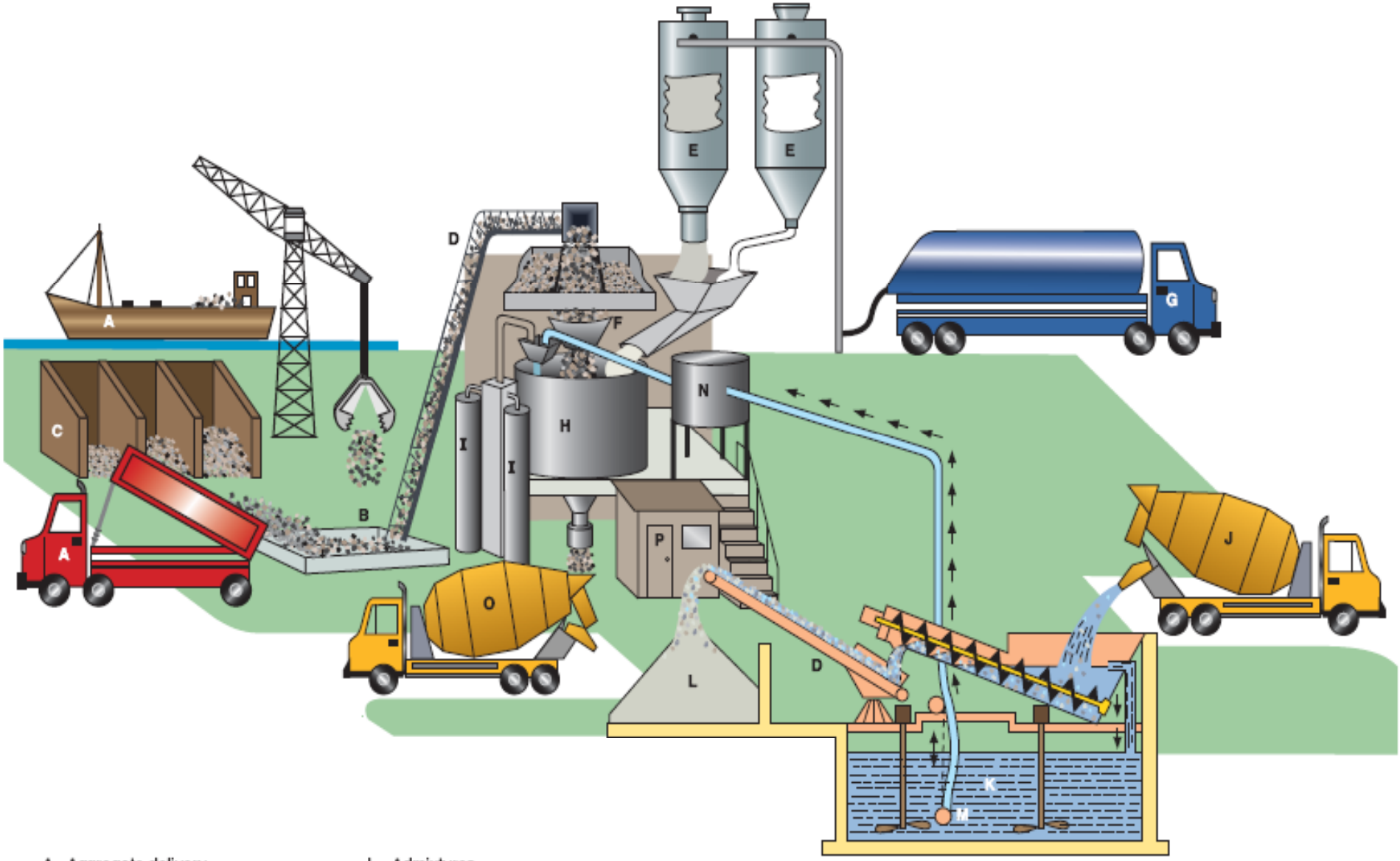
*Different seas contain different amounts of dissolved salts.

Municipal Reclaimed Water



Recycled Water

- Mixer wash water
- Stormwater runoff
- Water containing concrete ingredients



A Aggregate delivery
B Aggregate receiving hopper
C Aggregate storage
D Conveyor belt
E Cementitious material storage
F Weigh hopper
G Cement delivery
H Mixer
I Admixtures
J Ready mix truck with returned concrete
K Recycled water
L Reclaimed aggregates
M Pump
N Water storage
O Concrete loaded in ready-mix truck
P Control Room


KING'S

Acceptance Criteria for Questionable Water Supplies

	Limits	Test method
Compressive strength, minimum percentage of control at 7 days	90	C31, C39
Time of set, deviation from control, hr:min	From 1:00 earlier to 1:30 later	C403

*Comparisons should be based on fixed proportions of a concrete mix design representative of questionable water supply and a control mixture using 100% potable water.

Optional Acceptance Criteria for Combined Water Supplies

Chemical or type of construction	Maximum concentration, ppm*	Test method
Chloride, as Cl		ASTM C114
Prestressed concrete or concrete in bridge decks	500**	
Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1,000**	
Sulfate, as SO_4	3,000	ASTM C114
Alkalies, as (Na_2O + 0.658 K_2O)	600	ASTM C114
Total solids by mass	50,000	ASTM C1603

* ppm is the abbreviation for parts per million.

** The requirements for concrete in ACI 318 shall govern when the manufacturer can demonstrate that these limits for mixing water can be exceeded. For conditions allowing the use of calcium chloride ($CaCl_2$) accelerator as an admixture, the chloride limitation is permitted to be waived by the purchaser.

ACI 318 Limits for Chloride Ion Content in Concrete

- Prestressed 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%

Note: No limits for concrete not containing steel

Impurities and Strength

High Impact	Sodium Sulfide Salts of Zinc, Copper, and Lead Sugar Algae

Impurities and Strength

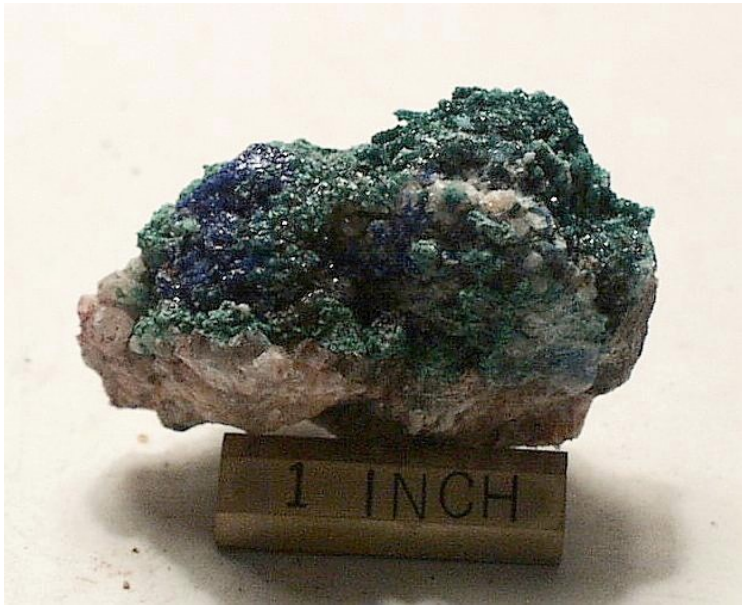
Moderate Impact	Alkali Carbonate/Bicarbonate
	Salts of Manganese and Tin
	Sodium Iodate/Phosphate/Borate/Arsenate
	Organic Acids
	Industrial Wastewater
	Seawater

Impurities and Strength

Low Impact	Calcium/Magnesium Bicarbonate
	Magnesium Sulfate/Chloride
	Iron Salts
	Inorganic Acids
	Alkali Hydroxides
	Oils

Impurities and Setting Time

High Impact	Sodium Carbonate Salts of Zinc, Copper, and Lead Sugar



Impurities and Setting Time

Moderate Impact	Alkali Bicarbonate Salts of Manganese and Tin Sodium Iodate/Phosphate/Borate/Arsenate Sodium Sulfide Alkali Hydroxides Industrial Wastewater

Impurities and Durability

Alkali-Aggregate Reactivity	Alkalis, Seawater
Corrosion Resistance	Chlorides, Seawater
Freeze-Thaw Resistance	Algae
Sulfate Attack	Sulfates, Seawater

Impurities and Other Properties

Workability	Silt or Suspended Particles
Efflorescence	High salt contents (Seawater)
Admixture Compatibility	Competing ionic species (Sulfates with water-reducers)

Typical Impurities

Cations

- Calcium (Ca^{+2})
- Magnesium (Mg^{+2})
- Sodium (Na^{+})
- Potassium (K^{+})

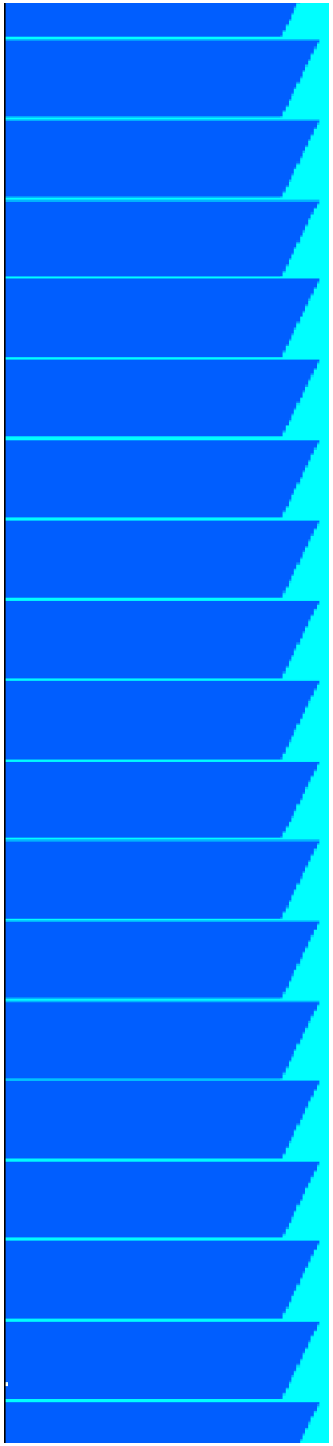
Anions

- Bicarbonate (HCO_3^{-})
- Carbonate (CO_3^{-2})
- Sulfate (SO_4^{-2})
- Chloride (Cl^{-})
- Nitrate (NO_3^{-})

Most fresh water does not contain other impurities over 15 ppm.

Summary

- ASTM C1602 - Performance Specification
- Water has many sources
- Impurities can affect more than just strength and setting time



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