

Chapter 4:

Water Quality for Concrete

Water is an important ingredient of concrete, and a properly designed concrete mixture, typically with 15 to 25% water by volume, will possess the desired workability for fresh concrete and the required durability and strength for hardened concrete.

The total amount of water in concrete and the water-to-cement ratio may be the most critical factors in the production of good-quality concrete. Too much water reduces concrete strength, while too little makes the concrete unworkable. Because concrete must be both strong and workable, a careful selection of the cement-to-water ratio and total amount of water are required when making concrete.

4.1 Mixing water

water is the free water encountered in freshly mixed concrete. It has three main functions:

- (1) it reacts with the cement powder, thus producing hydration products;
- (2) it acts as a lubricant, contributing to the workability of the fresh mixture; and
- (3) it secures the necessary space in the paste for the development of hydration products.

The amount of water added for adequate workability is always greater than that needed for complete hydration of the cement in practice.

Excessive impurities in mixing water not only may affect setting time and concrete strength, but also may cause:

- efflorescence,
- staining,
- corrosion of reinforcement,
- volume instability, and
- reduced durability.

There is a simple rule concerning the acceptability of mixing water: if water is potable, that is, fit for human consumption, with the exception of certain mineral waters and water containing sugar, it is also suitable for concrete making.

In other words, if water does not have any particular taste, odor, or color, and does not fizz or foam when shaken, then there is no reason to assume that such water will hurt the concrete when used properly as mixing water.

Some waters that are not fit for drinking may be suitable for concrete making provided that they satisfy the acceptance criteria laid by ASTM C 94.

Acceptance Criteria for Questionable Water Supplies (ASTM C 94)

	Limits	Test method
Compressive Strength, minimum percentage of control at 7 days	90	ASTM C 109 or T 106
Time of set, deviation from control, hr:min	From 1:00 earlier to 1:30 later	ASTM C 191 or T 131

4.2 Impurities in water

The unique ability of water in dissolving, to some extent, virtually every chemical compound and supporting practically every form of life means that raw water supplies contain many contaminants.

Water should be avoided if it contains large quantities of suspended solids, excessive amounts of dissolved solids, or appreciable amounts of organic materials. The major categories of impurities found in raw water include:

- (1) suspended solids;
- (2) dissolved solids, and
- (3) dissolved organic material.

Suspended solids in water include silt, clay, pipe work debris, organic matter, and colloids.

Usually up to about 2000 ppm (parts per million) or (mg/l) of suspended clay or silt can be tolerated.

Since the mix water quickly becomes a highly alkaline solution, organic materials may dissolve during mixing and subsequently retard setting and strength development by interfering with cement hydration.

Organic impurities may also entrain excessive amounts of air, thereby reducing strength, or, conversely, they may interfere with the action of air-entraining agents.

Water containing Total dissolved solids (TDS) less than 2000 ppm of dissolved solids can in most instances be used safely, although this depends on the nature of the dissolved material.

Use of Sea Water for Mixing Concrete: Sea water has a salinity of about 3.5 per cent. In that about 78% is sodium chloride and 15% is chloride and sulphate of magnesium. Sea water also contain small quantities of sodium and potassium salts. This can react with reactive aggregates in the same manner as alkalies in cement. Therefore, sea water should not be used even for Public Construction Concrete if aggregates are known to be potentially alkali reactive.

It is reported that the use of sea water for mixing concrete does not appreciably reduce the strength of concrete although it may lead to corrosion of reinforcement in certain cases.

Research workers agree that seawater can be used in un-reinforced concrete or mass concrete. Sea water slightly accelerates the early strength of concrete. But it reduces the 28 days strength of concrete by about 10 to 15 per cent. However, this loss of strength could be made up by redesigning the mix.

Soluble salts may be added deliberately as admixtures, the most common example being CaCl_2 , which is used as an accelerating agent. Soluble carbonates and bicarbonates can promote rapid setting; large quantities of carbonates and sulfates may cause a reduction in 28-day strength or long-term strength.

Some soluble inorganic salts may retard the setting and hardening of concrete. Soluble inorganic salts of up to 500 ppm can generally be tolerated in mixing water.

Organic acids may affect the setting and hardening of concrete. Alkaline waters, containing sodium or potassium hydroxide, may cause quick setting and low strengths at concentrations above 500 ppm.

Organic impurities in water usually arise from the decay of vegetable matter. These include detergents, fats, oils, solvents, and residues from pesticides and herbicides. In addition, water-borne organics may include compounds leached from pipe lines, tanks, and purification media.

Colored natural water generally indicates the presence of dissolved organic material, mostly tannic and humic acids, which may retard the hydration of cements. Many organic compounds that occur in industrial wastes may also severely affect the hydration of cement or entrain excessive amounts of air.

Thus, **untreated industrial wastewaters** should be used with caution, but if they have passed through a sewage treatment process, the organic matter will be reduced to safe levels.

Tolerable Concentrations of some impurities in Mixing Water

Impurity		Tolerable Concentration
Sodium and potassium carbonates and bi-carbonates	:	1,000 ppm (total). If this is exceeded, it is advisable to make tests both for setting time and 28 days strength
Chlorides	:	10,000 ppm.
Sulphuric anhydride	:	3,000 ppm
Calcium chloride	:	2 per cent by weight of cement in non-pre-stressed concrete
Sodium iodate, sodium sulphate, sodium arsenate, sodium borate	:	very low
Sodium sulphide	:	Even 100 ppm warrants testing
Sodium hydroxide	:	0.5 per cent by weight of cement, provided quick set is not induced.
Salt and suspended particles	:	2,000 ppm. Mixing water with a high content of suspended solids should be allowed to stand in a settling basin before use.
Total dissolved salts	:	15,000 ppm.
Organic material	:	3,000 ppm. Water containing humic acid or such organic acids may adversely affect the hardening of concrete; 780 ppm. of humic acid are reported to have seriously impaired the strength of concrete. In the case of such waters therefore, further testing is necessary.
pH	:	shall not be less than 6

Table 4.1: Limits of impurities in mixing water, mg per litre (ppm)

Impurity	BS 3148: 1980	BS EN 1008: 2002	ASTM C 1602/C 1602M-06
Chloride ion:			
prestressed concrete	500	500	500*
reinforced concrete		1000	1000
plain concrete		4500	...
Sulfate	1000 (SO ₃)	2000 (SO ₃)	3000 (SO ₄)
Alkali	1000	1500	600

4.3 Water for curing

The requirements for curing water are less stringent than those discussed above, mainly because curing water is in contact with the concrete for only a relatively short time. Such water may contain more inorganic and organic materials, sulfuric anhydride, acids, chlorides, and so on, than an acceptable mixing water.

Nevertheless, the permissible amounts of the impurities are still restricted. In cases of any doubt, water samples should be sent to a laboratory for testing and recommendations.