

INTRODUCTION

- Water is the most important and least expensive ingredient of concrete. A part of mixing water is utilized in the hydration of cement to form the binding matrix in which the inert aggregates are held in suspension until the matrix has hardened. The remaining water serves as a lubricant between the fine and coarse aggregates and makes concrete workable, i.e., readily place able in forms.
- Generally, cement requires about three-tenth of its weight of water for hydration. Hence the minimum water-cement ratio required is 0.30. But the concrete containing water in this proportion will be very harsh and difficult to place. Additional water is required to lubricate the mix, which makes the concrete workable. This additional water must be kept to minimum, since too much water reduces the strength of concrete. The water-cement ratio is influenced by the grade of concrete, nature and of types of aggregates, the workability and durability, etc.
- If too much water is added to concrete, the excess water along with cement comes to the surface by capillary action and this cement water mixture forms a scum or thin layer of chalky material known as laitance. This laitance between prevents bond formation between the successive layers of concrete and forms a plane of weakness. Excess water may also leak through the joints of the formwork and make the concrete honeycombed. As a rule, the smaller the percentage of water, the stronger is the concrete subject to the condition that the required workability is available.

QUALITY OF MIXING WATER

- The water used for the mixing and curing of concrete should be free from injurious amounts of deleterious materials. The unwanted situations, leading to the distress of concrete, have been found to be a result of, among others, the mixing curing water being of inappropriate quality. Potable water from the sources is generally considered satisfactory for mixing concrete. In the case of doubt about the suitability of water, particularly in remote areas or where water is derived from sources not normally utilized for domestic purposes, water should be tested.

Effect of Impurities in Water on Properties of Concrete

- The strength and durability of concrete is reduced due to the presence of impurities in the mixing water. The effects are expressed mainly in terms of difference in the setting times of Portland cement mixes containing proposed mixing water as compared to distilled water, and concrete strengths compared with those of control specimens prepared with distilled water. A difference in 28-days compressive strength up to 10 per cent of control test is generally considered to be a satisfactory measure of the quality of mixing water. IS: 456-2000 prescribes a difference in initial setting time of ± 30 minutes with initial setting time not less than 30 minutes. The effluents from sewerage works, gas works, and from paint, textile, sugar and fertilizer industry are harmful for concrete. The tests shows that water containing excessive amounts of dissolved salts reduces compressive strength by 10 to 30 per cent of that obtained using potable water. In

addition, water containing large quantities of chlorides tends to cause persistent dampness, surface efflorescence and increases the corrosion of the reinforcing steel. The problem is more in tropical regions, particularly with lean mixes.

The adverse effects on compressive strength of concrete due to various dissolved Salts are given in Table 4.1.

Table 4.1 Effects of dissolved salts in water on compressive strength

Percentage of salt in water	Percentage reduction in compressive strength
0.5 SO ₄	4
1.0 SO ₄	10
5.0 NaCl	30
CO ₂	20

The effects of various impurities on the properties of concrete are summarized below.

Suspended Particles

- The presence of suspended particles of clay and silt in the mixing water up to 0.02 per cent by weight of water does not affect the properties of concrete. Even higher percentage can be tolerated so far as strength is concerned, but other properties of concrete are affected. IS: 456-2000 allows 2000 mg/liter of suspended matter. The muddy water should, however, remain in settling basins before use

Miscellaneous Inorganic salts

- The presence of salts of manganese, tin, zinc, copper and lead in water causes reduction in the strength of concrete. The zinc chlorides retard the setting of concrete to such an extent that no strength tests are possible at 2 and 3 days. The effect of lead nitrate is completely destructive, some salts like sodium iodate, sodium phosphate, sodium arsenate and sodium borate reduce the initial strength of concrete to a very low degree.
- The carbonates of sodium and potassium may cause extremely rapid setting and in large concentrations, reduce the concrete strength. On the other hand, the presence of calcium chloride accelerates setting and hardening. The quantity of calcium chloride is restricted to 1.5 per cent by weight of cement.

Salts in seawater

- Seawater generally contains 3.5 per cent of dissolved salts. The chemical composition of seawater throughout the world is remarkably uniform and all the chloride is associated with sodium except for a very small amount with potassium and all the sulfate is associated with magnesium. The approximate percentages of various ions due to the salts in seawater are: chloride, 51.3; sulphate, 7.2; sodium, 28.5; magnesium, 3.6; calcium, 1.3;

potassium. 1.0 .However, the total amount of any ion varies widely. For a given mass of seawater the ingress into the concrete of any given ion is proportional to the salinity of that seawater. From the standpoint of chemical effects of seawater on plain or unreinforced concrete, it is the sulfate content which is problematic, hence. The need for sulfate-resisting cement. However, this need is greatly reduced by employing concrete of lower water-cement ratio. The salts present in seawater reduce the ultimate strength of concrete. The reduction in strength of concrete may be of the order of 10 to 20 per cent. However, the major concern is the risk of corrosion of reinforcing steel due to chlorides. In general, the risk of corrosion of steel is more when the reinforced concrete member is exposed to air than when it is continuously submerged under water. The presence of chlorides in water is also responsible for efflorescence. It is advantageous to use cement with as much C3A as can be tolerated without incurring sulfate attack in concrete containing corrodible metal. The more is the C3A in the cement, the more chloride ion will be intercepted by aluminate (precipitated as non-detrimental calcium chloroaluminate), taking longer for the ions to build up at the surface of the steel.

- There are two sources for the presence of chloride ion in the concrete, the first is calcium chloride added as an accelerating admixture and the second one is the intentional use of seawater as mixing water. For normal cements that are not highly sulfate-resisting, the use of CaCl_2 reduces the sulfate-resistance, but not when appropriate sulfate-resisting cement is employed. The use of CaCl_2 as an accelerator can be permitted in cold weather with sulfate-resisting cement to the same limited extent as with ordinary cements. However, the codes forbid the use of calcium chloride when sulfate-resisting cement is being used. Under unavoidable circumstances, it may be used for plain concrete when it is constantly submerged in water.

Acids and Alkalies

- The industrial waste water containing acids or alkalies is usually unsuitable for concrete construction. With reference to acidity, the water having pH value higher than 6 can be used. However, the pH value may not be a satisfactory measure of the amount of acid. The effect of acidity in water is best gaged on the basis of total acidity, the extent of which should satisfy the following requirement:
- The amount of 0.02 normal NaOH required to neutralize 100 ml sample of water using phenolphthalein as indicator should not be more than 5 ml.
- This acidity is equivalent to 49 ppm of H_2SO_4 or 36 ppm of HCl.

Algae

- Algae may be present in mixing water or on the surface of aggregate particles. It combines with cement and reduces the bond between aggregates and cement paste. The water containing algae has the effect of entraining large quantities of air in concrete and thus lowering the strength of concrete.

Sugar

- If the amount of sugar present in the mixing water is less than 0.05 per cent by weight of water there is no adverse effect on the strength of concrete. Small amounts of sugar up to 0.15 per cent by weight of cement retard the setting of cement and the early strengths may be reduced whereas the 28-day strength may be improved. When the quantity of

sugar is increased to 0.20 per cent by weight of cement, setting is accelerated. When quantity is further increased, rapid setting may result and 28-day strength is reduced.

Oil Contamination

- Mineral oils not mixed with animal or vegetable oils have no adverse effect on the strength of concrete. If the concentration of mineral oil is up to two per cent by weight of cement, a significant increase in strength has been noticed. For a percentage of mineral oil (more than eight per cent), the strength is slightly reduced. The vegetable oils have detrimental effect on the strength of concrete, particularly at later ages.

Limit of Impurities in Water

- The amounts of solid impurities in the mixing water shall be restricted as per the Table 4.2. The pH value of water suitable for concrete construction shall generally be between 6 and 8. The water which is fit for drinking purposes will be fit for concrete construction. The test for determination of solid contents shall be conducted as per IS: 3025.

Table 4.2 Limits of permissible impurities

Type of impurities	Permissible percentage of solids by weight of water
Organic	0.02
Inorganic	0.30
Sulfates (as SO ₃)	0.04
Alkali Chlorides (as Cl ₂)	
(a) Plain concrete	0.20
(b) Reinforced concrete	0.05

CURING WATER

- The use of water in curing the concrete is intended to penetrate the concrete. If steps are taken to prevent loss of water from the concrete, no added water will be needed as a part of curing process except in the circumstances: (i) when the water-cement ratio is less than 0.4; and (ii) when the concrete is produced using expansive cement. Even at a water-cement ratio of 0.48, empty capillary pores exist, however, there is enough water in the mixture for hydration to proceed to completion, but it is necessary for the water to be uniformly distributed throughout the mass of concrete. In structural members, there is inevitably some loss of water by evaporation from the surface. Consequently, hydration may effectively proceed in the interior of the member but, near the surface, there is an inadequate amount of water in the capillaries so that penetration by curing water is highly desirable. However, if the water used for curing is seawater, chloride ions enter

the surface zone and from there move inwards by diffusion. From the standpoint of durability, it is the near surface zone that is much more important than the concrete in the interior of the mass-many durability problems start at the surface or through attack progressing from the surface inwards.

- In the case of marine structures cast on land, but destined for immersion in the sea, the risk of imbibitions of seawater is high, unless thorough curing with fresh water has been done previously.
- The water which is satisfactory for mixing concrete can also be used for curing it but should not produce any objectionable stain or unsightly deposit on the surface. Iron and organic matter in the water are chiefly responsible for staining or discoloration and especially when concrete is subjected to prolonged wetting, even a very low concentration of these can cause staining. According to IS: 456-2000, the presence of tannic acid or iron compounds in curing water is objectionable.
- It is generally recommended that the seawater should not be used as mixing water for hydraulic-cement concrete works containing corrodible embedded ferrous metals, particularly in the tropics. However, under unavoidable circumstances it may be used for mixing and curing in plain concrete after due evaluation of possible disadvantages and consideration of the use of appropriate cement system.