Effect of Water Cement Ratio

The *water/cement ratio* is defined as the ratio of the weight of water to the weight of cement used in a concrete mix. Let us consider the following two cases

Case 1 : *When the water/cement ratio is* ***high.***

If the w/c ratio is high, a large amount of water is available per unit weight of cement in the concrete mix. So if a fixed volume of concrete is poured into a cube of formwork, there are a large number of water-filled voids in the cube. So when the hydration reaction starts on the surface of the cement particle, the gel-like products of hydration get precipitated in the water - away from the surface of cement particles.

The gels formed in such a case are termed as *Outer Products of Hydration.* Now there are two reasons why the strength of concrete is low in this case, namely –

1. Since there is a large space for them to develop, the outer products of hydration are large in size. And we know, from the *size effect,* that *larger sized particles have lower strength compared to particles of smaller size.*
2. No matter how high the water consumption rate of the reaction is, due to the large amount of water present in the mix, some water will still be left when the concrete hardens and is ready for use. This trapped water will gradually evaporate, leaving some voids in the concrete block. The presence of voids results in greatly reduced strength.

Case 2 : *When the water/cement ratio is* ***low.***

In this case, there will be very less amount of water in the block of formwork when the concrete is poured into it, and hence lesser voids. When the hydration reaction proceeds, the gels formed do not have enough space to migrate out and precipitate in the voids. So they get deposited on the surface of the cement particle itself. Such products of hydration are termed as *Inner Products of Hydration.* The space available for the crystals to grow is limited, so they remain much smaller in size compared to the outer products of hydration.

The strength of concrete is more when the w/c ratio is low, because of the following reasons -

1. As per the law of *size effect,* the smaller sized gels formed in this case have much greater strength as compared to those formed when the w/c is high.
2. Since the water available for hydration is very less, almost all of it is utilized during the reaction. So no water is left to get evaporated later, and hence the strength-reduction due to subsequent void formation is also much lower when the w/c ratio is low.