Lecture 7

3- Shrinkage of Concrete

• Shrinkage of Concrete

Shrinkage of concrete is the time-dependent strain measured in an unloaded and unrestrained specimen at constant temperature The term shrinkage is used to describe the various aspects of volume changes in concrete due to loss of moisture at different stages due to different reasons.

- *Types of shrinkage of concrete*

1. Plastic Shrinkage:

- this type of shrinkage happens soon after the concrete is placed in the forms while the concrete is still in the plastic state. Loss of water by evaporation from the surface of concrete or by the absorption by aggregate results in a reduction of volume, this causes the concrete on the surface to collapse.
- The aggregate particles or the reinforcement comes in the way of subsidence due to which cracks may appear at the surface or internally around the aggregate or reinforcement
- High water/cement ratio, badly proportioned concrete, rapid drying, greater bleeding, unintended vibration etc., are some of the reasons for plastic shrinkage.
- Plastic shrinkage can be reduced mainly by preventing the rapid loss of water from surface.
- It can be reduced by covering the surface with polyethylene sheeting immediately after it is poured

2.Drying Shrinkage:

- The loss of free water contained in hardened concrete does not result in any appreciable dimension change. It is the loss of water held in gel pores that causes the change in the volume.
- Just as the hydration of cement is an everlasting process, the drying shrinkage is also an everlasting process when concrete is subjected to drying conditions.
- Under drying conditions, the gel water is lost progressively over a long time, as long as the concrete is kept in drying conditions.
- The magnitude of drying shrinkage is also a function of the fineness of gel, The finer the gel the more is the shrinkage.
- It has been pointed out earlier that the high-pressure steam cured concrete with low specific surface of gel, shrinks much less than that of normally cured cement gel.

Factors Affecting Drying Shrinkage

- Type, content and proportion of the constituent materials of concrete (cement, water, aggregates, etc.),
- Size and shape of the concrete structure,
- Amount and distribution of reinforcement, • •Relative humidity of the environment.
- Drying shrinkage is directly proportional to the water-cement ratio and inversely proportional to the aggregate-cement ratio.
- the interaction of the effects of aggregate-cement and water-cement ratios, it is possible to have a rich mix with a low water-cement ratio giving higher shrinkage than a leaner mix with a higher water-cement ratio

3.Autogenous Shrinkage:

• In a conservative system i.e. where no moisture movement to or from the paste is permitted, when the temperature is constant some shrinkage may occur. The shrinkage of such a conservative system is known as an autogenous shrinkage. **Autogenous shrinkage** is of minor importance and is not applicable in practice to many situations except that of a mass of concrete in the interior of a concrete dam.

4. Carbonation Shrinkage:

- Carbonation shrinkage is a phenomenon very recently recognized and is very important.
- Carbon dioxide present in the atmosphere reacts in the presence of water with hydrated cement.
- Calcium hydroxide [Ca(OH)2] gets converted to calcium carbonate and also some other cement compounds are decomposed.
- Such a complete decomposition of calcium compound in hydrated cement is chemically possible even at the low pressure of carbon dioxide in normal atmosphere.
- Carbonation penetrates beyond the exposed surface of concrete only very slowly.
- The rate of penetration of carbon dioxide depends also on the moisture content of the concrete and the relative humidity of the ambient medium.

1..Plastic shrinkage

2..Drying shrinkage:

3..Autogeneous shrinkage:

4..Carbonation shrinkage:

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Factors Affecting Shrinkage

1..Drying conditions:

- The most important factor is the drying condition or the humidity in the atmosphere.
- No shrinkage will occur if the concrete is placed in one hundred percent relative humidity.

2..Time:

- The shrinkage rate will decrease rapidly with time.
- It has been documented that fourteen to thirty-four percent of the twenty year shrinkage will occur within two weeks of it being poured.
- Within one year of the concrete being poured, shrinkage will be about sixty-six to eighty-five percent of the twenty year shrinkage.

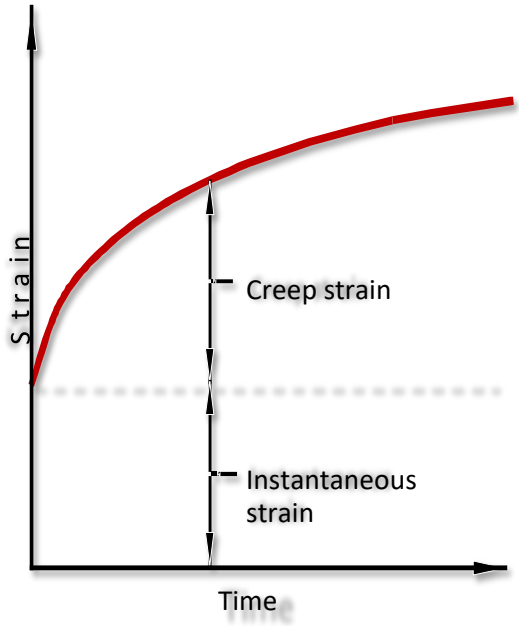
3..Water cement ratio:

- The water to **cement ratio** will influence the amount of shrinkage that occurs.
- The concrete's richness also affects the shrinkage.
- The process of swelling and then drying affects the concrete's integrity and the shrinkage.

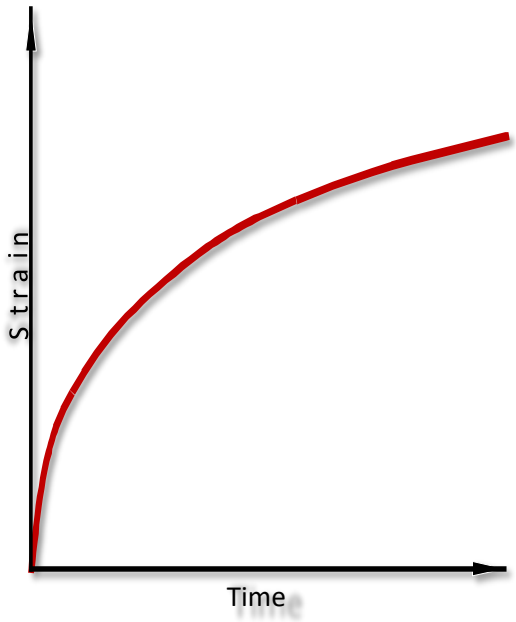
Effects of Shrinkage

- Shrinkage of concrete between movement joints causes joints to open or makes it wider. Therefore joints must be designed to accommodate the widening caused by shrinkage.
- Where other materials, such as ceramic tiles, are fixed on top of concrete surface, shrinkage of the concrete causes relative movement between the different materials. The resulting stresses can cause failure at the interface.
- If shrinkage is restrained, the concrete is put into tension and when tensile stress becomes equal to tensile strength, the concrete cracks
- Shrinkage of the concrete causes the concrete to grip reinforcing bars more tightly. This increases friction between concrete and steel and so improves bond strength, especially for plain bars
- The deflection of flexural members is increased by shrinkage. This is because the lightly reinforced compression zone is free to shrink more than heavily reinforced tension zone
- Shrinkage causes a reduction in pre-stressing force. When calculating pre-stressing forces, designers take into account to ensure that residual stress is structurally adequate

Creep and Shrinkage Typical Time Curve



TYPICAL CREEP – TIMECURVE



TYPICAL SHRINKAGE – TIMECURVE