# CONCRETE TECHNOLOGY (IV Sem)

## Unit-2

**(Part-3 Short Notes)**

### Modulus of Elasticity:

The modulus of elasticity of concrete would be a property for the grace when the material is treated as elastic. Young's modulus ( E ) describes tensile elasticity, or the tendency of an object to deform along an axis when opposing forces are applied along that axis; it is defined as the ratio of tensile stress to tensile strain. It is often referred to simply as the elastic modulus.

When reinforced concrete is designed by elastic theory it is assumed that a perfect bond exists between concrete and steel. The stress in steel is "m" times the stress in concrete where "m" is the ratio between modulus of elasticity of steel and concrete, known as modulus ratio. The accuracy of design will naturally be dependent upon the value of the modulus of elasticity of concrete because the modulus of elasticity of steel is more or less a definite quantity.

Modulus of elasticity may be measured in tension, compression or shear. The modulus in tension is usually equal to the modulus in compression.

The modulus of elasticity of concrete is a function of the modulus of elasticity of the aggregates and the cement matrix and their relative proportions. The modulus of elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develops. The elastic modulus of the hardened paste may be in the order of 10-30 GPa and aggregates about 45 to 85 GPa. The concrete composite is then in the range of 30 to 50 GPa.

### Shrinkage:

Concrete is subjected to changes in volume either autogenous or induced. Volume change is one of the most detrimental properties of concrete, which affects the long-term strength and durability. To the practical engineer, the aspect of volume change in concrete is important from the point of view that it causes unsightly cracks in concrete. The term shrinkage is used to describe the various aspects of volume changes in concrete due to loss of moisture different stages due to different reasons.

Hardened Concrete undergoes in three types of shrinkage that are important with respect to its dimensional stability:

1. Plastic shrinkage.
2. Drying shrinkage.
3. Carbonation shrinkage.

1. **Plastic shrinkage-** The hydration of cement causes a reduction in the volume of the system of cement class water to an extent of about 1% of the volume of dry cement. This contraction is plastic strain and is due to loss of water by evaporation from the surface of concrete, particularly under hot climates and high winds this can result in surface cracking.

2. **Drying shrinkage-** The shrinkage that takes place after the concrete has set and hardened is called drying shrinkage and most of it takes place in the first few months. Withdrawal of water from concrete stored in unsaturated air voids causes drying shrinkage. A part of this shrinkage is recovered on immersion of concrete in water. It is termed moisture movement.

3. **Carbonation shrinkage-** The carbon dioxide ($CO_2$) present in atmosphere reacts in the presence of moisture with the hydrated cement minerals, carbonating $Ca(OH)_2$ to $CaCO_3$. The carbonation penetrates beyond the exposed surface of concrete only slowly. Carbonation is accompanied by increase in weight and shrinkage. The shrinkage due to carbonation occurs mainly at intermediate humidities. Carbonation also results in increased strength and reduced permeability. The only advantage of shrinkage is that it causes the concrete to grip the Steel tightly does increasing the bond.

**Shrinkage is affected by the following factors:**

1. **Water- Cement ratio-** The shrinkage increases with the increase in the water-cement ratio.
2. **Cement content-** The shrinkage increases with cement content
3. **Ambient humidity-** The shrinkage increases with the decrease in humidity and the immersion in water causes expansion.
4. **Type of aggregate-** The aggregate which exhibit moisture movement themselves and have low elastic modulus cause large shrinkage. An increase in maximum size decreases the shrinkage. The grading and shape has little effect on shrinkage.
5. **Size and shape of specimen-** Both the rate and the ultimate magnitude of shrinkage decreases with surface/volume ratio of the specimen.
6. **Type of cement-** The rapid hardening cement shrinks some what more than the others.
7. **Admixtures-** The shrinkage increases with the addition of calcium chloride and reduces with lime replacement.
8. **Other factors-** The steam curing has little effect on shrinkage unless applied at high pressure.

**Creep:**

Creep is defined as the deformation of structure under sustained load. Basically, long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is being applied. Like a concrete column getting more compressed, or a beam bending. Creep does not necessarily cause concrete to fail or break apart. When a load is applied to concrete, it experiences an instantaneous elastic strain which develops into creep strain if the load is sustained.

The increase of strain in concrete with time under sustained stress is termed creep. The shrinkage and creep occur simultaneously and they are assumed to be additive for simplicity. When the sustained load is removed, the strain decreases immediately by an amount equal to the elastic strain at the given time. This instantaneous recovery is then followed by a gradual decrease in strain, called creep recovery which is a part of the total creep strain suffered by the concrete. If a loaded specimen is viewed as being subjected to a constant strain, the creep decreases the stress progressively with time. This is called relaxation.

The rate of creep decreases with time. Types of aggregate, cement , admixtures, entrained air, mix proportions, mixing time and consolidation, age of concrete, level of sustained stress, ambient humidity, temperature, and the size of the specimen are among the factors influencing creep.

**Durability:**

Durability is the second most important quality of hardened concrete. It may be defined as the capacity of hardened concrete to withstand all the forces of deterioration that are likely to act on it, after setting, in a given environment. A durable it is the one that performs satisfactorily under anticipated exposure conditions during its service life span. Even though concrete is a durable material requiring little or no maintenance in normal environment but when subjected to highly aggressive or hostile environments it has been found to deteriorate resulting in premature failure of structures a reach state requiring costly repairs. Main characteristics influencing the durability of concrete is its permeability to the ingress of water, oxygen, carbon dioxide, chloride, sulphate and other potentially deleterious substances.

Among these forces, the following are more likely to act are:

4. Frost action.
5. Abrasive forces.
6. Chemical action.
7. Alkali-aggregate reaction.

**Causes of lack of durability:**

The factors affecting the durability may be external or internal causes. The external causes may be physical chemical and mechanical which are grouped in the following categories:

1. Environmental, occurrence of extreme temperatures, abrasion and electrostatic actions.
2. Attack by natural or industrial liquid and gases.

The internal causes include the following:

1. Alkali-aggregate reaction.
2. Volume change due to difference in thermal properties of the aggregate and cement paste.

Common forms of chemical attack are:

(i) Leaching out of cement
(ii) Carbonation
(iii) Chloride-ion penetration
(iv) Sulphate-attack
(v) Marine environment
(vi) Natural slightly acidic water.

**Thermal properties of concrete:**

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Concrete is a material used in all climatic regions for all kinds of structures. The important properties that will be discussed are:

- � Thermal conductivity
- � Thermal diffusivity
- � Specific heat
- � Coefficient of thermal expansion

**1. Thermal Conductivity**

This measures the ability of material to conduct heat. Thermal conductivity is measured in joules per second per square meter of are conductivity of concrete depends on type of aggregate a of body when the temperature difference is 1degree C per meter thickness of the body.

The conductivity of concrete depends on type of aggregate moisture content, density and temperature of concrete. When the concrete is saturated, the conductivity ranges generally between about 1.4 to 3.4 $Jm/m^2s^oC$

**2. Thermal Diffusivity**

Diffusivity represents the rate at which temperature changes within the concrete mass. Diffusivity is simply related to the conductivity by the following equation:

**Diffusivity=Conductivity/CP**

Where C is the specific heat, and P is the density of Concrete. The range of diffusivity of concrete is between 0.002 to 0.006$m^2$/h

**3. Specific heat**

It is defined as the quantity of heat, required to raise the temperature of a unit mass of a material by one degree centigrade. The common range of values for concrete is between 840 to 1170 j/$^{kg3/C}$

**4. Coefficient Thermal Expansion**

It is defined as the change in unit length per degree change of temperature. In concrete, it depends upon the mix proportions. The coefficient of thermal expansion of hydrated cement paste varies between $11x10^{-6}$ and $20x10^{-6}$ per degree C. The coefficient of thermal expansion of aggregates varies between $5x10^{6}$ and $12x10^{-6}$ per degree C Limestone and Gabbro will have low values and gravel and Quartzite will have high values of coefficient of thermal expansion.

**Acid Attack:**

Concrete also used for storing liquids, some of which harmful for concrete. In industrial plants concrete floors come in contact with liquids which damage the floor. In damp conditions, $SO_2$ and $CO_2$ and other acid fumes present in the atmosphere affect concrete by dissolving and removing part of the set cement. Concrete is also attacked by water containing free $CO_2$. Sewage water also very slowly causes deterioration of concrete.

**Efflorescence:**

The water leaking through cracks or faulty joints or through the areas of poorly compacted porous concrete, dissolves some of the readily soluble calcium hydroxide and other solids, and after evaporation leaves calcium carbonate as white deposit on the surface. These deposits on the surface of concrete resulting from the leaching of calcium hydroxide and subsequent carbonation and evaporation, are termed efflorescence. Unwashed seashore aggregate, gypsum and alkaline aggregate also cause efflorescence.

**Fire Resistance:**

Fire resistance of concrete is the ability of concrete to withstand fire or to give protection against fire. This involves the ability of concrete structural element to continue perform a specific structural function or confine fire or both.

Fire resistance is controlled by both the physical and thermal properties of the structural element. Factors governing the structural performance include stress level in the concrete and the steel, concrete cover, tendency of aggregate and free moisture to cause spalling, and lateral restraint conditions.

Concrete has good properties with respect to fire resistance i.e. , time under fire during which concrete continues to perform satisfactorily is relatively high and no toxic fumes are emitted. The length of time over which the structural concrete preserves structural action is known as fire rating. Under sustained exposure to temperature in excess of 35 degree celsius along with the condition that a considerable loss of moisture from concrete is allowed leads to decrease in strength and modulus of elasticity. The loss of strength at higher temperatures is greater in saturated then and dry concrete. Excessive moisture at the time of fire is the primary cause of spalling.

Leaner mixes appear to suffer a relatively lower loss of strength than rich ones. Low conductivity of concrete improves its fire resistance, and hence a lightweight concrete is more fire resistant than ordinary concrete. The calcined material aggregate having a low density leads to a good fire resistance of concrete.

**Water Tightness or Im-permeability:**

Water-tightness is the ability of concrete to keep water out or in. Watertight is a versatile range of specialized ready mix concretes designed to protect a structure from water ingress or to retain water within a structure.
Water-tight concrete, or concrete made water-tight by some kind of waterproof coating, is frequently required, either for inclosing a space which must he kept dry, or for storing water or other liquids. Concrete, even when most carefully prepared from materials of the highest grade, is never of itself completely waterproof.

When excess of water in concrete evaporates, it leaves voids inside the concrete element creating capillaries which are directly related to the concrete porosity and permeability. The volume of water which may pass through concrete depends in its permeability. Permeability is governed by porosity, which in turn is a direct consequence of the water-cement ratio of the concrete mix. By proper selection of ingredients and mix proportioning, and following good construction practices almost impervious concrete can be obtained. The well-packed aggregate has reduced the amount of space to be filled by water and cement paste. This has helped to improve the pore structure of concrete and hence, its permeability

The study of permeability of concrete is important for the following reasons:

1. The permeability by materials in solution may adversely affect the durability of concrete.
2. In case of reinforced concrete, ingress of moisture and air will result in corrosion of steel which leads to an increase in the volume of steel, and to cracking and spalling of concrete cover.
3. The moisture penetration depends on permeability and if the concrete can become saturated with water it is more vulnerable to frost action.

4. The permeability is also important in connection with water tightness of liquid retaining structures and the problem of hydrostatic pressure in the interior of the dams.

**Micro-cracking in Concrete:**

The term micro cracking refers to very small cracks that form in concrete but are not visible to the naked eye. Some micro cracking occurs as a natural part of the cement hydration process, but it also occurs as compressive loads are applied. Bond cracks form where the coarse aggregate and the cement meet.

Micro-Cracking of concrete can be defined as a separation of the individual components of concrete resulting in discontinuous material. Depending upon the extent of cracks can be classified as micro-cracks, macro-cracks and semi micro-cracks.

According to the location, the cracks can classify as bond cracks, mortar cracks, and aggregate cracks. The bond cracks are formed at the interface of the aggregate and mortar, whereas the mortar cracks and aggregate cracks are formed through the mortar and the aggregate, respectively.

A knowledge of the microcracking of concrete contributes considerable to the understanding of its properties such as its inelastic nature, the descending portion of the stress strain curve, the strength under combined, repeated and sustained loading. The stress-strain curve is related to the internal cracking. The non-linearity of the stress-strain relation is due to the propagation of bond and mortar cracks. The bond between aggregate and mortar plays an important role in controlling the strength characteristics of concrete.