4.3 DETERMINATION OF STRENGTH PROPERTIES OF HARDENED CONCRETE

Properties Of Hardened Concrete

1. Strength

(A) Compressive Strength

(B) Tensile

(C) Shear Or Flexural

2. Durability

3. Permeability

4. Dimensional Stability

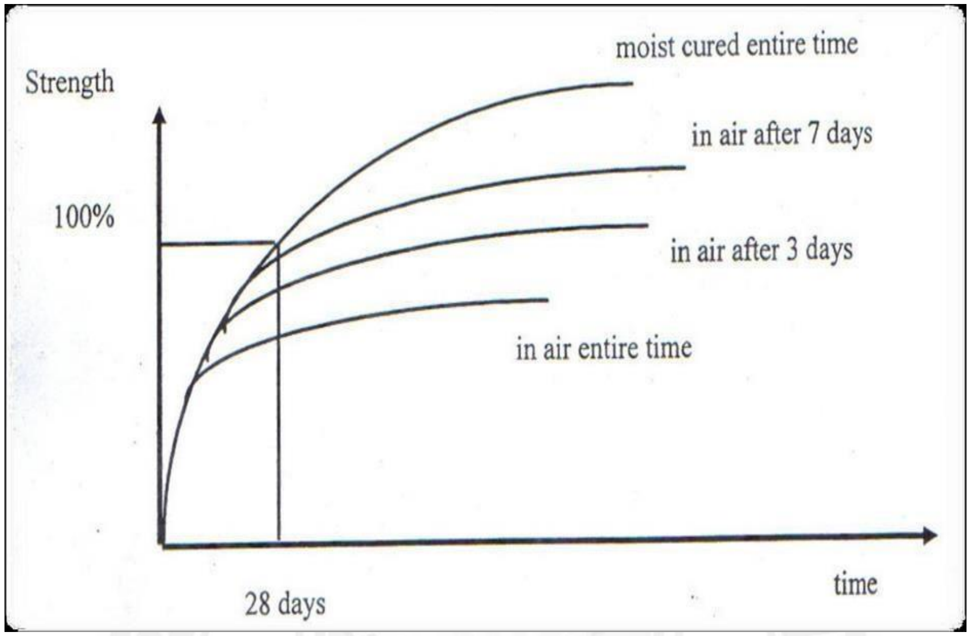
5. Creep

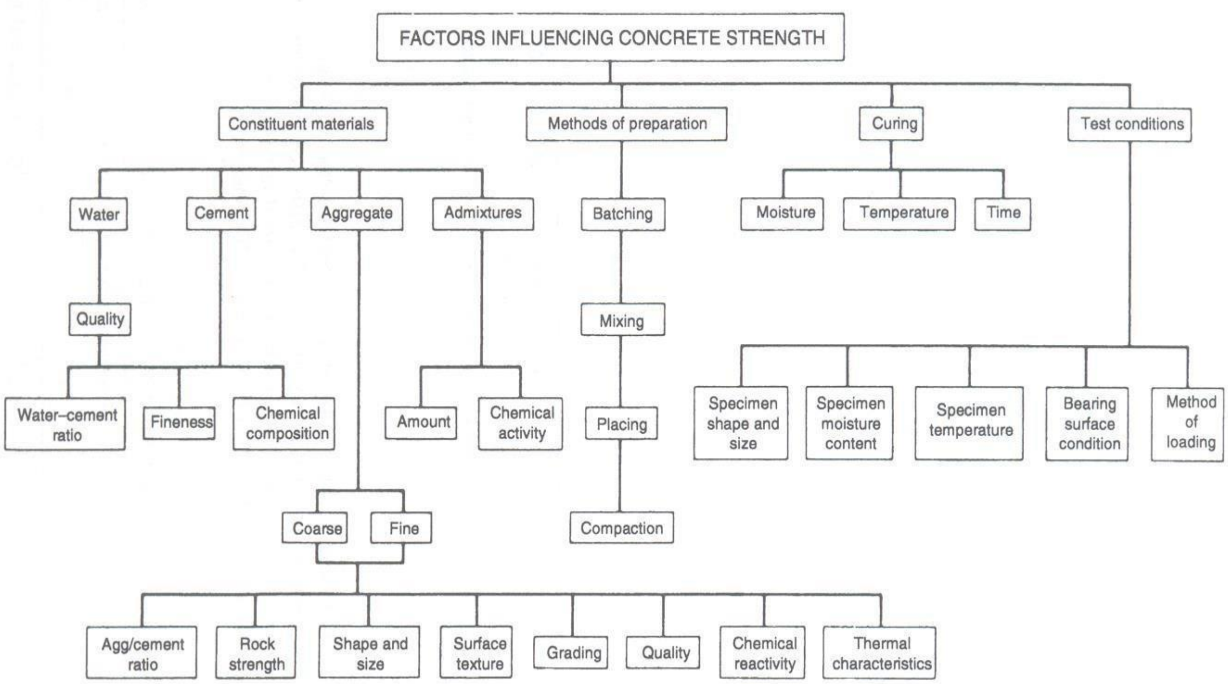
6. Shrinkage

7. Modulus Of Elasticity

1. Strength

- Strength of concrete is defined as the max stress it can resist or the max it can carry.
- Cubes, cylinders and prisms are the 3 type of compression test specimens.
- Flexural tensile test is used to estimate the load at which the concrete members may crack.
- Compressive Strength taken as the maximum compression load it can carry per unit area.





- Many destructive and non-destructive tests are conducted on hardened concrete to measure their properties such as strength, permeability and durability;

Destructive testing (Specimen is broken down) →

- **Compressive strength test**
- **Flexural Strength test**
- **Splitting tensile test**
- **Modulus of elasticity**
- Pull out test etc.

Non-Destructive testing (Specimen is not broken down) →

- Ultrasonic pulse velocity test
- Rebound hammer test
- Electrical resistivity test
- Other corrosion studies

– Before starting these tests some of the points should be considered,

- Concrete mix should be uniform and well compacted
- Curing should be proper
- At least three specimens are needed for a single test and average value of these three specimens is taken.

Each specimen test result should not exceed 5% of the result of other specimens, if exceeded it indicates the poor mix of concrete.

FACTOR INFLUENCING THE STRENGTH OF CONCRETE

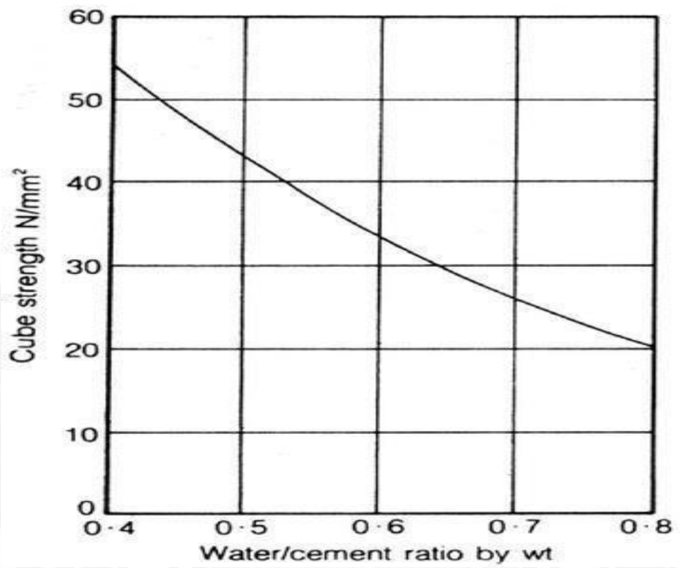
1. Influence of the constituent materials.

a) Cement

- Fineness of cement increase strength.
- Chemical composition.
- Type of cement (eg. RHPC, SRPC, LHPC).

b) Water

- Water cement ratio (w/c) required for hydration process.
- The lower w/c, the greater is the compressive strength and vice versa.



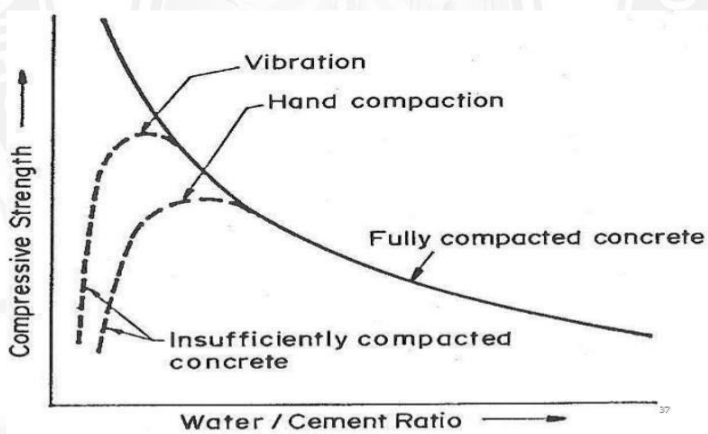
c) Aggregate

- Bond strength between aggregate influence by surface texture, shape and cleanliness.
- The compressive strength of concrete tends to increase with the decrease in the size of coarse aggregate. This due to the facts that smaller size aggregates provide larger surface area for bonding with the mortar matrix.
- Aggregate surface roughness has a considerable effect on bond strength (greater the roughness, higher is the bond strength) due to improvement in mechanical interlocking.

- **d) Admixture**
- Effect of particular admixture (eg. accelerator, retarder, plasticizer etc.) depend on the precise nature of the admixtures themselves.

2. Degree of Compaction

- Proper compaction increase strength.
- When the concrete compacts, it has a very low porosity, thus result in a very high strength.
- The increase in the strength of concrete is probably influenced by the volume of voids in concrete i.e. entrapped air, capillary pores, gel pores or entrained air.



Influence of curing

- Curing is used for promoting the hydration of cement and consists of a control of temperature and moisture movement from and into the concrete.
- The longer period of curing, the greater its final strength.

- Early-age: ages less than 7 days
- Later-age: ages exceeding 28 days.

Influence of test conditions

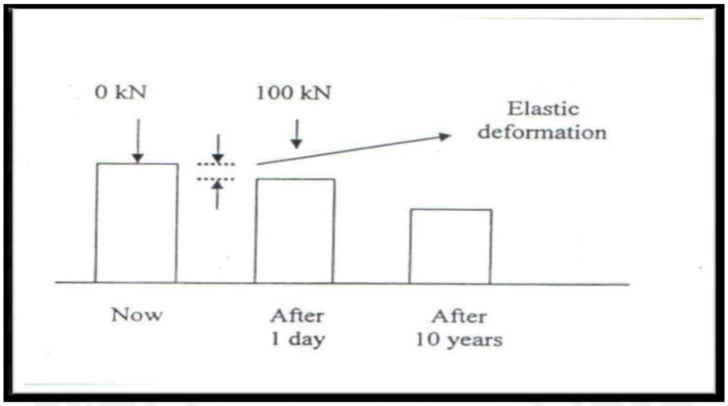
- Specimen shape and size – cube, cylinder and square prism.
- Specimen moisture content and temperature.
- Method of loading.

DEFORMATION UNDER LOAD

- It is a stress strain relationship under normal loading and under sustained loading.
- Under normal loading: the first effect of applying a load to concrete is to produce an elastic deformation i.e. as the load increases deformation increases.
- Under sustained loading: the continue application of stress causes a slow deformation known as creep. The increase of deformation is not proportional , as the time passes the deformation is lesser.

ELASTIC DEFORMATION:

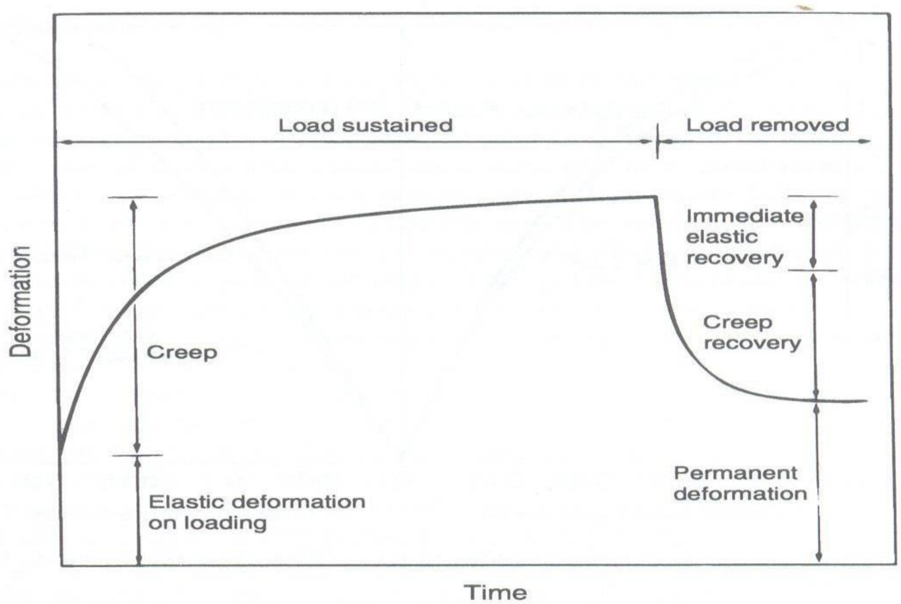
- When the applied load is released, the concrete does not fully recover its original shape.
- Under repeated loading and unloading, the deformation at a given load level increases.



MODULUS OF ELASTICITY

- Defined as the ratio of load per unit area (stress) to the elastic deformation per unit length (strain).
- The modulus of elasticity for most concretes at 28 days, ranges from 15 – 40 kN/mm^2.

$$E = \frac{\text{Stress}}{\text{Strain}} \quad \frac{\sigma}{\varepsilon}$$



Durability

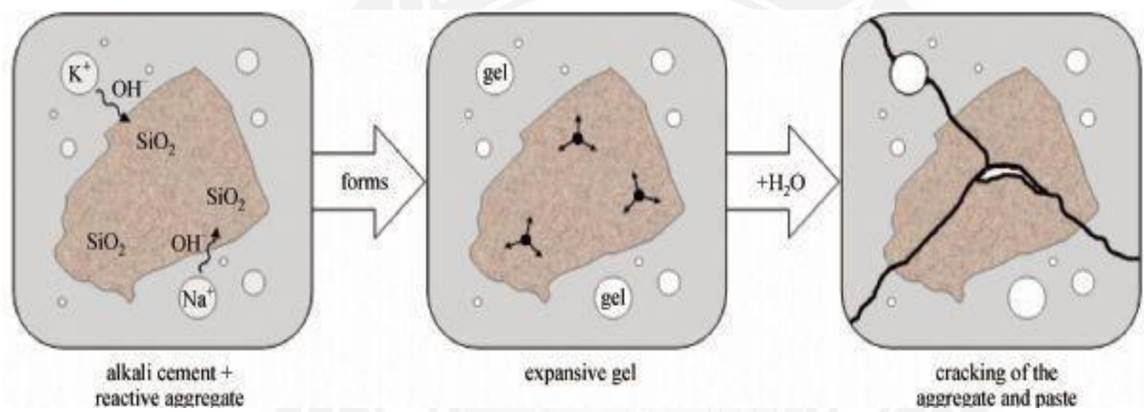
- Defined as its resistance to deterioration processes that may occur as a result of interaction with its environment (external) or between the constituent materials or their reaction with contaminants present (internal).
- Ability to with stand the damaging effects of the environment over a long period of time.
- The absence of durability maybe caused either by the environment to which the concrete is exposed i.e. external or internal causes.

Internal causes

- The alkali-aggregate reaction, volume changes due to the differences in thermal properties of aggregate and cement paste and the permeability of the concrete.

External causes

- physical, chemical and mechanical
- weathering, occurrence of extreme temperature, abrasion, electrolytic action.
- The common forms of chemical attack : leaching out of cement and action of sulphates



Permeability

- Concrete has a tendency to be porous due to the presence of voids formed during or after placing.
- Penetration by substance may adversely affect durability e.g. $Ca(OH)_2$ leaches out.
- Ingress of air and moisture resulting in corrosion.
- Important with regards to water tightness of liquid retaining structure.
- To produce concrete of low permeability, full compaction & proper curing is essential.

- Low permeability is important in increasing resistant to frost action and chemical attack and in protecting embedded steel against corrosion.
- The permeability of cement paste varies with the age of concrete or with progress of hydration.
- With age, the permeability decreases because gel gradually fill the original water filled space.
- For the same w/c ratio, the permeability of paste with coarser cement particles is higher than those with finer cement.
- In general, the higher the strength of cement paste, the lower will the permeability.

Factors influencing permeability are:

i. W/C Ratio
ii. Curing
iii. Method of compaction
iv. Workability
v. Soundness & porosity of the aggregate
vi. Age (permeability decrease with age)
vii. Grading of aggregate
viii. Type of structure

Shrinkage

- Caused by the settlement of solids and the loss of free water from the plastic concrete (plastic shrinkage), by the chemical combination of cement with water and by the drying of concrete (drying shrinkage).
- The shrinkage is dependent on the amount of drying that can take place.

Influenced by the humidity and temperature of the surrounding air, the rate of air flow over the surface and the proportion of the surface area to volume of concrete

2 types of shrinkage:

a) Plastic Shrinkage

- Shrinkage which takes place before concrete has set.
- Occurs during the first few hours after fresh concrete is placed.
- During this period, moisture may evaporate faster from the concrete surface than it is replaced by bleed water from lower layers of the concrete mass.

Plastic cracking (Plastic Shrinkage Cracking) is cracking that occurs in the surface of the fresh concrete soon after it is placed and while it is still plastic.

b) Drying Shrinkage

- When a hardened concrete, cured in water, is allowed to dry it first loses water is drawn out of its cement gel.
- After an initial high rate of drying shrinkage concrete continues to shrink for a long period of time but at a continuously decreasing rate.

Factors affecting Shrinkage are:

1. ***Aggregate*** -Concrete with higher aggregate content exhibits smaller shrinkage. Concrete with aggregates of higher modulus of elasticity or of rougher surfaces is more resistant to the shrinkage process.
2. ***Water-cement ratio*** - The higher the W/C ratio is, the higher the shrinkage. As W/C increases, paste strength and stiffness decrease; and as water content increases, shrinkage potential increases.
3. ***Member size*** - Shrinkage decrease with an increase in the volume of the concrete member. However, the duration of shrinkage is longer for larger members since more time is needed for shrinkage effects to reach the interior regions.
4. ***Medium ambient conditions*** - The rate of shrinkage is lower at higher values of relative humidity. Shrinkage becomes stabilized at low temperatures.
5. ***Admixtures*** - effect varies from admixture to admixture. Any material which substantially changes the pore structure of the paste will affect the shrinkage characteristics of the concrete. In general, as pore refinement is enhanced, shrinkage is increased.

Strength of concrete

- The strength of a concrete specimen prepared, cured and tested under specified conditions at a given age depends on:

  1. w/c ratio
  2. Degree of compaction

    - Compressive Strength is determined by loading properly prepared and cured cubic, cylindrical or prismatic specimens under compression.

Permeability is important because:

1. The penetration of some aggressive solution may result in leaching out of $Ca(OH)_2$ which adversely affects the durability of concrete.
2. The moisture penetration depends on permeability & if concrete becomes saturated it is more liable to frost - action.
3. In some structural members permeability itself is of importance, such as, dams, water retaining tanks.