सूखने से होने वाली सिकुड़न
DRYING SHRINKAGE

1 सामान्य/ General :

Most of the building materials having pores in their structure in the form of intermolecular space, expand on absorbing moisture from atmosphere and shrink on drying. These movements are reversible, causing cracks in building in the form of Drying shrinkage.

Drying shrinkage occurs when water starts evaporating from the exposed surface and the moisture differential along the depth of the slab causes strain which induces tensile stresses. Due to this drying shrinkage, cracks are noticed on the surface of concrete. Normally, these are the non-structural cracks and do not affect on the safety and stability of the building but show poor quality of construction, faulty execution and show a feeling of instability.



When concrete is placed,
Typically the concrete contains more water than is required to hydrate the cementinious materials. This excess water or water of convenience is for workability and placement purposes. Most of this excess water begins to exit the concrete during placement/curing and causes the concrete to shrink.

While the concrete is shrinking
Many things such as reinforcement or the sub grade restrain the concrete. This restraint creates tensile stresses in the concrete slab, which in turn may produce drying shrinkage cracking.

Drying shrinkage cracking can be the unfortunate in the concrete slab and result of a combination of factors related to material choices, construction planning, placement, and curing periods.

Knowledge of these factors are contributing a lot to minimize the drying shrinkage, which occurs due to evaporation of water from the hydrated cement paste.

Water exist in hydrated cement paste in different states like capillary water , absorbed water, interlayer water, and subject to relative humidity of the surrounding atmosphere.

- **कैपलरी जल/ Capillary water:** It is generally assumed that the water present in the capillary pores larger than 0.05.microns does not create drying shrinkage. However, water present in the capillary pores smaller than 0.05 micron is held by capillary tension and therefore its removal can cause shrinkage.
- **अवशोषित जल/ Absorbed water:** Water close to the solid surface is physically held by hydrogen bonding under the influence of attractive forces. Water is physically absorbed on to the solid surface of hydrated cement paste. A major portion of this water can be lost due to drying of hydrated cement paste. This loss of absorbed water is mainly responsible for shrinkage which ultimately results in cracking of concrete.
- **अन्त: परत जल/ Inter-layer water :** The hydrated cement paste water layers are present between the layers of calcium-silicate hydrate structure (C-S-H). This water is strongly held by hydrogen bonding.
  The water is removed by hydrated cement paste only when strong drying takes place. This causes C-S-H structure to shrink considerably due to loss of water between its layers.
- **सापेक्षिक आद्रता के कारण जल की कमी/ Water loss due to relative humidity (RH) :** At 100% RH there is no loss of water from hydrated cement paste and no drying shrinkage occurs. As soon as RH falls below 100% the free water held in large capillary pores begins to escape in the atmosphere. Further drop in RH can loss of absorbed water and cause drying shrinkage.

2. कारण / Causes :

There are so many factors that may cause drying shrinkage, some of them are as under,

i) Due to use of excessive water than its design requirements.
- By adding extra water at site for convenience of workability purpose.

ii) Due to relative humidity of surroundings.
- Relative humidity imparts a major role to evaporate the water.

iii) Due to lack of curing.
- Lack of Curing results in shrinkage due to water loss from the hydrated cement paste.

iv) Due to use of excessive cement content than its design requirements.
- Excessive cement content undergoes a rapid hydration and has a large volume of hydrated cement paste. This results in greater amount of drying shrinkage.

v) Due to improper compaction and moisture content.

vi) Due to size of aggregate used and mix proportion.

- Most important property of aggregate which affects the drying shrinkage, is the modulus of elasticity of the aggregate. Aggregates of high elasticity modulus show low drying shrinkage.

vii) Due to geometry of concrete member.

- Geometry of concrete member also affects the drying shrinkage.

viii) Due to improper use of minerals and chemical additives.

- Generally low dosage of chemical additives does not affect the drying shrinkage but use of high dosage affects considerably on drying shrinkage.

ix) Due to lack of control joints.

- Contraction joins are to be required to minimize the drying shrinkage effects.

3. रोकथाम एवं उपचार/ Preventive and remedial measures :

It is often observed that whenever efforts are made to improve one property of concrete, it affects other properties. So, the remedial measures required to reduce or prevent drying shrinkage and as a consequence cracking, need to be carefully examined. Some remedial measures required to be taken for reducing drying shrinkage are as follows :

- Always adopt good construction practices including placement and compaction of concrete.
- Avoid concreting in extreme weather, as relative humidity imparts a major role in drying shrinkage.
- **अनुकूलतम सीमेंट का उपयोग/ Use optimum cement :** Use quantity of cement as less as possible without sacrificing strength or durability requirements.
- **अनुकूलतम पानी का उपयोग/ Use optimum water :** Use quantity of water in the mix as less as possible without sacrificing the workability. This can be achieved by using appropriate admixtures compatible with cement and other materials being used in the concrete mix. Avoid extra use of water for convenience of workability purpose . Always use water as required in design only.
- **तराई में सुधार/ Improve curing :** If it is not possible to reduce cement content and water content beyond a certain quantity then curing has to be improved. Curing has to be continuous and for a longer duration than 7 days especially when the exposed surfaces are large and moisture gradient between the opposite faces is likely to occur as in case of pavement slabs, concrete roads and slabs on grade. In rich mixes, rapid hydration of cement can take place due to large moisture loss from within the cement hydrated paste resulting in excessive drying shrinkage and cracking. Curing has to be commenced as early as possible and should be continuous throughout the curing period to prevent any moisture loss.



- **एग्रिगेट की गुणवत्ता/ Quality of aggregates :** Aggregates, which have high elastic modulus and low porosity are preferred.



- **मिनरल और रासायनिक एडीटिव/ Mineral and chemical additives:** Mineral admixture like fly ash, slag or micro silica result in formation of fine pores in cement hydration product. This increases chances of drying shrinkage. This is also observed in case of chemical admixtures, which disperse the cement particles and cause pore refinement. Improvement in curing will greatly help, whenever such additives are used to improve durability of concrete in aggressive environment. Dosages of chemical additives above the recommended dosage are to be avoided.

  Low dosage of chemical additives normally does not create drying shrinkage. If dosage are more than 2% by weight of cement then there is a considerable influence on drying shrinkage.

  Rate of water loss is proportional to the length of the path travelled by the water from the interior of the concrete to the atmosphere. Some structure shows faster drying shrinkage than others by virtue of their geometry and location. For example, floor slabs dry much slower than slabs exposed on both side or beams exposed on four sides. Top surface of slab shrinks due to drying but the bottom of slab does not dry easily and takes longer time.

- **संकुचन जोड़ का प्रावधान / Provision of Contraction joints:** Contraction joints are required to be provided to prevent drying shrinkage cracks.
- Contraction joints are induced by forming a groove in the plastic concrete or by sawing in the hardened concrete within 72 hours of finishing the slab.



The spacing of the joints is of utmost importance and is generally dependent on the thickness of the slab.

Contraction joints spacing is to be laid as specified.

If concrete is expected to shrink more than normal, the joints should be closer. If concrete is expected to shrink less than the normal, the joints should be farther apart.

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