Chapter 7: Properties of Fresh Concrete

**Fresh concrete:** from time of mixing to end of time concrete surface finished in its final location in the structure

**Operations:** batching, mixing, transporting, placing, compacting, surface finishing

**Treatment (curing)** of in-placed concrete 6-10 hours after casting (placing) and during first few days of hardening is important.

**Fresh state properties enormously affect hardened state properties.**

- The potential strength and durability of concrete of a given mix proportion is very dependent on the degree of its compaction.

- The first 48 hours are very important for the performance of the concrete structure.

- It controls the long-term behavior, influence $f'c$ (ultimate strength), $F_c'$ (elastic modulus), creep, and durability.
Workability

Definition:

- Effort required to manipulate a concrete mixture with a minimum of segregation.

- The amount of mechanical work or energy required to produce full compaction of the concrete without segregation or bleeding.

Workability measurement methods

1. Slump test
2. Compacting factor test
3. Vebe test
4. Flow table test
1. Slump test - simplest and crudest test

- Fill concrete into frustum of a steel cone in three layers
- Hand tap concrete in each layer
- Lift cone up.
  Define slump as downward movement of the concrete

Lift cone up
**Slump**
- **True**
  - Valid slump measurement
  - 0-175 mm
- **Shear**
  - Mixes having tendency to segregate
  - Repeat test
- **Collapse**
  - Slumps greater than 175 mm - self-leveling concrete

<table>
<thead>
<tr>
<th>Consistency grade</th>
<th>Slump (mm)</th>
<th>Recommended method of compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiff, K1</td>
<td>0 - 60</td>
<td>Mechanical compaction like vibration</td>
</tr>
<tr>
<td>Plastic, K2</td>
<td>60 – 130</td>
<td>Mechanical or hand compaction (rodging, tampering)</td>
</tr>
<tr>
<td>Flowing, K3</td>
<td>130 – 200</td>
<td>Hand compaction or no compaction</td>
</tr>
<tr>
<td>Self compacting, K4</td>
<td>≥ 200</td>
<td>No compaction</td>
</tr>
</tbody>
</table>
2. **Compacting factor test**  
(to distinguish between low slump mixes)

1. Concrete is placed in an upper hopper.
2. Dropped into a lower hopper to bring it to a standard state and then allowed to fall into a standard cylinder.
3. The cylinder and concrete weighed (partially compacted weight)
4. The concrete is fully compacted, extra concrete added and then concretes and cylinder weighed again (fully compacted weight)

\[
\text{Compacting factor} = \frac{\text{weight of partially compact concrete}}{\text{weight of fully compacted concrete}}
\]

3. **Vebe test**

1. A slump test is performed in a container?
2. A clear perspex disc, free to move vertically, is lowered onto the concrete surface.
3. Vibration at a standard rate is applied

Vebe time is defined as the time taken to complete covering of the underside of the disc with concrete. 

container.
4. Flow table test  
(to differentiate between high workability mixes)

1. A conical mould is used to produce a sample of concrete in the centre of a 700 mm square board, hinged along one edge
2. The free edge of the board is lifted against the stop and dropped 15 times

Flow = final diameter of the concrete 
(mean of two measurements at right angles)

Segregation and Bleeding

From placing to final set, concrete is in a plastic, semi-fluid state. Heavier particles (aggregates) have tendency to move down (SEGREGATION). Mix water has a tendency to move up (BLEEDING)

BLEEDING
A layer of water (~ 2 % or more of total depth of concrete) accumulates on surface, later this water evaporates or re-absorbed into concrete.
Methods of reducing segregation and bleed and their effects

**CAUSES OF BLEEDING**

- Poorly graded aggregate with a lack of fine material with particle size < 300μm
- High workability mixes

**REMEDIES**

1. Increase sand content
2. Air entrain concrete as substitute for fine materials

Provide high workability with superplasticizers rather than high water contents

Use very fine materials such as silica fume
Chapter 7: Properties of Fresh Concrete (cont.)

Workability: The amount of mechanical work or energy required to produce full compaction of the concrete without segregation or bleeding.

Factors affecting workability

- Water content of the mix.
- Mix proportions.
- Aggregate properties (Max. aggregate size)
- Time and temperature.
- Cement characteristics.
- Admixtures.

Water content of the mix

- The most important factor
- Increasing water increase the ease of flows and compaction. \[\rightarrow\] Reduce strength and durability. \[\rightarrow\] May lead to segregation and bleeding.

- mixing water is divided into three parts
  1- adsorbed on the particle surfaces
  2- filled the spaces between the particles.
  3- lubricates the particles by separating them with a film of water. \[\rightarrow\] finer particles require more water.
Aggregate properties

There are two important factors here

1- amount of aggregates.
2- the relative proportions of fine to coarse aggregates.

- increase of aggregate/cement ratio decreases workability
- more cement is needed when finer aggregate grading are used.
- Harsh concrete: deficiency in fine aggregate resulting in lack of the desired consistency resulting in segregation.
- Shape and texture of aggregate particles.
- Nearly spherical particles give more workable concrete. Spherical particles give lower surface – to – volume ratio, less mortar to coat the particles, leaving more water to enhance workability.
- The porosity of the aggregates can absorb a great deal of water and less will be available to provide workability.

Time and temperature.

Considerable evidence that temperature increase will decrease workability as higher temperatures will increase both the evaporation rate and hydration rate. Very warm weather will require more water to maintain the same workability.
Cement characteristics.
Less important factor in determining workability than the aggregate properties.

However, increased fineness of type III (rapid-hardening 0 cements will reduce workability at a given w/c ratio.

Admixtures.
This factor will be explained later

B) Curing

Curing; protection of concrete from moisture loss from as soon after placing as possible, and for the first few days of hardening

Curing methods

• Spraying or ponding surface of concrete with water

• Protecting exposed surfaces from wind and sun by windbreaks and sunshades

• Covering surfaces with wet hessian and/or polythene sheets

• Applying a curing membrane, a spray-applied resin seal, to the exposed surface to prevent moisture loss

Effect of curing temperature
Hydration reactions between cement and water are temperature dependent and rate of reaction increases with curing temperature

At early ages, rate of strength gain increases with curing temperature (higher temperatures increases rate of reaction, *thus more C-S-H and gel is produced at earlier times, achieving a higher gel/space ratio and thus higher strength*)

At later ages, higher strength are obtained from concrete cured at lower temperatures.

*(C-S-H gel is more rapidly produced at higher temperature and is less uniform and hence weaker than produced at lower temperatures)*

Standard curing temperature is $22 \pm 1 \degree C$

Hydration proceeds below $0 \degree C$, stop completely at $-10 \degree C$