CHAPTER 5

FRESH CONCRETE
5.1 Introduction

• The strength of concrete of a given mix proportions is very seriously affected by the degree of its compaction;

• it is vital, that the consistency (ability to flow) of the mix be such that, the concrete can be transported, placed and finished sufficiently easily and without segregation.
5.2. Workability

• The ease with which concrete mixes can be compacted as completely as possible while using the lowest possible water/cement ratio.

• Should be obtained by the use of a well-graded aggregate which has the largest maximum particle size possible.

• The use of smooth and rounded, rather than irregularly shaped aggregate also increase workability.

• Air entraining admixtures improve the workability of mixes but causes a loss of strength up to about 15 percent.
Factors affecting workability

► **Water content of the mix:** Adding water increases workability and decreases strength.

► **Maximum size of aggregate:** Less surface area to be wetted and more water in medium.

► **Grading of aggregate:** Poor grading reduces the consistency.

► **Shape and texture of aggregates:** Smooth surfaces give better workability.
Measurement of Workability

There is no accepted test, which measure directly the workability.
There are indirect methods.
5.2.1. Measurement of Workability

There are 5 types of test, which can measure workability indirectly. Unfortunately, there are no accepted tests, which can measure directly the workability.

- **Slump Test**: Gives good results for rich mixes.
- **Compacting Factor Test**: Used for low workable concretes.
- **Flow Table Test**: Used for high workable concretes.
- **VeBe Test**: Used for low workable concretes (fiber reinforced concrete).
- **Kelly Ball Test**: It is practical in field test.
Measurement of Workability

1. SLUMP TEST

• This is a test used extensively in site work all over the world. Very useful in detecting variations in the uniformity of a mix of given nominal proportions.

• Rich mixes behave satisfactorily, their slump being sensitive to variations in workability.
Slump Test

**Fig. 5.2:** Slump: true, shear, and collapse
2. COMPACTING FACTOR TEST

• The degree of compaction, called compacting factor, is measured by the density ratio, i.e. the ratio of the density of actually achieved in the test to the density of the same concrete fully compacted.

• Test is more sensitive at the low workability.
Compacting Factor Test
3. FLOW TEST

Measures the diameter of spread after vibration.
4. VEBE TEST
Start time after removing cone and stop counter once the transparent rider is covered with paste. Record in seconds. This is VeBe time.
5. KELLY BALL TEST:
Measures the depth of penetration.
Table 5.1 Workability, slump and compacting factor of concretes with 19 or 38 mm (0.75 or 1.50 in.) maximum size of aggregate.

<table>
<thead>
<tr>
<th>Degree of workability</th>
<th>Slump (mm)</th>
<th>Compacting factor</th>
<th>Uses for which concrete is suitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>0-25</td>
<td>0.78</td>
<td>Roads vibrated by power operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand operated machines</td>
</tr>
<tr>
<td>Low</td>
<td>25-50</td>
<td>0.85</td>
<td>Roads vibrated by hand operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregate of rounded or irregular shaped. Mass concrete foundations without vibration or lightly reinforced sections with vibration.</td>
</tr>
<tr>
<td>Medium</td>
<td>50-100</td>
<td>0.92</td>
<td>At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration.</td>
</tr>
<tr>
<td>High</td>
<td>100-175</td>
<td>0.95</td>
<td>For sections with congested reinforcement, not normally suitable for vibration.</td>
</tr>
</tbody>
</table>
Table 5.2 Range of slump and VeBe time for different construction types.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Suitable slump</th>
<th>Suitable Vebe time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>In.</td>
</tr>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Uncongested precast concrete</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Power vibrated pavements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass concrete</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Slabs</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Footings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncongested walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Columns</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Beams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normally reinforced walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congested narrow sections</td>
<td>100</td>
<td>175</td>
</tr>
</tbody>
</table>

Total 28
5.3 Segregation

• Segregation is separation of the constituents of a heterogeneous mixture so that their distribution is no longer uniform.

• There are two forms of segregation:
  ▶ first form: Coarse particles tend to separate out since they tend to settle more than fine particles.
  ▶ second form: Occurs in wet mixes; it is manifested by the separation of (cement+water) from the mix.
5.3 Segregation

- **Causes of segregation:**
  - Dropping concrete from a considerable height,
  - Passing along a chute, particularly with changes of direction and discharging against an obstacle,
  - Concrete should always be placed direct in the position in which it is to remain and must not be allowed to flow or be worked along the form.
  - Improper use of a vibrator increases segregation.
  - Use of coarse aggregate whose specific gravity differs appreciably from that of fine aggregate would lead to increased segregation.
Segregation of a reinforced concrete column
Segregation due to over-vibration

Over vibrated

Fig. 3: Segregation in over-vibrated concrete. The cylinder on the left was vibrated longer.
5.4 Bleeding

- Bleeding (water gain) is a form of segregation, in which some of the water in the mix tends to rise to the surface of freshly placed concrete.

**Reason:** Caused by the inability of the solid constituents of the mix to hold all of the mixing water when they settle downwards.

**Result:** Top of every lift may become too wet and if the water is trapped by concrete, porous, weak, and non-durable concrete will result.

If the bleeding water is remixed during finishing of the top surface a weak wearing surface will be formed.

This can be avoided by delaying the finishing operations until the bleeding water has evaporated.

- Some of the rising water becomes trapped on the underside of coarse aggregate particles or of reinforcement, thus creating zones of poor bond.
5.4 Bleeding

• Is it always harmful?

Bleeding need not necessarily be harmful. If it is undisturbed and the water evaporates the effective water/cement ratio may be lowered with a resulting increase in strength. If the rising water carries with it a considerable amount of the finer cement particles a layer of scum will be formed. At the top of a slab a porous surface will form and result with a permanently dusty surface. At the top of a lift a plane of weakness would form and the bond with the next lift would be inadequate. For this reason, scum should always be removed by brushing and washing.

• How can we reduce bleeding?

• Bleeding is decreased by increasing the fineness of cement or adding of calciumchloride to cement.
• Rich mixes are less prone to bleeding than lean ones.
• Reduction in bleeding is obtained by the addition of pozzolans or of aluminium powder.
• Air entrainment effectively reduces bleeding so that finishing can follow casting without delay.
5.5 Compaction of Concrete

• In the process of compacting the concrete consists essentially of the elimination of entrapped air in concrete.

This can be achieved by:

  1. Ramming (manually by hand)
  2. Vibration (by machines)

• The two basic means of compaction require mixes of different workabilities: too dry mix cannot be sufficiently worked by hand; and, conversely, too wet mix should not be vibrated as segregation may result.
• A drier mix needs stronger formwork compared to wet mixes. This will increase the cost.

  — **Types of Vibrators**
  • Internal vibrator
  • External vibrators
  • Vibrating tables & surface vibrators
a) Internal Vibrators (immersion vibrator)

• Consists of a poker, housing an eccentric shaft driven through a flexible drive from a motor. The poker is immersed in concrete and thus applies vibration to it.

• Gradual withdrawal of the poker is recommended, so that the hole left by the vibrator closes fully without any air being trapped.

• Time required: Every 0.5-1.0 m for 5 seconds to 2 minutes depending on the consistence of the mix.
Poker Vibrator for concrete (internal)
Fig. 7.11: Placing of poker vibrators
(Based on *ACI Manual of Concrete Practice.*)
b) **External Vibrators**

- Vibrator is rigidly clamped to the formwork resting on an elastic support, so that both the form and the concrete are vibrated.
- External vibrators are used for precast or in situ sections of such shape or thickness that an internal vibrator cannot be used.
- When an external vibrator is used, concrete has to be placed in layers of suitable depth as air cannot be expelled through too great a thickness of concrete. The position of the vibrator may have to be changed as concreting progress.

c) **Vibrating Tables**

This can be considered as a case of formwork clamped to the vibrator instead of the other way round, but the principle of vibrating the concrete and formwork together is unaltered. The table is subjected to a simple harmonic motion in the vertical direction only.

d) **Surface Vibrator:**

It applies vibration through a flat plate direct to the top of the concrete. In this manner, the concrete is restrained in all directions so that the tendency of segregation is limited. They can be used for thin slabs.
Compaction of fresh concrete (vibration table)
Surface & external vibration
Lack of compaction
Fig. 8-18. Relationship between slump, duration of vibration, and air content of concrete (Brewster 1949).
5.6 Quality of Mixing Water

- In many specifications, the quality of water is covered by a clause saying that water should be fit for **drinking**.

- **Seawater** has a total salinity of about 3-5 per cent, and produces a slightly higher early strength but a lower long-term strength; the loss of strength is usually no more than 15 percent and can therefore often be tolerated.

- Water containing large quantities of **chlorides** (e.g. sea water) tends to cause persistent dampness and surface efflorescence. Such water should therefore, not be used where appearance of the concrete is important.

- In the case of **reinforced concrete**, seawater is believed to increase the risk of corrosion of the reinforcement, although there is no experimental evidence that the use of sea water in mixing leads to attack on the reinforcing steel.

- However in practice it is generally considered inadvisable to use sea water for mixing unless this is unavoidable.