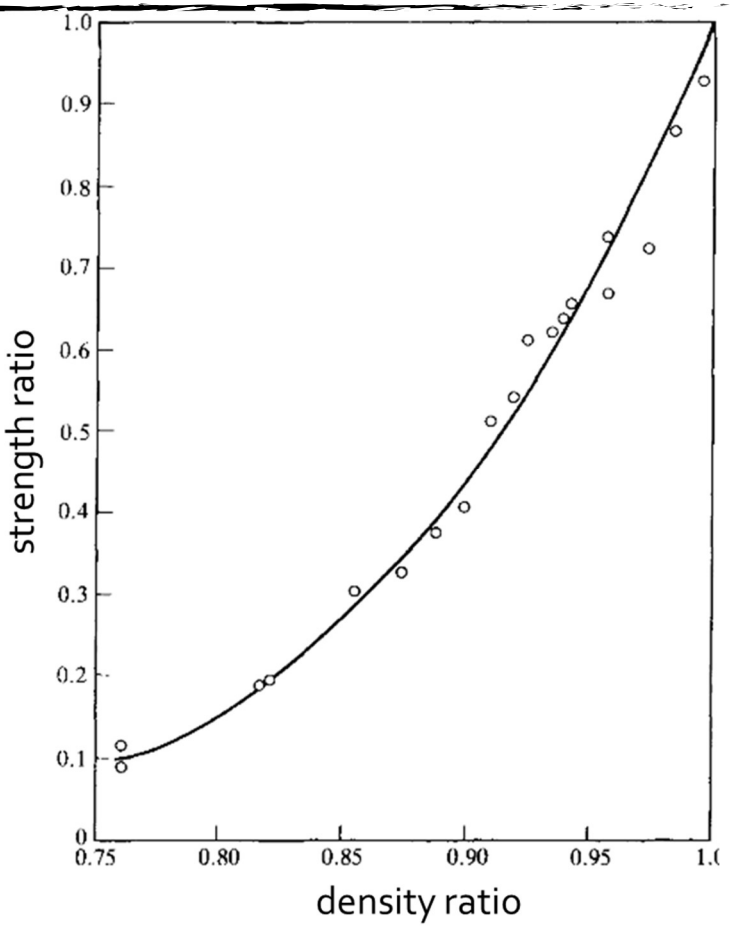
Fresh concrete

Chapter 6

Introduction

- Fresh concrete contains about 30% voids and seldom confirm to the shape of the mold unless compacted.
- In general, the long-term properties of hardened concrete such as strength, volume stability, and durability are seriously affected by its degree of compaction in the casting stage. Accordingly, fresh concrete shall have the following characteristics:
- Uniformity: homogeneous mixture, with evenly dispersed constituents;
- Consistency: the ability to flow;
- Stability: the resistance to segregation;
- Finishability: ease of performing finishing operations to achieve specified surface characteristics.



Relation between strength ratio and density ratio of concrete.

Workability

Definition

- **Theoretically, workability** is often defined in terms of the amount of mechanical work, or energy, required to produce full compaction of the concrete without segregation.
- **In general, Workability** is the ease of placing, consolidating, and finishing freshly mixed concrete and the degree to which it resists segregation.
- In practice, it is difficult to measure the workability as defined, so **CONSISTENCY** or the ease with which a material will flow is considered a close indication of workability. In fresh concrete **consistency** can be taken to mean the degree of wetness of the mix (i.e Dry, Stiff, Plastic, ….)
- In addition to consistency, fresh concrete properties related to workability include the Finishability and stability (segregation resistance).

Workability

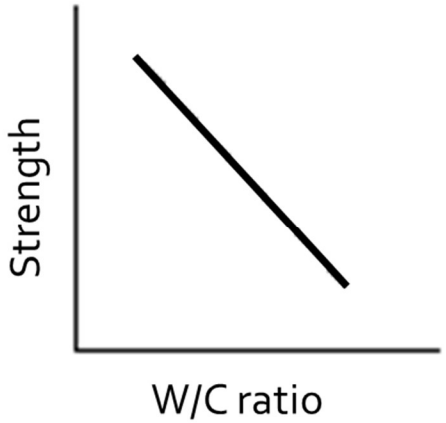
Factors Affecting Workability

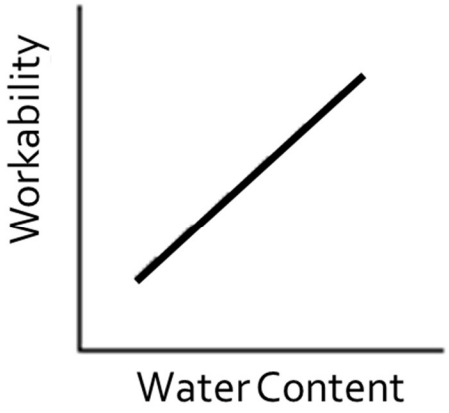
- Water content of the mix, which identify it is initial consistency (slump).
- Grading, shape, and surface texture of fine and coarse aggregates
- Quantity and characteristics of cementitious materials
- Concrete and ambient air temperatures.
- The method and duration of transportation
- Admixtures

Factors Affecting Workability

1. Water Content of the Mix

It is the single most important factor governing the workability of concrete. Increasing the amount of water will increase the ease with which concrete flows and can be compacted. However, apart from reducing the strength, increased water may lead to segregation (settling of the coarse aggregate).





Factors Affecting Workability

2. **Influence of Aggregate**

   - **Amount of aggregate**: For a constant water/cement ratio, the workability increases as the aggregate/cement ratio is reduced because the amount of water relative to the total surface of solids is increased.
   - **Relative proportions of fine and coarse aggregate**: high ratio of coarse aggregate to fine aggregate can result in segregation and in a lower workability, so that the mix is harsh and not easily finished. Conversely, too many fines lead to a higher workability, but such an "oversanded" mix makes less durable concrete.
   - **The shape and texture of aggregate particles** can also affect the workability. As a general rule, the more nearly spherical and smooth the particles, the more workable the resulting concrete will be. The porosity of the aggregates may also affect workability. If the aggregate can absorb a great deal of water less will be available to provide workability.

Factors Affecting Workability

3. Quantity and characteristics of cementitious materials

The cement characteristics are much less important in determining workability than are the aggregate properties. However, the increased fineness of Type III (high early strength) cements will reduce workability at a given w/c ratio, as these cements have a higher water requirement because of their higher specific surface area and because they also hydrate more rapidly.

4. Time and Temperature

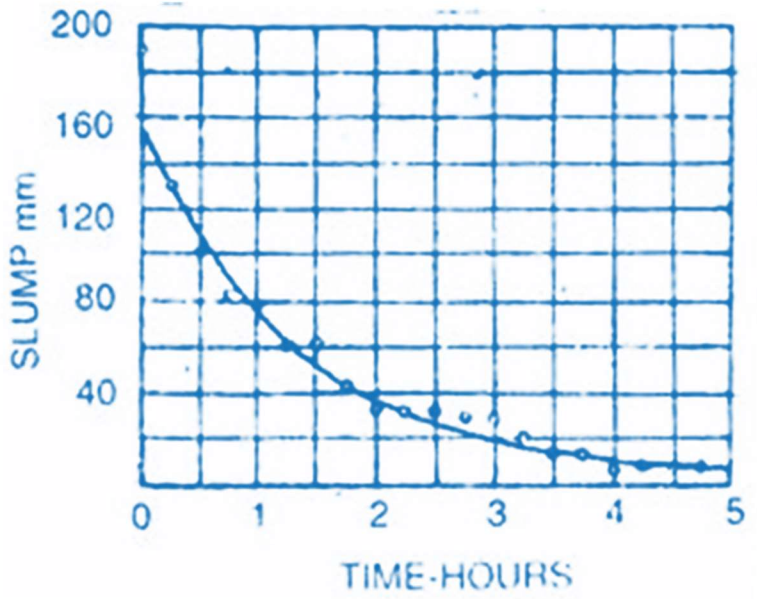
Time impact

- Freshly mixed concrete stiffens with time as some of the mixing water is absorbed by the aggregate, some is lost by evaporation (particularly if the concrete is exposed to the sun or wind), and some is removed by initial chemical reactions.
- The stiffening of concrete is effectively measured by a loss of workability with time, known as slump loss, which varies with richness of the mix, type of cement, temperature of concrete, and initial workability.

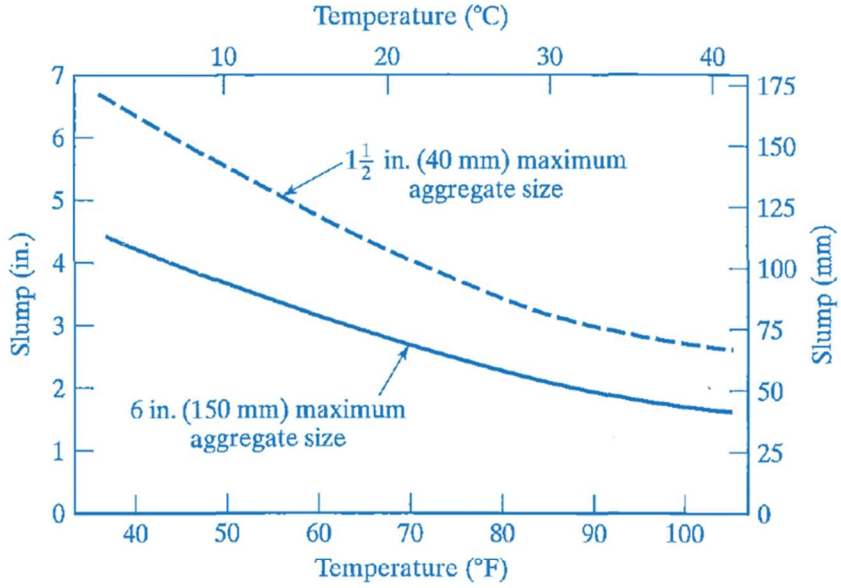
Factors Affecting Workability

Temperature impact

As the ambient temperature increases, the workability decreases, as shown in the Figure, since higher temperatures will increase both the evaporation rate and the hydration rate.



Relationship between slump and time



Influence of temperature in slump of concrete

Factors Affecting Workability

5. Admixtures

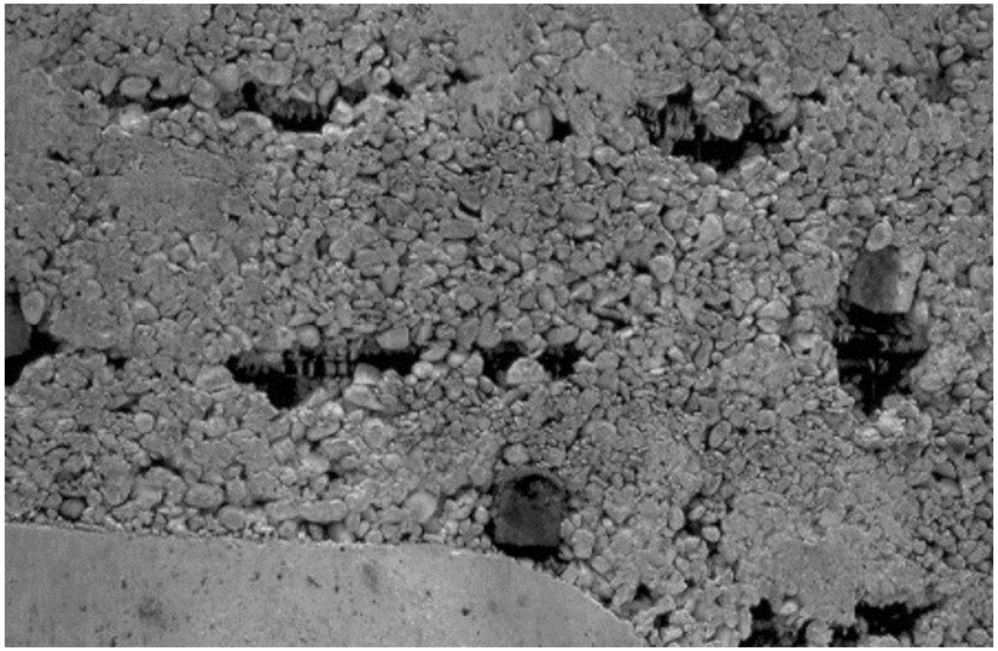
Use of admixtures is one of the most import factor which affects the workability of concrete, for example

- Plasticizers and superplasticizers greatly improve the workability.
- Use of air-entraining agent also improve workability
- Similarly, the fine glassy pozzolanic materials, in spite of increasing the surface area, offer better lubricating effects for giving better workability.

Segregation and Bleeding

Segregation

Segregation refers to a separation of the components of fresh concrete, resulting in a non uniform mix. (see photos below)



Segregation

The factors that contribute to increased segregation are:

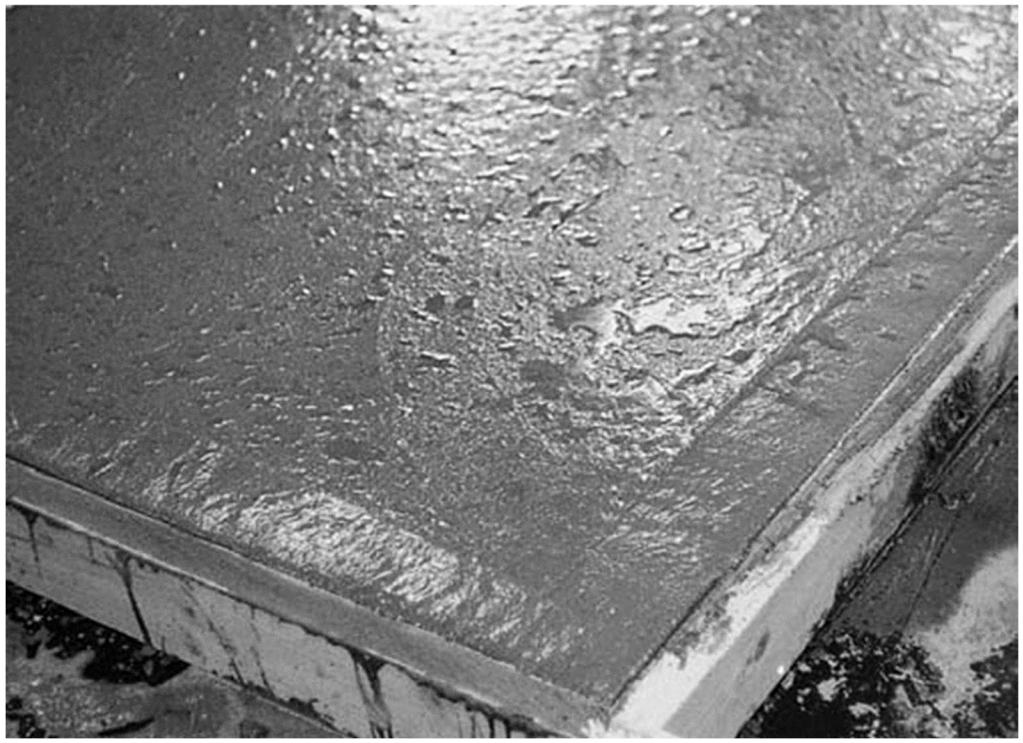
1. A high specific gravity of the coarse aggregate compared to that of the fine aggregate.
2. Using larger maximum particle size (over 25 mm) and proportion of the large particles.
3. A decreased amount of fines (sand or cement).
4. Changes in the particle shape away from smooth, well-rounded particles to odd shaped, rough particles.
5. Mixes that are either too wet or too dry.

Segregation can be reduced by:

- The use of finely divided mineral admixtures or air-entraining agents reduces the tendency toward segregation,
- Careful handling and placing of concrete are more important in reducing segregation.

Bleeding

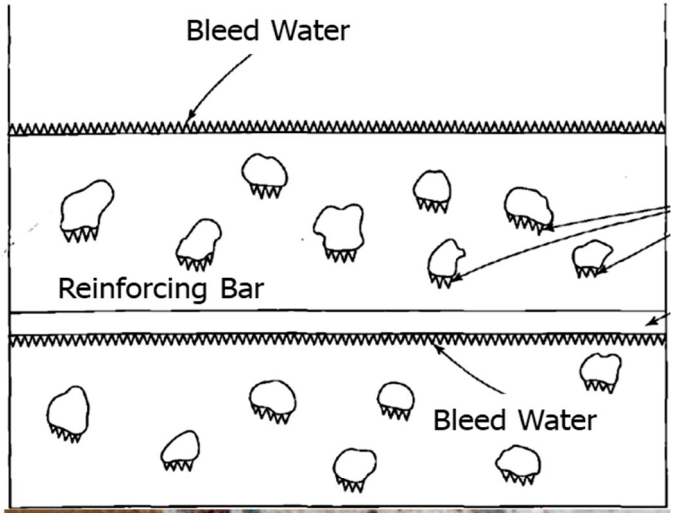
- Bleeding is a form of segregation in which a layer of water is developed at the top or surface of freshly placed concrete.
- It is caused by settlement of solid particles and the simultaneous upward migration of water.
- Bleeding depend on
  - Water content of the mix.
  - And largely on the properties of cement

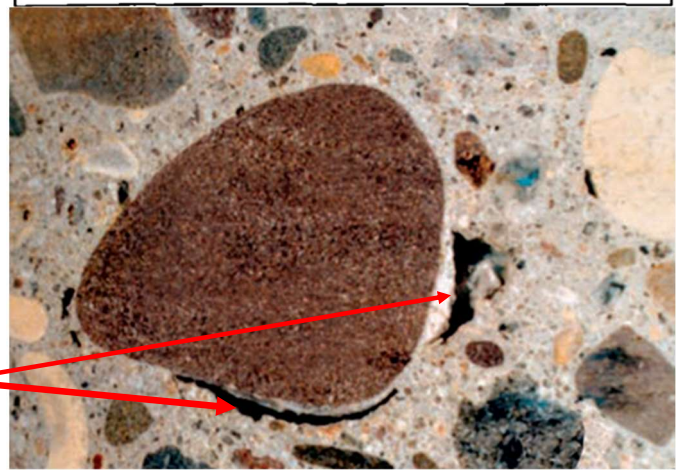


Bleeding

Significant

- Due to bleeding, the upper layer of the concrete may become rich in cement paste, which has a *w/c* ratio that is too high. This leads to weakness, porosity, and a lack of durability.
- Water pockets may form under large aggregate particles or reinforcing bars, leaving weak zones in the concrete and reducing bond.
- If the bleed water evaporates quickly, which often occurs in hot, dry weather, plastic shrinkage cracks can form





Accumulation of bleed water under and alongside coarse aggregate particles

Bleeding

Bleeding can be reduced in a number of ways:

1. By increasing cement fineness or by using pozzolans or other mineral admixtures.
2. By increasing the rate of hydration of the cement (using cements with high C_3A contents which may, however, have other undesirable effects)
3. by using $CaCl_2$ as an admixture (Accelerator admixture, which may also be undesirable).
4. Through air entrainment, which is very effective.
5. By reducing the water content, if this can be done while maintaining an acceptable workability.

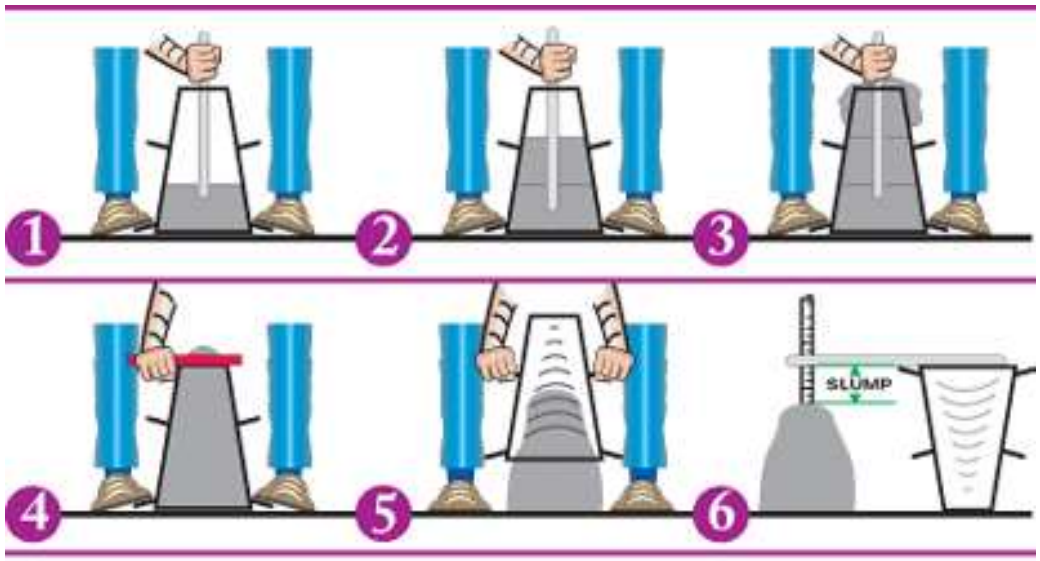
Workability Tests

Workability Tests

- There is no acceptable test which will measure directly the workability as defined earlier.
- However, several empirical methods have been developed to give a measure of workability which is applicable only with reference to the particular method. These methods have found universal acceptance and their merit is chiefly that of simplicity of operation with an ability to detect variations in the uniformity of a mix of given nominal proportions.
- Common tests include:
  - **Slump Test**
  - **Compacting Factor Test**
  - **Vebe Test**
  - Flow table test
  - Ball penetration test

Slump Test

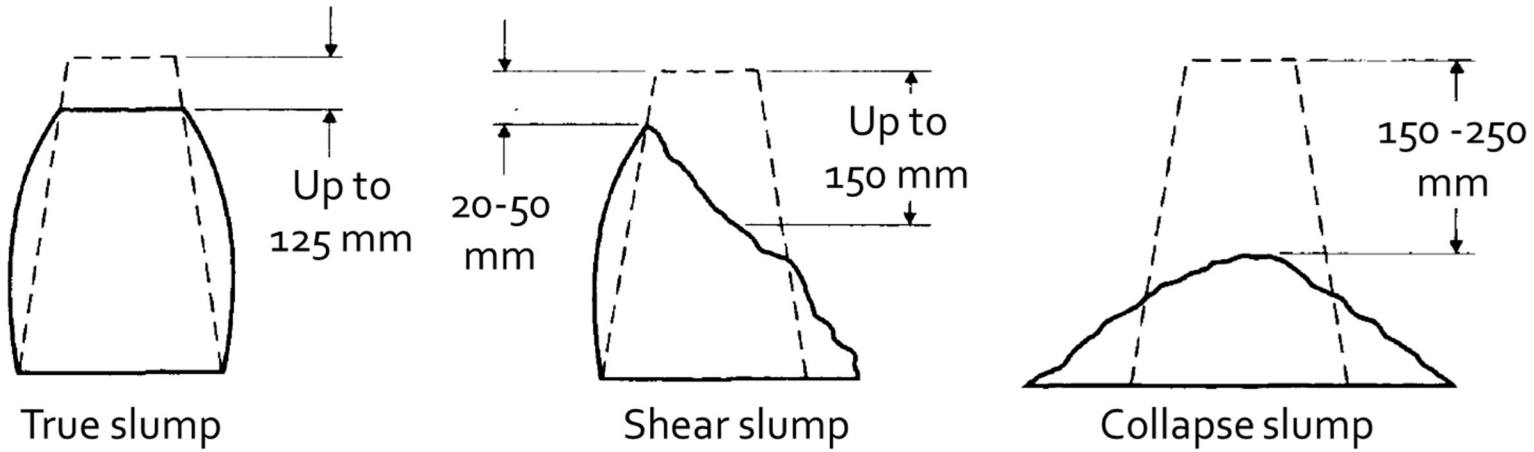
The slump test described by ASTM C143 (AASHTO T 119), is the most generally accepted method used to measure the consistency of concrete. In this context, the term consistency refers to the relative fluidity of fresh concrete.



Slump Test

Depending on the mix, three distinct types of slump may occur:

- "True" slump consists of a general subsidence of the mass, without any breaking up.
- Shear slump often indicates a lack of cohesion; it tends to occur in harsh mixes or in mixes prone to segregation. Shear slump may indicate that the concrete is not suitable for placement.
- Collapse slump generally indicates a lean, harsh, or more likely, a very wet mix



Slump Test

Recommended slump

- Usually specifications recommends workability level based in the construction type or concrete use.
- The table shows the recommended Workability level and the corresponding Slump and Compacting Factor of Concretes made of 20 or 40 mm Maximum Aggregate Size.

Degree of workability	*Slump mm*	*Compacting factor*		*Use for which concrete is suitable*
		Small appartus	*Large appartus*	
Very Low compacting factor is suitable	–	0.78	0.80	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.
Low	25–75	0.85	0.87	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 shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	50–100	0.92	0.935	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
High	100–150	0.95	0.96	For sections with congested reinforce-ment. Not normally suitable for vibrat-ion. For pumping and tremie placing
Very High	–	–	–	Flow table test is more suitable.

Slump Test Advantages & Limitations

Advantages

- Can provide useful information. In general, concretes of similar slump *can* be used the same way.
- More important, the slump test is a valuable quality-control tool. Changes in slump on a given job generally indicate that a change has occurred in the aggregates or in the amount of water or admixture being used.

Test Limitations

- The test is completely empirical and is not related to our earlier definition of workability.
- With different aggregates or mix properties, the same slump can be measured for very different concrete consistencies.
- In addition, the slump test cannot differentiate between different low-workability concretes. Concretes with slumps less than 25 mm should be tested by another procedure.

Compacting Factor Test

- The compaction factor test measures the degree of compaction resulting from the application of a standard amount of work.
- The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted.

Advantages

- The compaction factor test gives more information about concrete compactability than the slump test.
- The test is more suitable for concrete at the low workability end of the scale.

Compacting Factor Test

Limitations

- Apparatus is not very suitable for field use
- Some mixes stick to the sides of the hoppers. So the amount of work applied to the concrete being tested is a function of the friction between the concrete and the hoppers, which may not reflect field conditions.
- The test method does not use vibration, the main compaction method used in the field.
- It has also been found that mixes with the same compacting factor do not necessarily require the same amount of work for compaction.

Vebe Test

Procedure

- A standard slump cone is placed in a cylinder 240 mm in diameter and 200 mm high. The slump cone is filled in the standard manner, removed, and a disc-shaped rider (weighing 2.75 kg) is placed on top of the concrete.
- Compaction is achieved using a vibrating table with an eccentric weight rotating at 50 Hz so that the vertical amplitude of the table with the empty cylinder is approximately ±0.35 mm (±0.014 in.).

- Compaction is assumed to be complete when the transparent rider is totally covered with concrete and all cavities in the surface of the concrete have disappeared.
- This is judged visually, and the difficulty of establishing the end point of the test may be a source of error

Vebe Test

Test Concept

The Vebe test measures the remolding ability of concrete under vibration. The test results reflect the amount of energy required to remold a quantity of concrete under given vibration conditions. The Vebe test is applicable to concrete with slumps less than 5 cm.

Advantages

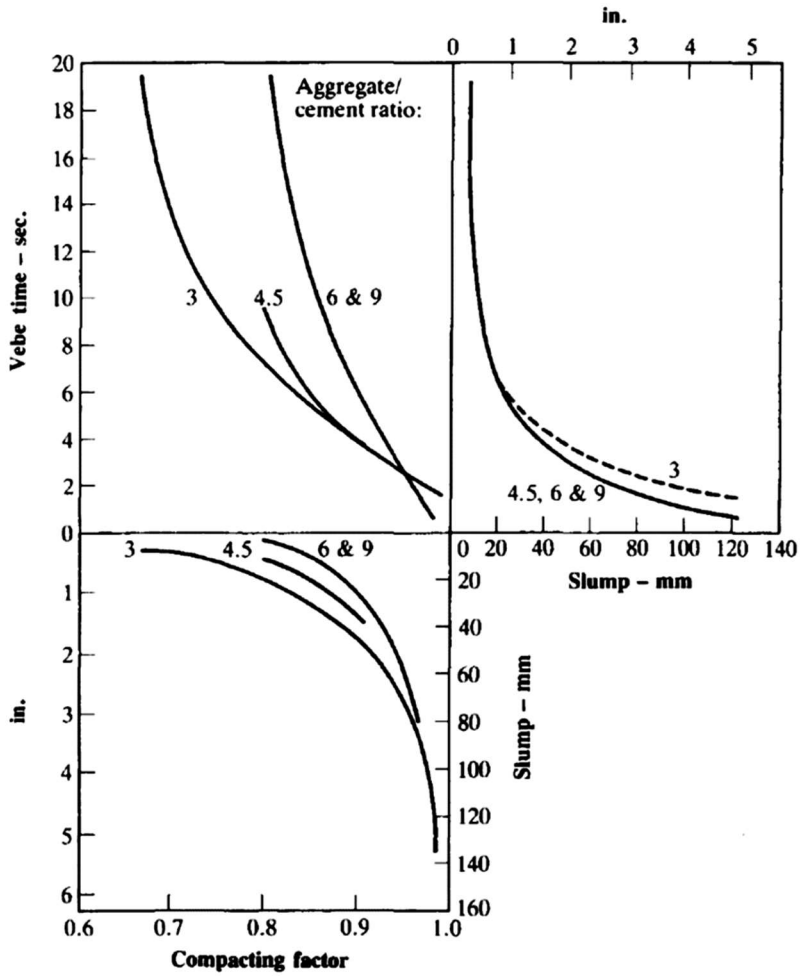
- The Vebe test is a dynamic test and can be used on concretes that are too dry for the slump test.
- The treatment of concrete during the test is comparatively closely related to the method of placing in practice.

Disadvantages

- The size of the test device makes the Vebe test generally unsuitable for field use.
- The test device only works for low slump concretes.

Comparison of Tests

- There is no unique relation between the results of the various tests as each test measures the behavior of concrete under different conditions. However there are available charts (formulas) that can be used for approximate conversion.
- Vebe and slump are a measure of flowability while compacting factor measure compactibility.
- Vebe is more sensitive for stiff mixes as fiber reinforced concrete. In the other hand slump is suitable for flowable concrete. Compacting factor is sutabile for moderately flowable mixes.



Visual Inspection

- As already stated, the ideal test for workability has yet to be devised.
- For this reason, it is worth stressing the value of visual inspection of workability and of assessing it by patting with a trowel in order to see the ease of finishing.
- The 'by eye' test of experienced engineers, particularly for the purpose of checking uniformity, is both rapid and reliable.