Chapter -3

- What is Concrete?
- What is the materials that used for concrete?

What is Concrete?

Concrete is a composite material made up of inert materials of varying sizes, which are bound together by a binding medium.

The strength of concrete is dependent on the strength of the aggregate paste bond.

Composition of Concrete

Concrete

- Portland Cement
- *Water*
- *Air (entrapped or entrained)*

Paste

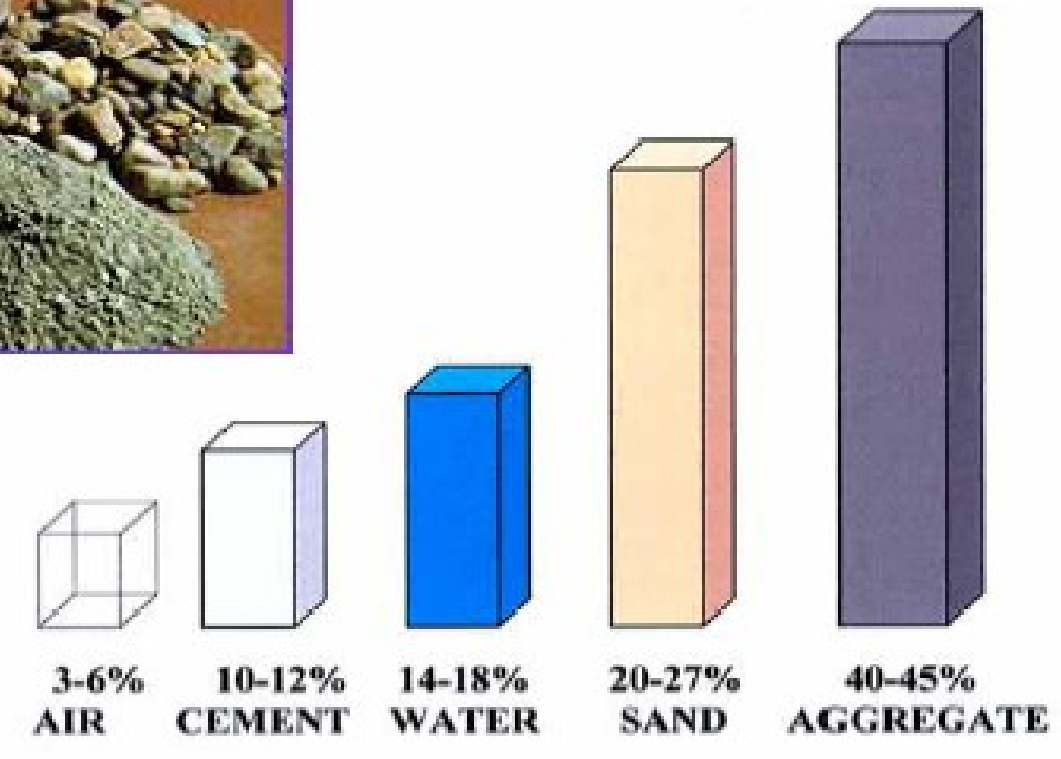
- Fine Aggregate (Sand)
- Coarse Aggregate (Gravel)

Aggregate

- Admixture (If required)

Composition of Concrete





Advantages of Concrete

Good-quality concrete has many advantages:

- It is economical when ingredients are readily available.
- Its long life and relatively low maintenance requirements increase its economic benefits.

- It is not as likely to rot, corrode, or decay as other building materials.
- It has the ability to be molded or cast into almost any desired shape.
- It is a non-combustible material which makes it fire-safe and able withstand high temperatures.

- It is resistant to wind, water, rodents, and insects. Hence, concrete is often used for storm shelters.
- It has high compressive strength, resistance to weathering, impact and abrasion.
- Building of the molds and casting can occur on the work-site which reduces

Disadvantages of Concrete

Some of disadvantages of concrete are:

- High cost of cement, steel and formwork (in developing countries).
- Difficult quality control on building sites, with the risk of cracking and gradual deterioration, if wrongly mixed, placed and insufficiently cured with water.

Disadvantages of Concrete

- In moist climates or coastal regions, corrosion of reinforcement (if insufficiently protected), leading to expansion cracks.
- Low tensile strength (but can be overcome with steel reinforcement).
- Demolishing concrete is difficult.

Ingredients of Concrete

- Portland Cement
- Water
- Aggregates
- Admixtures (Additives)

Portland Cement

- Dry power of very fine particles
- Forms a paste when mixed with water
- Chemical reaction –Hydration
- Paste coats all the aggregates together
- Hardens and forms solid mass

Usually, Portland cement is specified for general concrete construction work and should confirm to standard specifications. Various types of Portland cement as well as physical & chemical requirements were discussed in the previous course.

Water

Water serves two purposes in making concrete:

- It triggers the hydration of cement (only 1/3 of the water) and
- It makes the mix fluid and workable.

Surplus water = bad for strength, durability and permeability.

Clean water is important any impurities present will affect bond strength between the paste and aggregate.





Undesirable effects of impurities in mixing water:

Impurities in mixing water may cause any one
or
all of the following:

- ✓ Abnormal setting time
- ✓ Decreased strength
- ✓ Volume changes
- ✓ Efflorescence
- ✓ Corrosion of reinforcement

Aggregates



Quarry



Quarry



Aggregates

Aggregates are the filler materials which make up a large portion (roughly 65-80%) of the concrete volume.

Considerable care should be taken to provide the best aggregates available.



Types of rock commonly used as aggregate

Sedimentary rock



Shale



Siltstone



Sandstone



Limestone

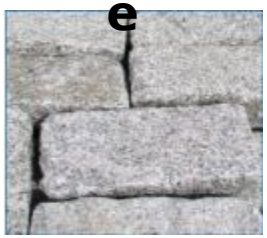
Igneous rock



Trap rock



Pegmat



Granite



Gabro

Metamorphic rock



Amphibolite



Gneiss



Slate



Marble

Classification of aggregates based on source_

Natural aggregates are taken from natural deposits without change in their nature during production, with the exception of crushing, sizing, grading, or during production. *In this group crushed stone, gravel, and sand are the most common.*

Manufactured aggregates include blast furnace slag and lightweight aggregates.

Recycled Aggregate – e.g. crushed concrete, clay bricks

Classification of aggregates based on size

- **Fine aggregate**: < 4.75 (No.4 sieve)
- **Coarse aggregate:** predominantly retained on the No.4 (4.75mm) sieve.

- **Coarse aggregate > 5 mm (10 mm, 20 mm, 40mm)**





Classification based on Condition

- Crushed

  From quarry - sharp, angular particles, rough surface, good bond strength, low workability



- Uncrushed

  From river - round shapes, smooth surface, low bonding properties, high workability



Aggregate Terms and Types

The terms used to describe aggregates are many and varied. These descriptive terms are based on source, size, shape, type, use and other properties.

Some typical terms used in describing aggregates are:

1. **Fine aggregate**- aggregate particles passing the No. 4 (4.75mm) sieve and retained on the No. 200 (75-m) sieve.

2. **Coarse aggregate**- aggregate predominantly retained on the No.4 (4.75mm) sieve.

3. **Crushed gravel (gravel and sand)-** that has been put through a crusher either to break many of the rounded gravel particles to a smaller size or to produce rough surfaces.

4. **Crushed rock**- aggregate from the crushing of rock. All particles are angular, not rounded as in gravel.

5. **Screenings**- the chips and dust or powder that are produced in the crushing of rock for aggregates.

6. **All-in-aggregate**- aggregate composed of both fine and coarse aggregate.

7. **Concrete sand**- sand that has been washed (usually) to remove dust & fines.

8. **Fines-** silty-clay or dust particles smaller than 75 micro m (No. 200 sieve) usually undesirable impurities in aggregates.

Properties of Aggregates

Important properties of aggregates include:

- Gradation (grain size distribution)
- Shape and surface texture
- Bulk unit weight
- Specific gravity (relative density)
- Absorption
- Hardness (resistance to abrasion or wear)
- Durability (resistance to weathering)
- Crushing strength
- Cleanliness (deleterious substances)
- Chemical stability

Gradation of Aggregates



Grading: is the distribution of particles of angular materials among various sizes



The gradation of aggregates influences:

- ✓ the amount of paste required
- ✓ the workability of the concrete
- ✓ the strength and
- ✓ water tightness of the finished product

In general, it is desirable that the size increase uniformly from fine sand to the maximum allowed for a given job.

Most specifications for concrete require a grain size distribution that will provide a dense and strong mixture.

Types of gradation

Aggregates may be:

- **Dense**
- **Well graded**
- **Gap-graded**
- **Uniform**
- **Open-graded**

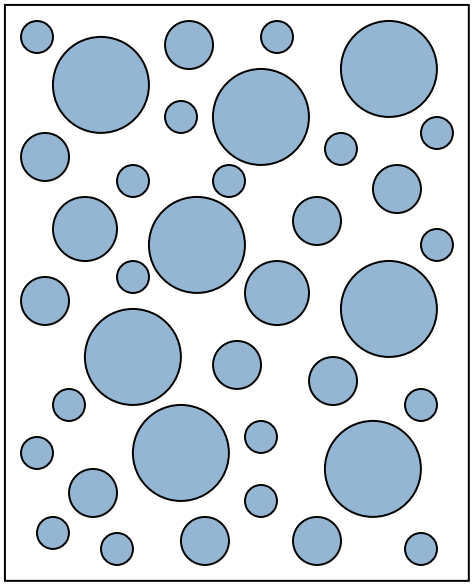
Well-graded

Poorly graded

The terms “dense” and “well-graded” are essentially the same, as are “gap”, “uniform” and “open-graded”

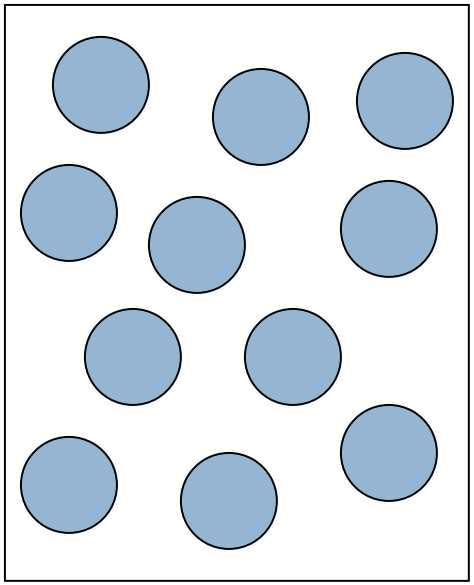
Grading of aggregates

Well graded



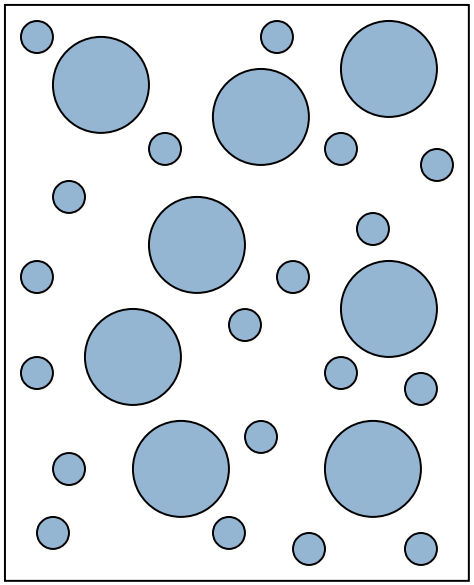
The range of size are approximately in equal amounts

Uniform graded



Most particles are of the same size

Gap graded



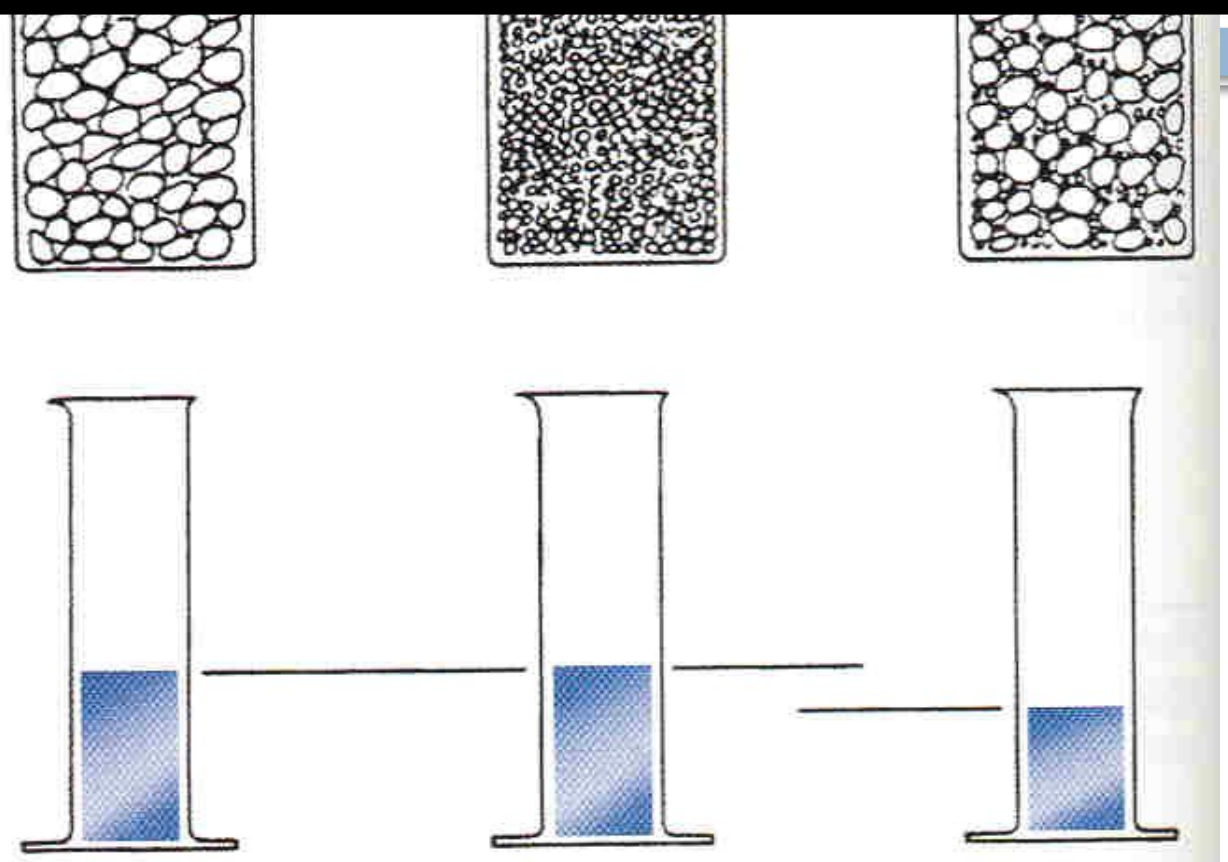
Most particles are of large or small size

Well graded aggregates:

- Improve workability of the concrete and economy of the cement.

  (Such aggregate has a decreased amount of voids between the particles and consequently requires less cement paste).

- Produces a stronger concrete than a poorly graded one (less water is required to give suitable workability)

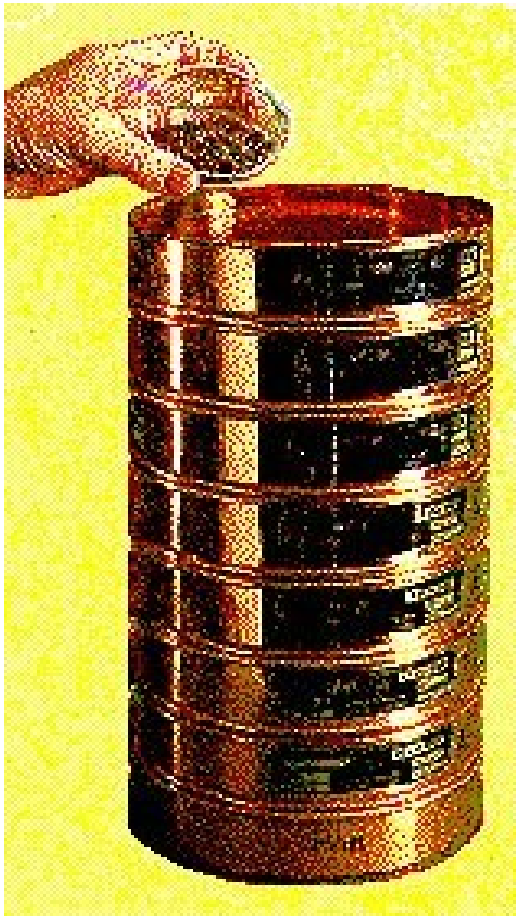


SIEVE ANALYSIS

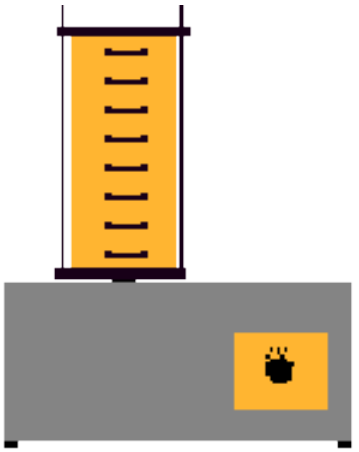
The grading or particle size distribution of aggregate is determined by sieve analysis.











Sieve Analysis



Sampling

Sample Reduction

Riffling or quartering are the two methods most often used to reduce a bulk sample to a representative size suitable for testing.

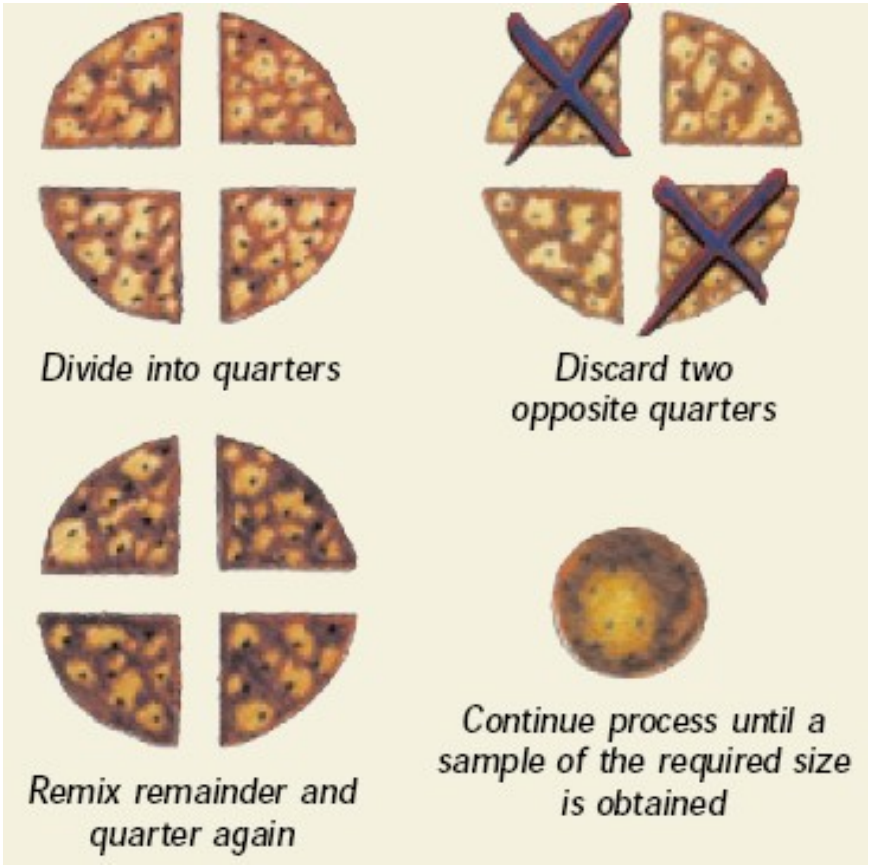
A Riffling, normally used for reducing material which is in a surface dry condition.

B Quartering can be used to reduce damp material down to a quantity which can be further prepared, e.g. by drying and then riffling.



Flatten the main sample

Quartering



Riffling



Standard size and square openings

Sieve Designation

Traditional	Metric
3”	75mm
2”	**50mm**
1 ½”	37.5mm
1”	**25mm**
¾”	19mm
½”	**12.5mm**
3/8”	9.5mm
No 4	4.75mm
No 8	2.36mm
No 16	1.18mm
No 30	600 micro m
No 50	300 micro m
No 100	150 micro m
No 200	75 micro m

7 standard sieves ranging from 150 µm to 9.5 mm (No. 100 to 3/8 in) for fine aggregates

Gradation Classifications

- **Well-graded:**
maximum density, high stability, low permeability
- **One-sized:**
particles same diameter, low stability, permeable
- **Gap-graded:**
Missing one or more sizes, stable, average permeability
- **Open-graded:**
Mostly large sizes, unstable, high permeability

Different standards and specifications specify grading limits for both fine and coarse aggregates.

There are several reasons for specifying grading limits and maximum aggregate size, they affect:

- Cement and water requirement
- Workability
- Economy
- Pumpability
- Relative aggregate proportions
- Shrinkage and durability of concrete

The following table shows the limits of ASTM C 33 with respect to fine aggregates, these limits are generally satisfactory for most concretes:

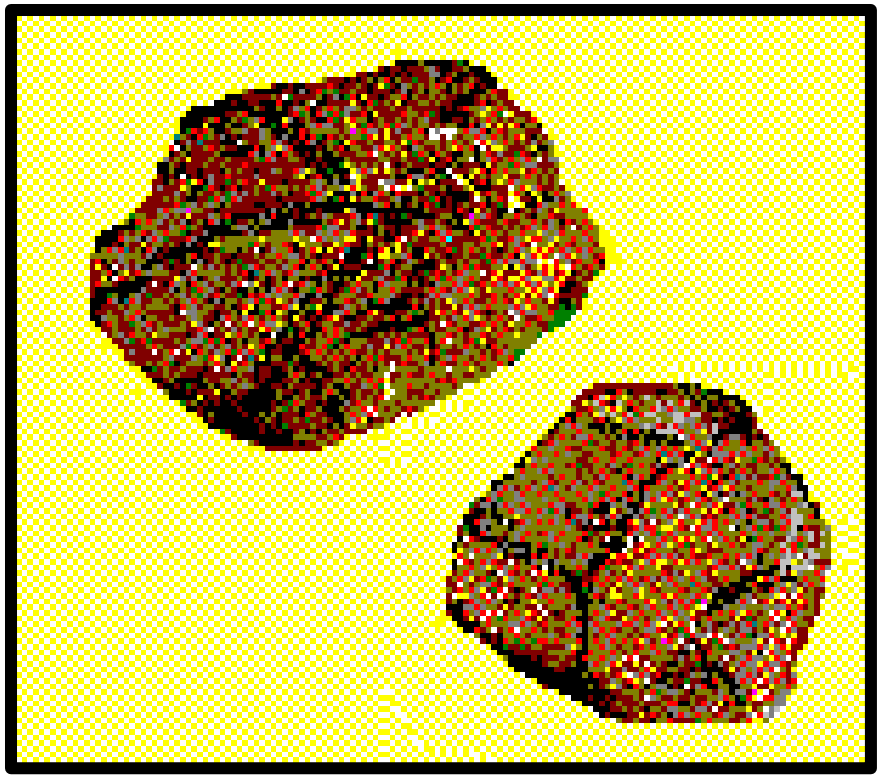
Sieve size		Percentage passing by mass
9.5 mm	(3/4 in)	100
4.75 mm	(No. 4)	95 to 100
2.36 mm	(No. 8)	80 to 100
1.18 mm	(No. 16)	50 to 85
600 µm	(No. 30)	25 to 60
300 µm	(No. 50)	5 to 30
150 µm	(No. 100)	0 to 10

Shape and Surface Texture of Aggregates

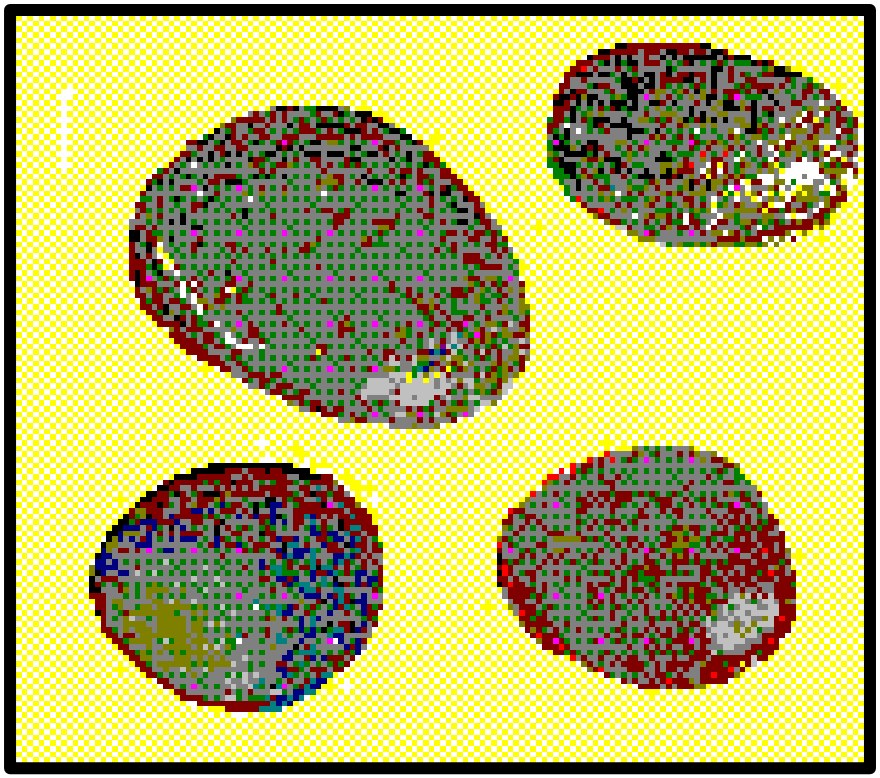




Aggregate Shapes

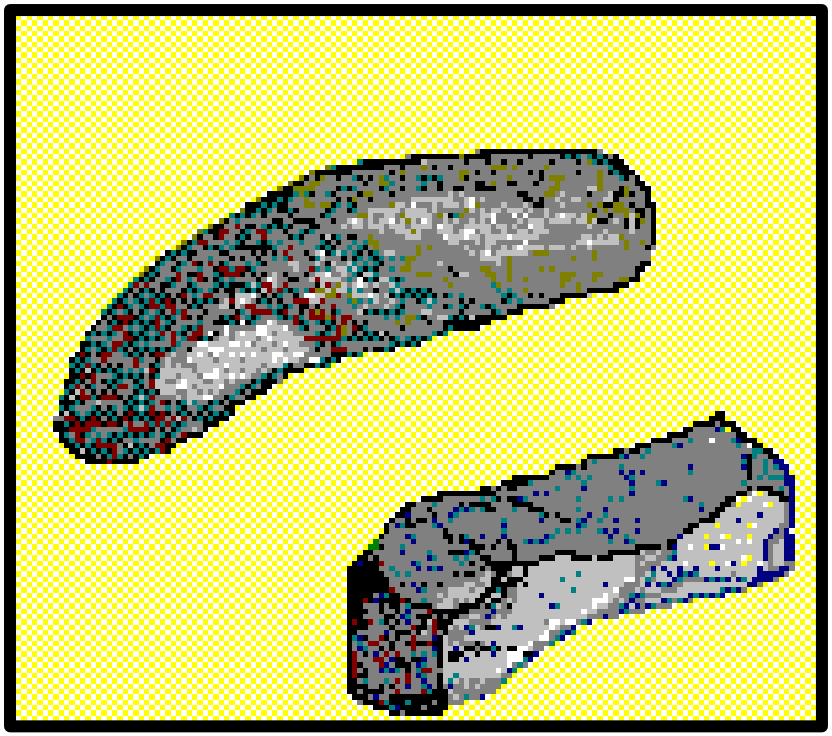


Rounded and angular



Rounded

Aggregate Shapes

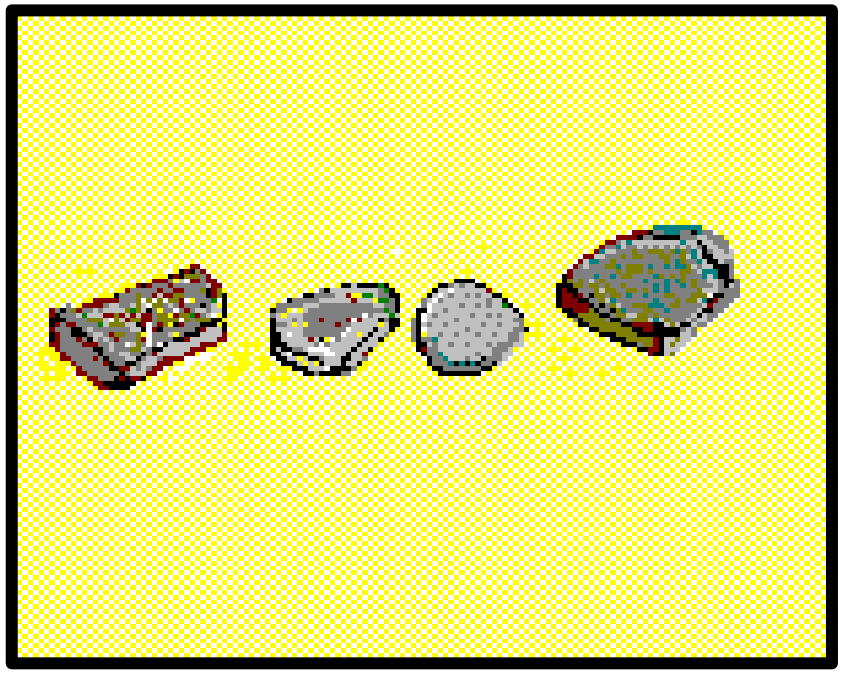


Elongated

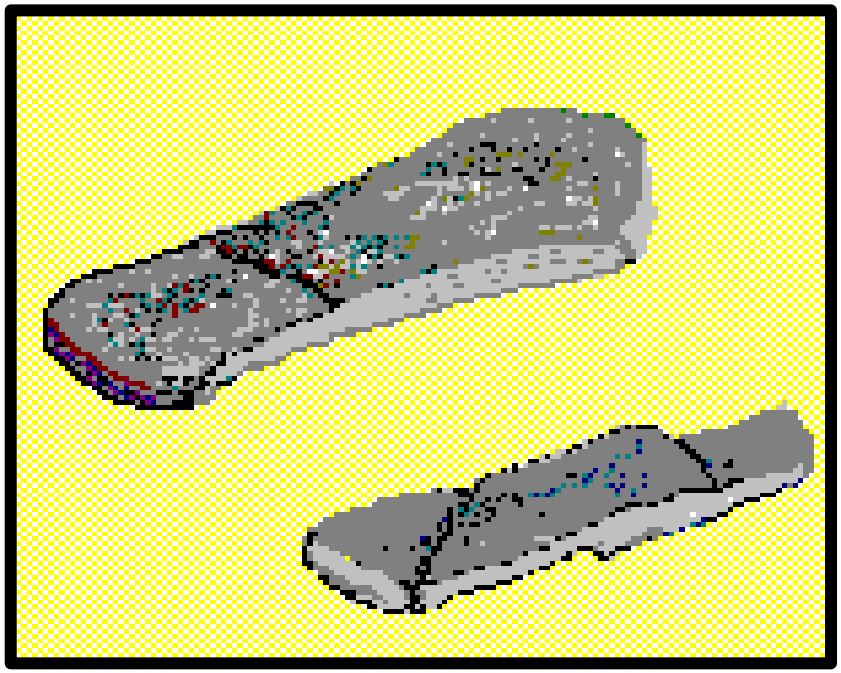


Angular

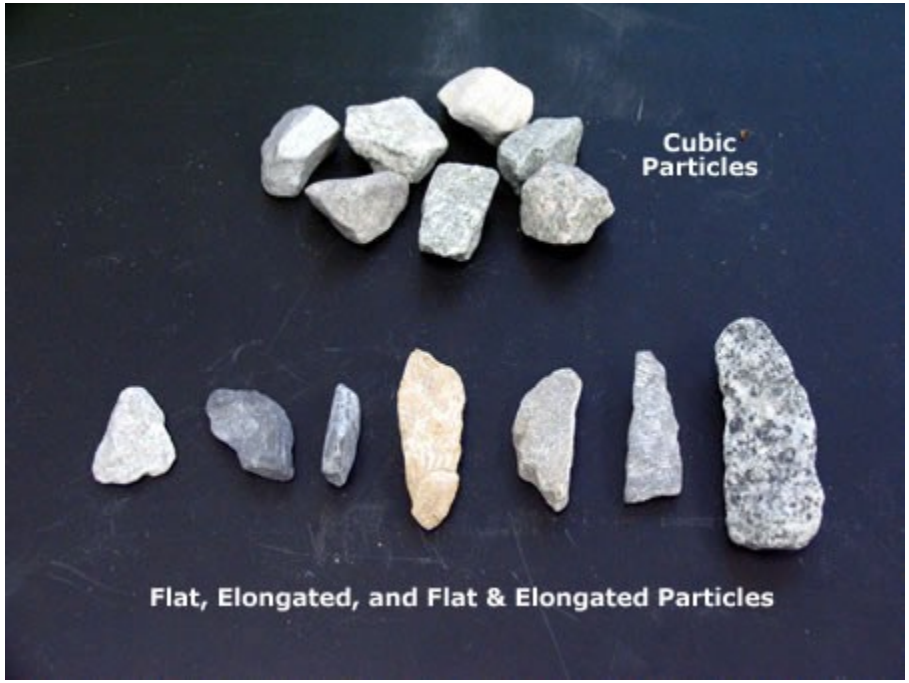
Aggregate Shapes

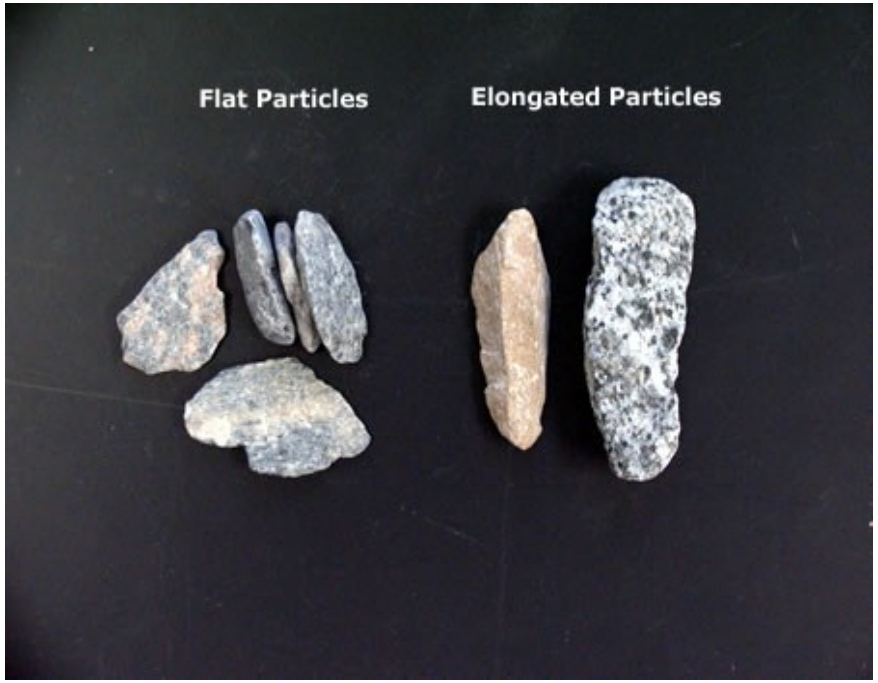


Flaky



Flaky and Elongated


Cubic Particles
Flat, Elongated, and Flat & Elongated Particles


Flat Particles
Elongated Particles

Moisture Content

Two types of moisture are recognized in aggregates:

- Absorbed moisture
- Surface moisture

Absorbed moisture is that which is taken in by the voids in aggregate particles and may not be apparent on the surface.

Surface moisture is that which clings to the surface of the particle.

Total moisture content

- The total amount of water present on the external and internal surfaces of aggregates.

  = Surface moisture + absorbed moisture

The moisture conditions of aggregates are designated as follows:



- ***Oven-Dry (OD)***: In this condition they are fully absorbent.
- ***Air-Dry (AD)***: Particles are dry at the surface but contain some interior moisture. They are therefore somewhat absorbent.
- ***Saturated Surface Dry (SSD)***: In this condition there is no water on the surface, but the particle contains all the interior moisture it will hold. It will neither absorb moisture from nor contribute moisture to the mix.
- ***Damp or Wet***: The particles contain an excess of moisture on the surface and will contribute moisture to a mix.

Cleanliness (Deleterious Substances)

The cleanliness of the aggregate affects the bond between the paste and the aggregate surface.

Deleterious (harmful substances) have the following effects on concrete:

- Weaken bondage between cement paste and aggregates
- Interfere with hydration
- Reduce of strength and durability
- Affect water tightness of the concrete
- Modify setting action and
- Cause efflorescence

HANDLING AND STOCKPILING OF AGGREGATES

The purpose of appropriate handling and stock piling of aggregates is to avoid breakage, segregation, contamination, and degradation.

Precautions:

- Storing on hard and dry ground or on platforms of planks, sheets, lean concrete
- Storing separately each aggregate size in compartments
- Avoiding segregation of aggregates resulting from free fall
- Damping consignments at different places.
- Proper collection and mixing of test batches is important to ensure that test samples accurately represent the aggregate in the entire stockpile.





Concrete Admixture







1. Definition

Admixtures are chemicals which are added to concrete at the mixing stage ***to modify*** some of the properties of the mix.

2. Uses of admixtures

- To increase workability without changing water content.
- To reduce water content without changing workability.
- To adjust setting time.
- To reduce segregation and/or bleeding.
- To improve Pumpability.
- To accelerate the rate of strength development at early ages.

3. Types of admixtures

Admixtures are classed according to function. There are five distinct classes of chemical admixtures:

1. Plasticizers (water-reducing agents)
2. Superplasticizers
3. Air entrainers
4. Accelerators
5. Retarders

3.1 Plasticizers

When added to a concrete mix, plasticizers (water-reducing agents) are absorbed on the surface of the binder particles, causing them to repel each other and deflocculate. This results in improved workability and provides a more even distribution of the binder particles through the mix.

Plasticizers Reduce the water requirement of a concrete mix for a given workability by about 10%.

- Concrete containing a plasticizer (water-reducing admixture) needs less water to reach a required slump than untreated concrete.
- The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement.

Uses of plasticizers

- Increase the slump of concrete with a given water content.
- Reduce the water requirement of a concrete mix for a given workability by about 10%.
- The addition of a plasticizer makes it possible to achieve a given strength with a lower cement content.
- Improve pumpability.

Problems associated with plasticizers

- Some plasticizers contain chlorides which may increase the danger of corrosion of reinforcing steel.
- Where plasticizers are used to increase workability, the shrinkage and creep will invariably be increased.

3.2 Superplasticizers

Also known as or high-range water reducers (HRWR), reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete.

As a result of the slump loss, superplasticizers are usually added to concrete at the jobsite.

Uses of superplasticizers

- In areas of congested reinforcement.
- Where workable concrete that can be placed with little or no vibration or compaction.
- For high-strength concretes by decreasing the water: cement ratio as a result of reducing the water content by 12–30%.

Problems associated with superplasticizers

- The effect of a superplasticizer may disappear as soon as 30-60 minutes after mixing.
- They have a relatively high unit cost.
- Where superplasticizers are used to produce very high workability, the shrinkage and creep will be increased.

3.3 Air entrainers

An air-entraining agent introduces air in the form of minute bubbles distributed uniformly throughout the cement paste.

Uses of air-entertainers

- Where improved resistance of hardened concrete to damage from freezing and thawing is required.
- For improved workability, especially in harsh or lean mixes.
- To reduce bleeding and segregation, especially when a mix lacks fines.

Air entrainment may reduce the strength of concrete and overdosing can cause major loss of strength. As a rule-of-thumb, 1% air may cause a strength loss of 5%.

It is therefore important that mixes be specially designed for air entrainment and that the percentage of air entrained during construction must be monitored.

3.4 Accelerators

Accelerators :

- speed up the chemical reaction of the cement and water and so....
- accelerate the rate of setting and/or early gain in strength of concrete.

Uses of accelerators

- Where rapid setting and high early strengths are required.
- Where rapid turnover of moulds or formwork is required.
- Where concreting takes place under very cold conditions.

Problems associated with accelerators

- Certain accelerators may increase drying shrinkage, cracking and creep.
- Many chloride-based accelerators promote corrosion of reinforcing steel.
- Calcium chloride should not be used in reinforced concrete
- Overdosing with these materials can cause marked retardation.
- Accelerators work more effectively at lower ambient temperatures.

3.5 Retarders

These admixtures slow the chemical reaction of the cement and water leading to longer setting times and slower initial strength gain.

Uses of retarders

- When placing concrete in hot weather, particularly when the concrete is pumped.
- To prevent cold joints due to duration of placing.
- In concrete which has to be transported for a long time.

Problems associated with retarders

- If a mix is overdosed beyond the limit recommended by the supplier, retardation can last for days.
- Retarders often increase plastic shrinkage and plastic settlement cracking.
- Delayed addition of retarders can result in extended retardation.

Fresh Concrete









Gathering Ingredients



Proportioning



Mixing



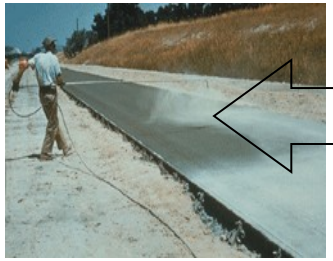
Transporting

Placing Compaction & finishing





Curing



Hardened Concrete




CHEMICAL
ADMIXTURE
CRUSHED
ROCK
WATER
SAND
PORTLAND
CEMENT





Major properties of fresh concrete

Fresh concrete is also known as plastic concrete. The major Properties of concrete in its plastic state are:

- **Workability**
- **Consistency**
- **Segregation**
- **Bleeding**
- **Stiffening and setting**

1. Workability

Workability is ease of placing and resistance to segregation of concrete.

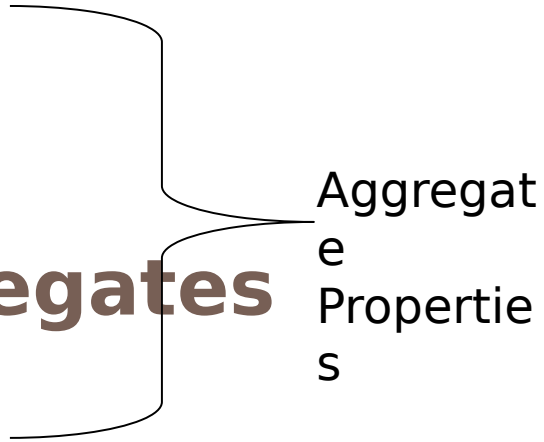
Workability means how easy it is to:

- PLACE
- HANDLE
- COMPACT and
- FINISH a concrete mix.

Concrete that is stiff or dry may be difficult to Handle, Place, Compact, and Finish will not be as strong or durable when finally hardened.

Factors that affect workability

- Water content
- shape of aggregates
- Grading of Aggregates
- Size of Aggregates
- Surface Texture of Aggregates
- Admixtures



Water content

If water content is increased the coarse particles settle and bleeding occurs. Cement slurry can escape through joints of formworks.



Aggregate properties

- **shape of aggregates**
- **Grading of Aggregates**
- **Size of Aggregates**
- **Surface Texture of Aggregates**

Angular, flaky, and elongated aggregates reduce workability.

Nonabsorbent aggregates and optimum percentage of fine aggregate contributes to workability .

Admixtures

- Workability admixtures improve the workability of concrete
- Air entraining agents produce numerous air bubbles that act as rollers to decrease bleeding and segregation, and as a result increase workability.

2. Consistency

Consistency refers to ***ability to flow*** of concrete and **indicates wetness** of concrete, and thus workability.

Concrete could have:

- ✓ Dry
- ✓ Plastic: can be shaped into ball
- ✓ Semi-fluid: spreads out slowly and with out segregation of aggregate
- ✓ Fluid consistency: spreads out fast and results in segregation of aggregates

3. Segregation

Segregation is separation of coarse aggregates from the mass of concrete.

Segregation results from:

- Uncontrolled pumping or falling
- Placing under waters
- Placing concrete in heavily reinforced members

Precautions to control segregation



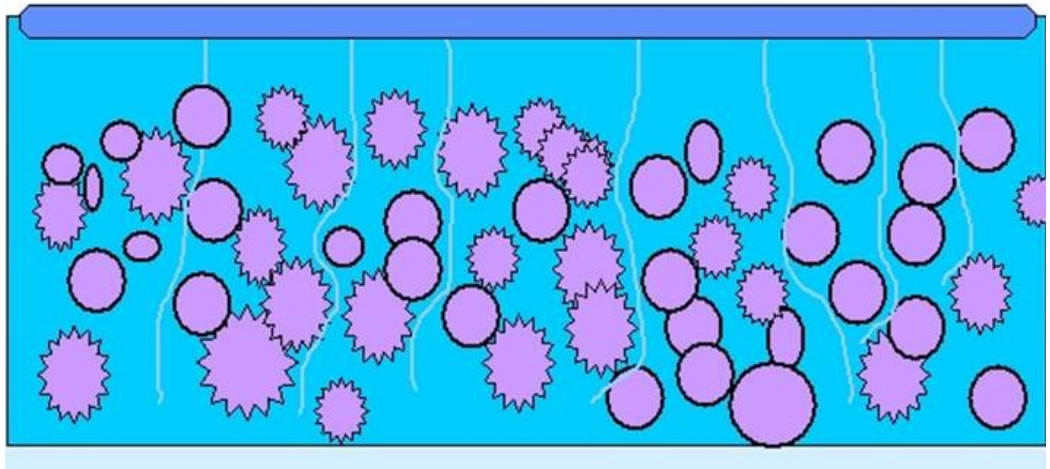
Placing concrete near its final position, instead of falling from greatest heights

Precautions to control segregation

- Careful handling, pacing, and consolidation of concrete
- Applying Admixtures : Plasticizer and air entraining admixture.

4. Bleeding

Bleeding is the appearance of water on concrete surface. As a consequence of bleeding, slum layer will be formed making concrete weak and porous.



Measures to minimize bleeding

- Using well graded and proportioned aggregates
- Increasing amount of cement
- Applying air entering agents
- Reducing amount of water

5. Stiffening and setting

Concrete is required to remain plastic for the time to be taken to transport, place, and consolidate it.

Temperature influences the stiffening of concrete. That is,

Low temperature⇒ delays

High temperature ⇒accelerates the stiffening of concrete.

MEASUREMENT OF WORKABILITY

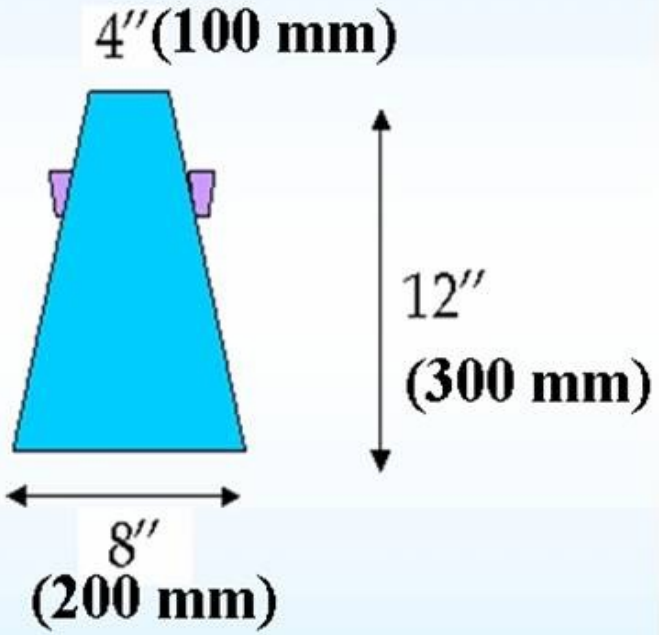
Some of the methods of measuring workability that is wetness or fluidity are:

- ✓ Slump test
- ✓ Compacting factor test

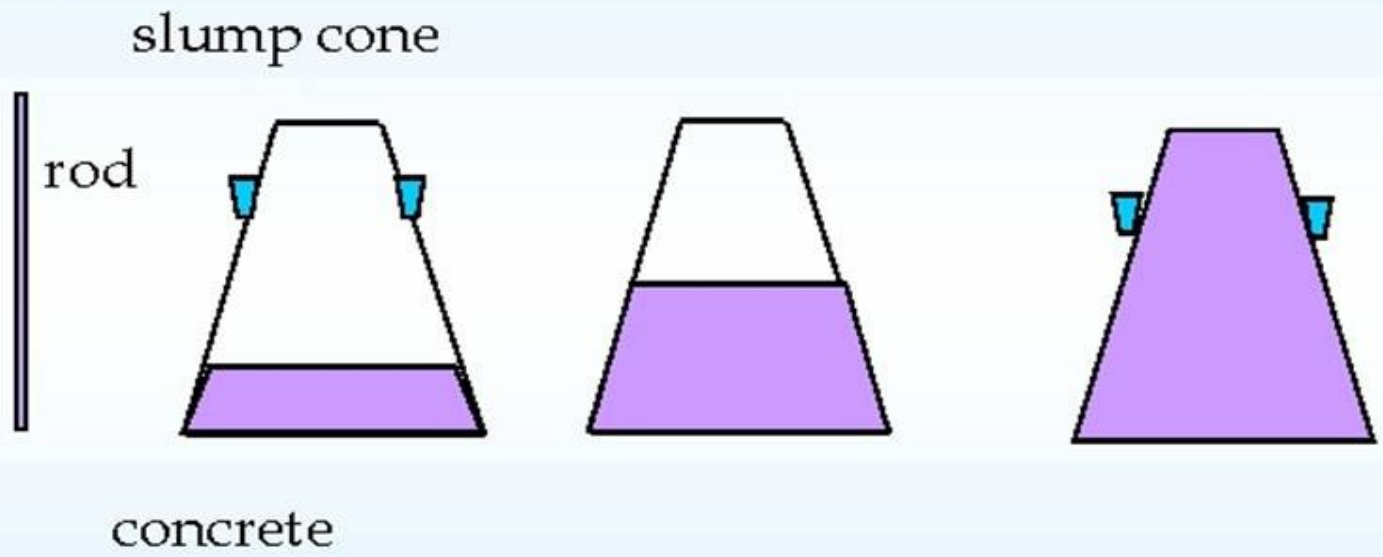
Slump Test

Slump is the subsidence of concrete cone after mold is lifted up.

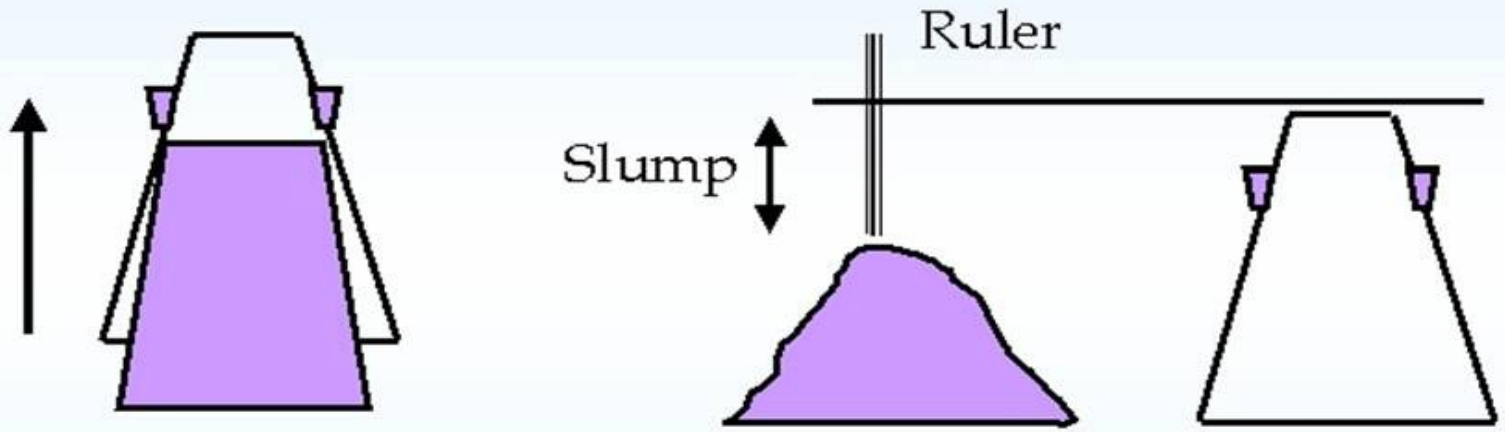
- Inverted cone
- fill it up with three layers of equal volume
- rod each layer 25 times
- scrape off the surface



Slump Test



Slump test









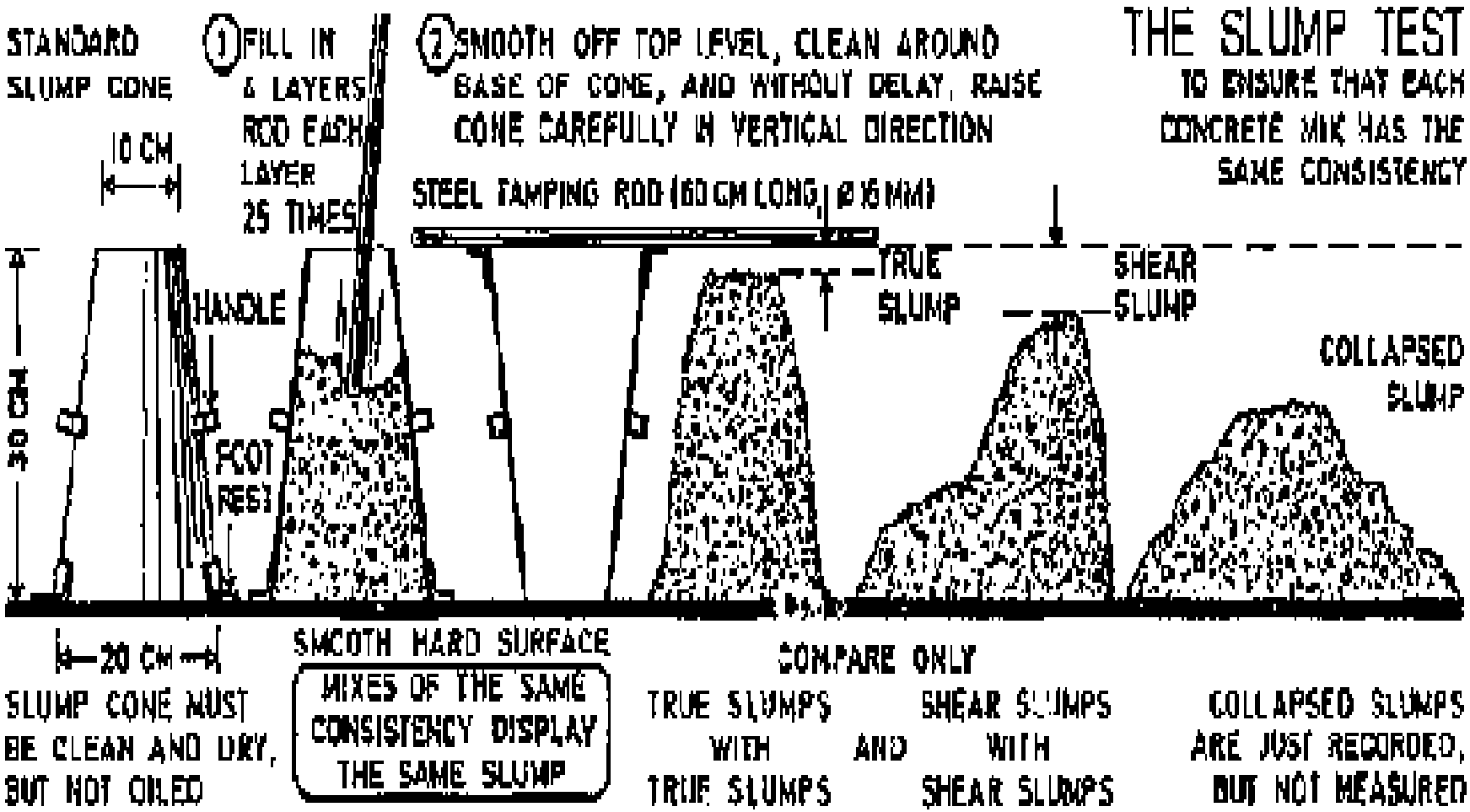








Types of slump



Types of slump (results of slump)

- **True Slump -** Has even subsidence
- **Shear Slump -** Half of the cone slides, difficult to measure, and results from harsh mixes deficient in fine aggregates.
- **Collapse Slump** - difficult to measure, results from very wet mixes.

Slump test results

Slump (mm)	Degree of workability (Suitability)
0-25	Very low (Massive sections, little reinforcement)
25-50	Low (little reinforcement)
50-100	Medium (Beam, columns)
100-175	High (For heavily reinforced sections

Limitations of slump test

- Not applicable for aggregates size greater than 40 mm .
- Applicable to plastic mixes only
- Not applicable to harsh and wet mixes

Compacting Factor Test

Drier mixes do not give slump. Therefore, compaction factor test should be done to determine degree of compaction (compacting factor) by falling the mix through successive hoppers with standard height using a compaction factor test apparatus.



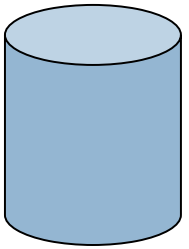
Compaction factor test apparatus

Compaction factor

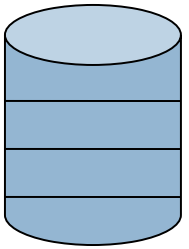
$$= \frac{\text{weight of partially compacted concrete}}{\text{weight of fully compacted concrete}}$$

(compacted in 4 layers, 25 x tempering each layer)

e.g.



weight of concrete partially compacted = 11.02 kg



weight of concrete fully compacted = 12.04 kg

Compaction factor = 11.02 kg / 12.04 kg

= 0.915

Compacting factor values

- For compacting factor values between 0.75-0.80, compacting concrete by hand is not permissible.
- For Compacting Values less than 0.75, pressure should be exerted into concrete to vibrate.
- Compacting factor test is suitable for both dry and wet mixes, since it gives constant results.

Vibe test

- most suitable test for determining differences in consistency of very dry mixes.
- however, only applicable to concrete with a maximum size of aggregate of less than 40 mm.
- For the test, a standard cone is cast. The mould is removed, and a transparent disk is placed on the top of the cone. Then it is vibrated at a controlled frequency and amplitude until the lower surface of the disk is completely covered with grout. The time in seconds for this to occur is the Vebe time. The test is probably most suitable for concrete with Vebe times of 5 to 30s. The only difficulty is that mortar may not wet the disc in a uniform manner, and it may be difficult to pick out the end point of the test.

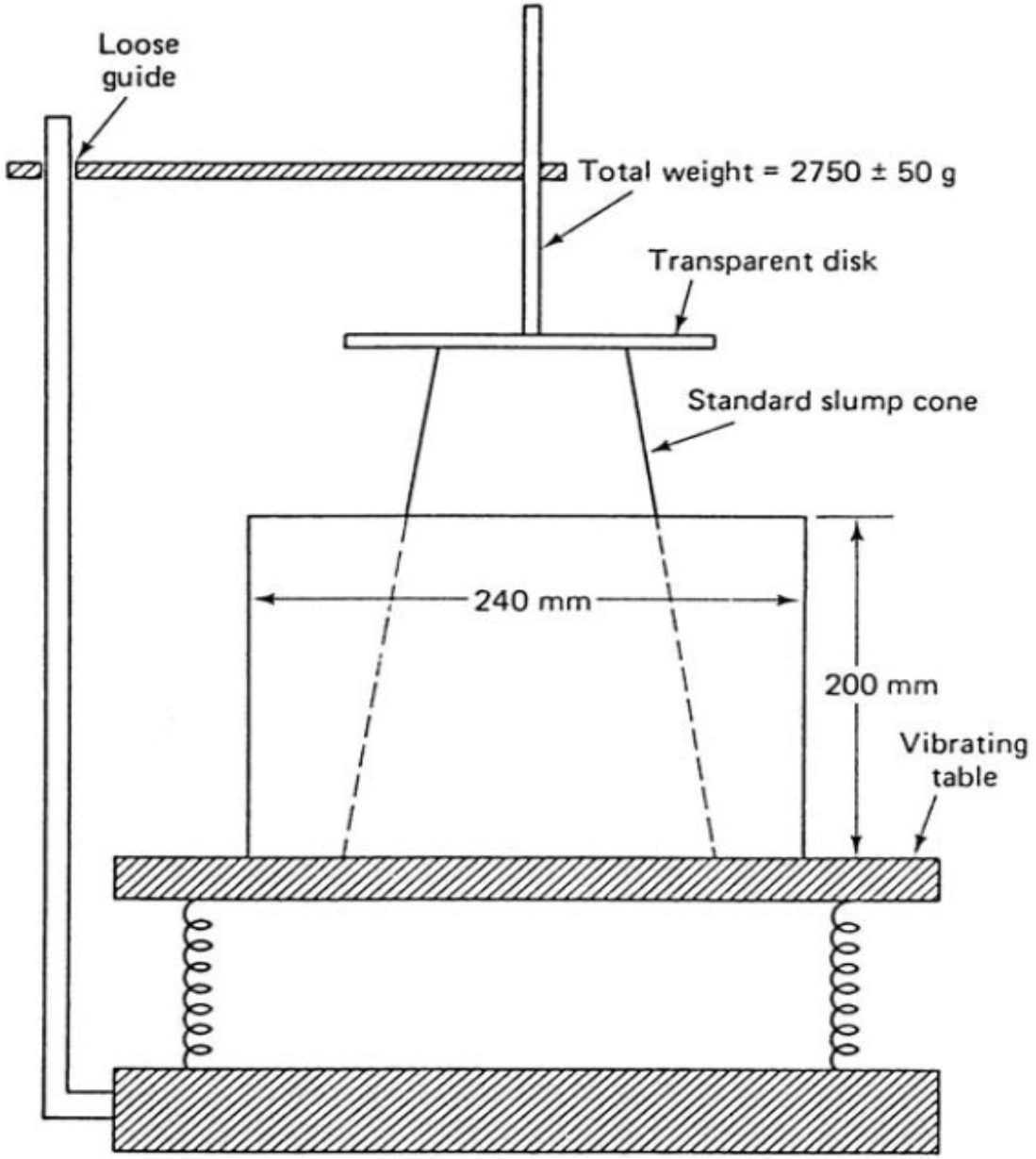
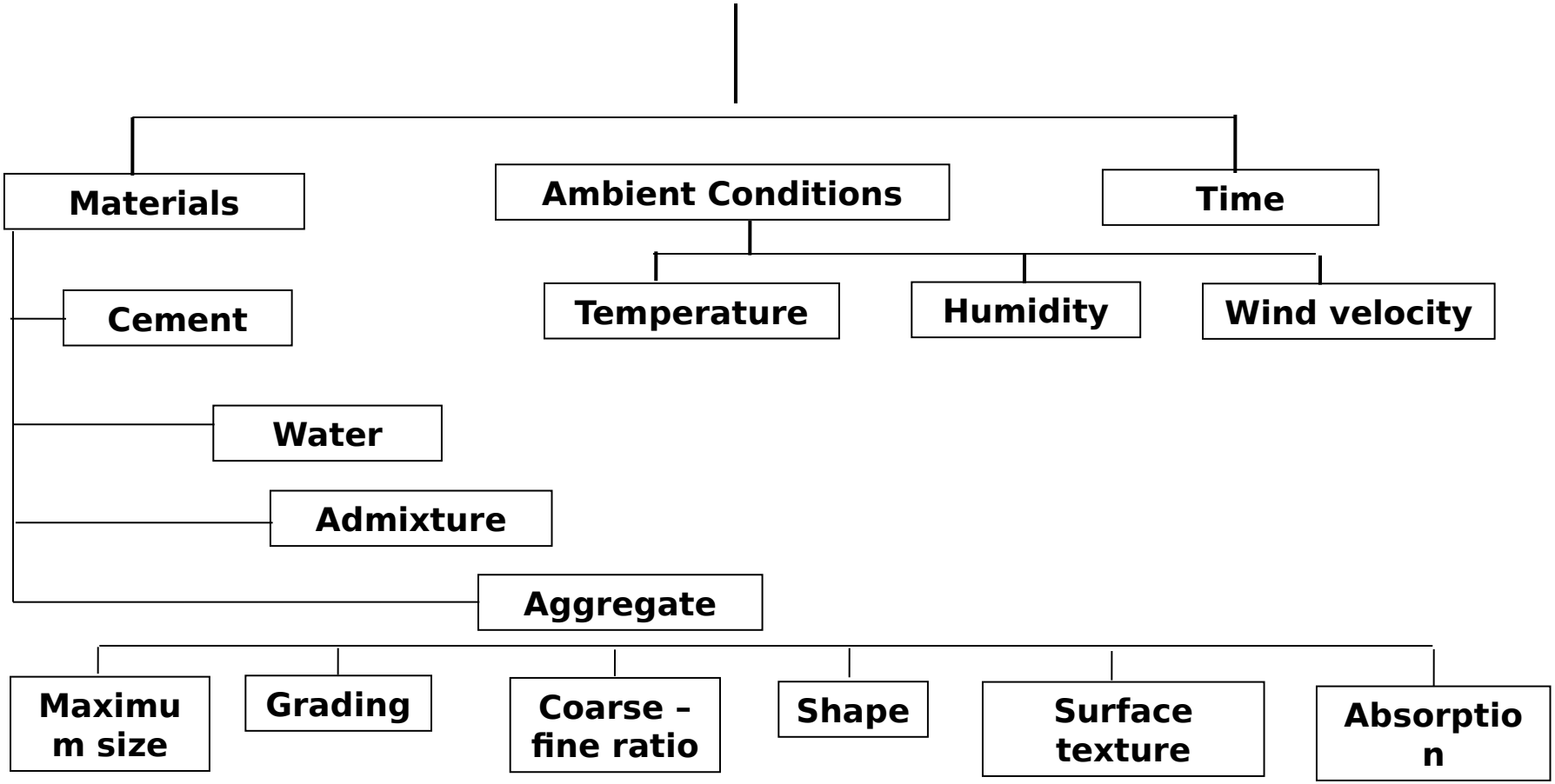


Figure Vebe apparatus.

Factors affecting workability



MIXING OF CONCRETE



Purpose of mixing

The purpose of concrete mixing is to provide a ***uniformly blended product*** of cement, water, and aggregates.

Basic requirement of mixing is to produce concrete of uniform consistency from beginning to end.

Mixing time 2 to 3 minutes

Methods of mixing

Two basic methods of mixing concrete;

i. **Hand (Manual) mixing**
ii. **Machine mixing**

Methods for mixing concrete

Machine mixing



Drum mixer



Pan

Manually





Readymixed

Hand Mixing

Adopted for small works and quantity of concrete used is small

Procedure:

- Sand + cement ⇒ dry mix
- Spread the sand -cement mix on a flat platform
- Spread the measured quantity of coarse aggregate on the cement-sand mix

- Mix the cement + sand + c.agg. At least three times by shoveling from center to the side and then back to the center and again to the side
- Make a hallow in the middle of the mixed pile and pour slowly into it half to three-quarter of the total quantity of water required
- Add the remainder of the water slowly, turning the mixture over and again until the color and consistency are uniform throughout the pile

Note: 1. Time of mixing should not exceed 3 minutes

2. Mixing platform is cleaned at the end of the days work, so that it is ready for use the next day

Machine mixing

- Used in case of a large quantity of concrete is to be produced
- Concrete can be produced at a faster rate at a lesser cost and of better quality

Note

- Care for mixer is very important!

1. Wash the mixer every day preferably with a hose
2. Hammering or hitting of the loading skip in order to accelerate the discharge of adhering sand and cement should not be permitted
3. When the mixer is installed at one place for a loner periods, it should be ensured that wheels and axle of the mixer do not get buried under accumulating materials
4. Before closing down a shift or day’s work, the interiors of the drum and blades are flushed clean
5. General upkeep and maintenance of the mixer engine be attended everyday, i.e., fuel, water, lubricant, etc.

Transporting Concrete

1. Pans
   - When quantity is small
   - When access to work is restricted
   - Method is tedious, slow and costly



2. Wheel barrows

Moderate distance and medium quantities



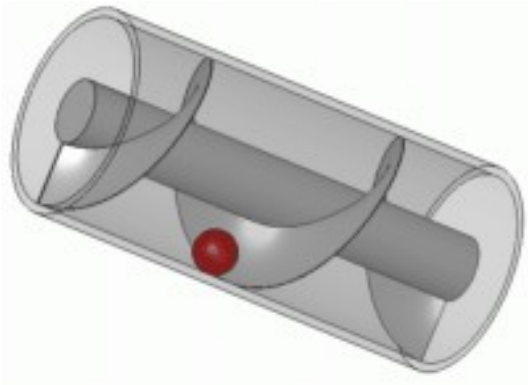
Wheelbarrow

Transporting Concrete

3. Truck mixer

- When place of deposit of concrete is at a very long distance from the mixer such that the concrete cannot be transported and placed in the forms within 30 minutes
- Happens in case of ready-mixed concrete
- Drum containing the concrete rotates continuously to prevent the concrete from being **stiff** and to prevent **segregation**


25 11:35 AM



4. Belt conveyors

- When the concrete is to be transported continuously and to a higher level
- Installed in an inclined position
- Concrete should be **stiff** consistency having a slump not more than 50 mm

5. Chutes

- When concrete is to be placed below ground level, the mixer may be placed on an upper level and concrete discharged to the lower level through a chute of corrugated iron or timber.



Chute



7. Pumps

- When large quantity of concrete is to be transported continuously to congested sites where mixing plant can not be installed

- To a ma) m horizontally ar ally



Methods for transporting te



Wheelbarrow



Concrete buggy



Chute



Bucket
(Large & massive construction. Handled by crane)



Concrete pump (through pipe)

Placing of concrete

- Concrete should be placed and compacted before setting commences

- Method of placing should be in such a way as to prevent **segregation** (should n dropped from a height m an about 1m)









An elevation column of h=3.71m is being casted with out a window at h=1.50m (one of the reasons for segregation).



Good construction methodology, in casting columns from convenient height by providing a window.

Formwork

Material

i. Timber ⇒ Most commonly used

ii. Plywood ⇒ Bounded with water proof synthetic resin adhesives

iii. Hard board ⇒ Manufactured from wood fibers, usually impregnated with drying oils and factory applied plastic coatings

iv. Metal forms ⇒ very common nowadays







worn-out timber formwork







Formwork?.....What formwork!

Compaction of Concrete



What is compaction?

Compaction is the process which expels entrapped air from freshly placed concrete and packs the aggregate particles together so as to increase the density of concrete.

Methods of compaction

i. Hand compaction (Tamping)

ii. Vibrators

- Internal vibrators
- Form vibrators
- Surface vibrators

Finishing concrete

Concrete that will be visible, such as slabs like driveways, highways, or patios, often needs finishing. Concrete slabs can be finished in many ways, depending on the intended service use.



Curing Concrete

Curing is the process which controls the loss of moisture from concrete either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur.

Since the hydration of cement does take time – days, and even weeks rather than hours – curing must be undertaken for a reasonable period of time if the concrete is to achieve its potential strength and durability.

Methods of curing

i. Shading concrete
ii. Covering concrete surfaces
iii. Sprinkling water
iv. Ponding method
v. Membrane curing
vi. Steam curing

Duration of curing

Concrete shall be covered and kept constantly wet for seven days from the date of placing



Sprinkling water



Polyethylene sheets



Straw or hay

HARDENED CONCRETE

Definition

Hardened concrete is a concrete which developed the required strength and changed to solid state.

Properties of Hardened concrete

The properties of Hardened concrete are properties which change contentiously with time. In its hardened state the various properties which need consideration are

1. Strength
2. Permeability
3. Durability
4. Dimensional Change (elasticity shrinkage, thermal expansion, creep)
5. Fire Resistance

Factors affecting properties of hardened concrete

- Water cement ratio
- Cement content
- Temperature
- Age
- Aggregates properties
- Curing
- Frost
- Entrained Air

Corrosion of Reinforced Concrete





Reinforced Concrete Corrosion



















Testes for Hardened Concrete





There are three basic categories of concrete testing , Namely :-

1. **Quality control**
2. **Compliance test**
3. **Secondary test**

for hardened concrete ,we mainly use the secondary test type.

Secondary test .



Distractive test

None distractive

Distractive Tests

- Cube/cylinder compressive strength test
- Flexure test
- Concrete Core Test

Cube/cylinder compressive strength test



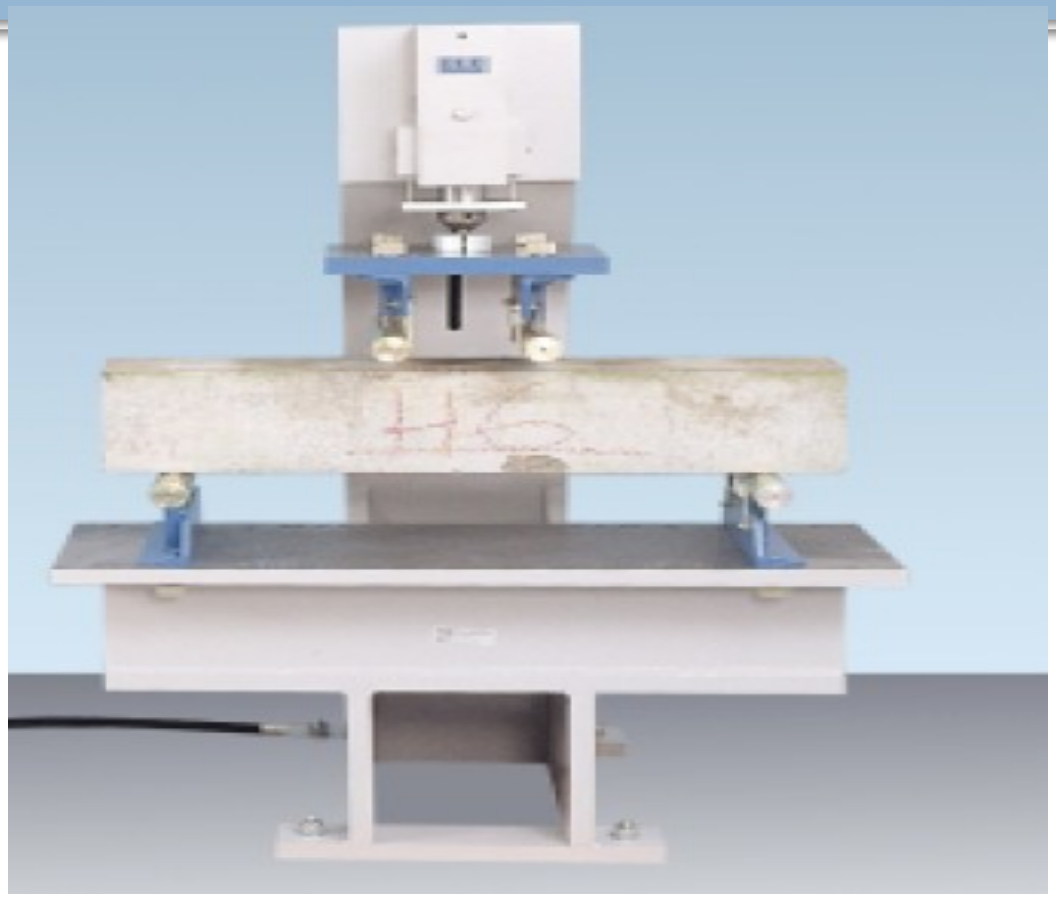






Flexure test





CONCRETE CORE TEST

The examination of compressive strength testing of core drilled from hardened concrete enable the visual inspection of interior region of the structural member along with the estimation of actual concrete strength.

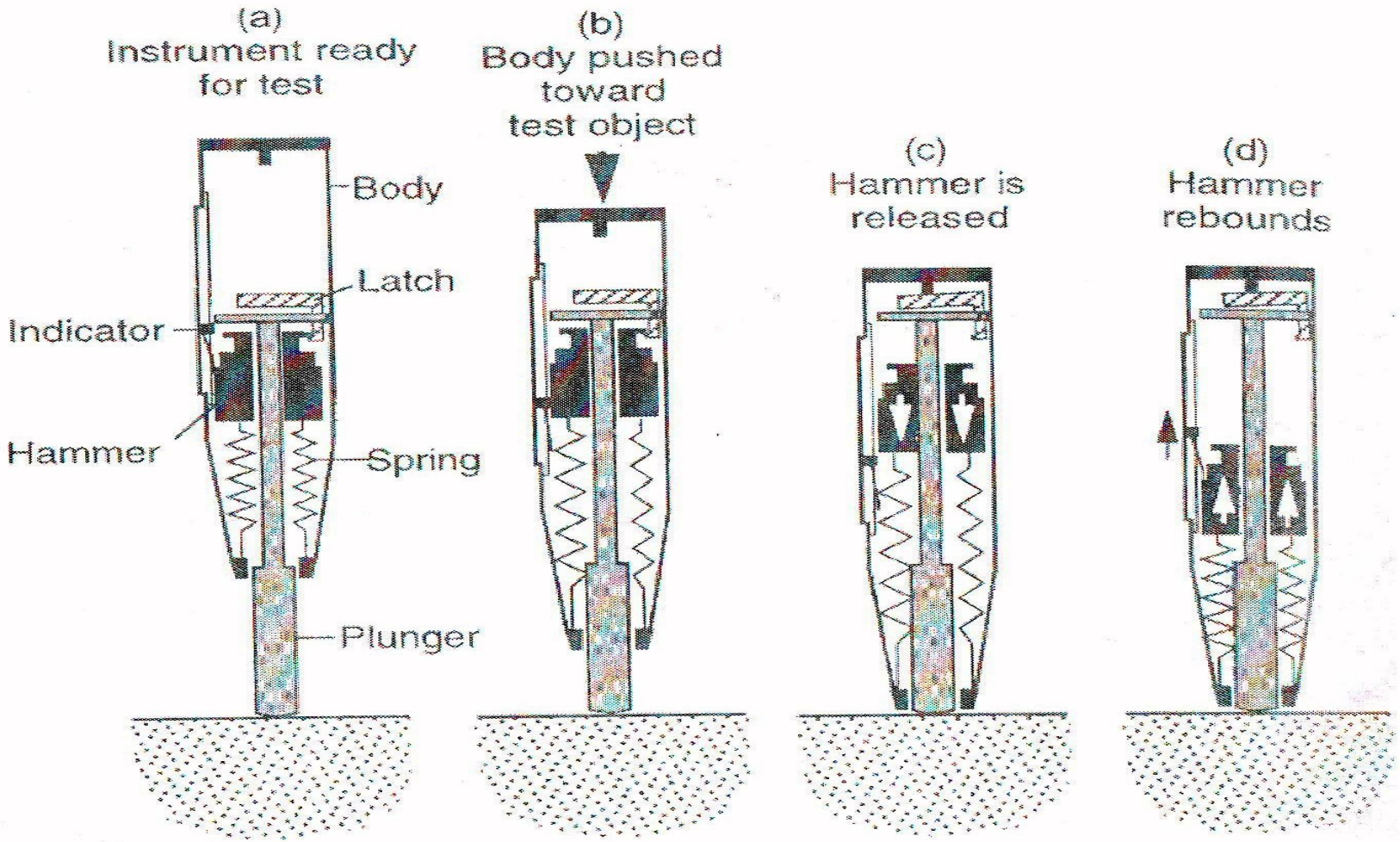
None Distractive test

- Rebound hammer test
- Ultrasonic test
- Probe penetration test
- Pullout test

REBOUND HAMMER TEST

- Is a test developed for testing concrete based on rebound principle .
- when concrete is struck by hammer , the degree of rebound is the indicator of the hardness of the concrete .
- In 1948, Ernest Schmidt, a Swiss engineer, developed a device for testing concrete based on the rebound principle .




(a)
Instrument ready
for test
(b)
Body pushed
toward
test object
(c)
Hammer is
released
(d)
Hammer
rebounds
Body
Latch
Indicator
Hammer
Spring
Plunger





Other tests

- Relative Newly Developed Methods
  - X-ray And Gamma Radiography
  - Neutron Moisture Gauges
  - Magnetic Cover Meters
  - Electrical Methods
  - Microwave Absorption, And
  - Acoustic Emissions Techniques.

VOLUME OF FRESH CONCRETE

$$V = V_a + V_w + V_c + V_{fa} + V_{ca}$$

VOLUME OF FRESH CONCRETE

The volume of the fresh concrete is equal to the sum of the absolute volumes of its components, including the naturally entrapped or purposely entrained air.

$$V = V_a + V_w + V_c + V_{fa} + V_{ca}$$

$$V = V_a + V_w + V_c + V_{fa} + V_{ca}$$

Where:

V_a = Volume of the air

V_w = volume of the water

V_c= absolute volume of the cement

V_{fa} = absolute volume of the fine aggregate

V_{ca} = absolute volume of the coarse aggregate

MIX DESIGN