1.1 Engineering Materials(Remaining)
1.2 Standards(NS and IS) and tests of civil Engineering materials

Er. Saurav Shrestha

1. Quartzite is a

a) metamorphic rock
b) argillaceous rock
c) calcareous rock
d) Igneous rock

2. Granite is

a) sedimentary rock
b) metamorphic rock
c) igneous rock
d) volcanic rock.

3. Sand stone is

a) sedimentary rock
b) metamorphic rock
c) igneous rock
d) volcanic rock.

4. Metamorphic rock with the most weather resisting property is

a) Marble
b) Quartzite
c) Slate
d) Lime stone

5.Which of the following term is used to indicate the art of building the structures in stones?

a) Mortar

b) Brick

c) Bond

d) Masonry

6. The clay to be used for manufacturing bricks for a large project, is dugout and allowed to weather throughout

a) the monsoon
b) the winter
c) the summer
d) none of these.

7. Minimum compressive strength of first class brick is:

a) 75 kg/cm2
b) 90 kg/cm2
c) 100 kg/cm2
d) 120 kg/cm2

8. Minimum compressive strength of second class brick is:

a) 75 kg/cm2
b) 90 kg/cm2
c) 100 kg/cm2
d) 120 kg/cm2

Tiles

Types of Tiles:

1. **Ceramic Tiles**: Made from clay materials, ceramic tiles are kiln-fired and come in various styles, including glazed and unglazed.
2. **Porcelain Tiles**: A type of ceramic tile with a denser body and lower water absorption rate, making them highly durable and suitable for both indoor and outdoor use.
3. **Natural Stone Tiles**: Quarried from natural stone materials such as marble, granite, limestone, slate, and travertine, these tiles offer unique colors and patterns.
4. **Glass Tiles**: Made from glass materials, these tiles are available in various shapes, sizes, and finishes, adding a reflective and modern touch to spaces.
5. **Mosaic Tiles**: Small tiles arranged in patterns or designs, typically used as decorative accents or for creating intricate designs.

Characteristics of Tiles:

1. **Durability**: Tiles are known for their durability and resistance to wear, moisture, and stains.
2. **Surface Finish**: Tiles can have different finishes such as matte, glossy, textured, or polished, affecting their appearance and slip resistance.
3. **Color and Design**: Available in a wide range of colors, patterns, and designs to suit various aesthetic preferences.
4. **Size and Shape**: Tiles come in various sizes and shapes, from small mosaics to large-format tiles, allowing for diverse design possibilities.
5. **Water Absorption**: Porosity varies among tiles, affecting their suitability for different applications, such as wet areas or outdoor use.

Composition of Tiles:

1. **Clay**: Ceramic tiles are primarily composed of clay materials, while porcelain tiles contain clay, sand, and other minerals.
2. **Glaze**: Glazed ceramic tiles have a protective layer of glaze applied to the surface, providing color, texture, and added durability.
3. **Natural Stone**: Natural stone tiles are made from quarried stone materials, such as marble, granite, or slate, which are cut into tiles and finished according to desired specifications.
4. **Glass**: Glass tiles are manufactured from molten glass materials, which are cooled and shaped into tiles of various sizes and finishes

Selection Criteria:

1. **Application**: Consider where the tiles will be installed, such as floors, walls, backsplashes, or outdoor areas.
2. **Durability**: Choose tiles with appropriate hardness, abrasion resistance, and water absorption properties for the intended use.
3. **Aesthetic Appeal**: Select tiles that complement the overall design scheme, including color, pattern, and texture.
4. **Maintenance**: Assess the ease of cleaning and maintenance required to keep the tiles looking their best over time.
5. **Cost**: Balance quality, aesthetics, and budget constraints when selecting tiles for a project.

Tiles

Usage of Tiles:

1. **Flooring**: Tiles are commonly used for flooring in residential, commercial, and industrial spaces due to their durability and versatility.
2. **Wall Cladding**: Tiles are applied to walls for decorative purposes, protection, and ease of maintenance, particularly in kitchens and bathrooms.
3. **Backsplashes**: Tiles are used as backsplashes in kitchens and bathrooms to protect walls from water, grease, and stains while adding visual interest.
4. **Countertops**: Certain types of tiles, such as porcelain and natural stone, are suitable for use as countertops in kitchens, bathrooms, and other areas requiring durable surfaces.
5. **Outdoor Spaces**: Porcelain, natural stone, and some ceramic tiles are used for outdoor patios, decks, walkways, and pool surrounds due to their resistance to weathering and moisture.

Testing Methods for Tiles:

1. **Water Absorption Test**: Determines the porosity of tiles, particularly important for assessing suitability for wet areas and outdoor use.
2. **Abrasion Resistance Test**: Measures the resistance of tiles to wear and abrasion, particularly relevant for flooring applications.
3. **Coefficient of Friction Test**: Evaluates the slip resistance of tiles, essential for areas prone to moisture and potential slipping hazards.
4. **Breaking Strength Test**: Assesses the load-bearing capacity and structural integrity of tiles under pressure.
5. **Chemical Resistance Test**: Determines the resistance of tiles to chemicals and stains, important for assessing suitability for specific applications and maintenance requirements.

Cements

Natural cement: manufactured from stones containing 20 to 40 % clay and remaining % occupied by calcareous material, either $CaCo_3$ or mixture of $CaCO_3$ and $MgCO_3$

Artificial cement: manufactured by burning appropriately proportioned mixture of calcareous material and clay material at high temperature, resulting in formation of clinker , which is grinded with addition of small % of gypsum.

Basic Ingredients of Cement(OPC)

Lime (CaO)- 60-67%
Silica (SiO_2)- 17-25%
Alumina (Al_2O_3)- 3-8%
Calcium sulphate ($CaSO_4$)- 3-5%
Ferrous Oxide (Fe_2O_3)- 0.5-6%
Magnesium oxides (MgO)- 0.1 - 4%
Sulphur Trioxides (SO_3)- 1.3 - 3%
Alkalies – 0.4 – 1.3%

Lime:

- Major constituents of cement
- Presence of lime in sufficient quantity is required to form silicates and aluminates of calcium
- Make cement sound and strong (if in right proportion)
- Excess lime causes cement unsound, causes expansion and disintegration

Silica:

- Major constituent of cement
- Helps in formation of di-calcium silicate and tri-calcium silicates
- Responsible for the strength of cement
- Excess silica increases the strength

Alumina:

- Imparts quick setting property to cements
- As flux, lowers the clinkering temperature of cement
- Excess amount reduces the strength of cement

Calcium sulphate:

- added to the cement in the form of gypsum in clinker during grinding
- Increases the initial setting time of cement

Ferrous oxides:

- Increases the hardness of cement
- Provides the color to the cement
- Acts as flux and helps to fuse raw materials of cement

Magnesium oxides:

Imparts hardness to the cement
Imparts color to the cement
Excess amount causes unsoundness of the cement

Sulphur trioxides:

Makes cement sound if in proper amount

Alkalies:

Should be present in small quantity
Excess alkalies causes efflorescence
Excess amount causes alkali-aggregate reaction in concrete, masonry works.

Harmful Ingredients of Cement

- Excess alkali oxides in cement such as potassium oxides and sodium oxides causes cracks in mortar made from such cement.
- K_2O and Na_2O <1 %
- MgO < 5%

Cements

Types of Cement

- OPC (Ordinary Portland Cement)
- High Alumina Cement
- Portland Slag cement
- Rapid Hardening Cement
- Low heat Cement
- Quick Setting Cement
- White Cement
- Colored Cement
- Portland Pozzolana Cement

Consistency Test of Cement

- 300gm of cement is taken with 25% water
- Fill the mould of Vicat's apparatus
- The interval between the addition of water to the commencement of filling of mould is known as the time of *gauging* and it should be $3^{3/4}$ to $4^{1/4}$ minutes
- Vicat's apparatus is attached with plunger having diameter and length as 10mm and 50mm respectively
- **Square needle(1mm*1mm) for initial setting time, plunger for consistency test, needle with annular collar for final setting time**
- Settlement of plunger is noted and if the penetration is bet^{n} 5 to 7mm from bottom of mould, the water added is correct.

Initial Setting Time Test

- Take a cement sample of 300gm and mixed with water (quantity from consistency test)
- Filled the Vicat's mould with the cement paste
- Using the square needle of 1mm*1mm or $1mm^2$ X-sectional area try to find the penetration of about 5 mm from bottom of the mould.(35 mm from top of mould)
- The initial setting time is the interval between the addition of water to cement and the stage when the needle ceases to penetrate completely. This time is to be 30 minutes for OPC.

Final Setting Time Test

- Cement paste is prepared as above and it is filled in the Vicat's mould as previously done.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus. This needle has a sharp point projecting in the centre with annular collar.
- The needle is gently released. The time at which the needle makes an impression on the test block and the collar fails to do so is noted.
- The final setting time is the difference between the time at which water was added to cement and time as recorded when needle only penetrates the paste. This time should be about 10 hrs for OPC.

Cements

Compressive Strength Test of Cement

% of water by wt of cement = (P/4 +3.5),

P= % of water for normal consistency

3 Moulds of either cube size 70.6mm or 76mm

Dry mix cement and sand then mix with water for uniform colour with in 3-4 mintues

Rod the mortar placed in mould 20 times in about 8 secs for full compaction

Store specimen of cubes for 24 hours in place of relative humidity 90 % and temperature 27 +_ $2^{O}C$.

Cubes are tested in compression testing machine at end of 3 days and 7 days

Load is applied uniformly at the rate of $350kg/cm^2$

C.S > $115kg/cm^2$ (3days),

C.S >$175kg/cm^2$(7 days)

Average of 3 moulds give compressive strength

Tensile Strength Test of Cement

% of water by wt of cement= (P * 0.2 +2.5),

P= % of water for normal consistency

12 standard briquettes are prepared

Six briquettes are tested after 3 days and 7 days . Rate of loading $35kg/cm^2$

X-sectional of briquette at least section is $6.45cm^2$

Ultimate tensile stress = failing load/6.45

At 3 days T.S>$20kg/cm^2$, at 7 days T.S>$25kg/cm^2$

Soundness Test

- Test to detect the presence of uncombined lime and magnesia in cement
- Test performed with the help of Le-Chatelier apparatus.
- Brass mould of 30mm dia. and 30mm height
- There is split in mould and it doesn't exceed 0.50mm

Procedure

On either side of split there are two indicators with pointed ends

Thickness of mould cylinder is 0.50mm

Cement paste is prepared (water = 0.78 P)

Using glass plate at bottom, fill the mould with paste, then cover upper surface of mould with glass plate along with small weight at top.

Submerge in water for 24 hrs (25^0C to 29^0C)

Then measure the distance between the points of indicator (Say: x_1)

Again, submerge the mould in water and apply the heat in such a way that boiling temperature of water is reached in about 30 minutes and boiling is continued for 3 hours.

The mould is taken out then left for cooling, again the distance between the points of indicators is again measured (say: X_2)

Difference between x_1 and x_2 must not exceed 10mm.

Lime

Lime is produced by heating limestone which is more or less pure calcium carbonate.

Uses

❖Used as binding material for mortar or concrete.
❖Used as aggregate in the form of crushed limestone.
❖Used as raw material for manufacture of glass.
❖Used as improving agent for good quality of soil.
❖Used in the purification of water, sewer treatment etc.

Properties

❖It posses good plasticity.
❖It is easily workable & durable.
❖It offers good resistance to moisture.
❖It gives strength to the masonry used as mortar.

Components of lime

Clay:

- Its presence produces hydraulicity in lime. In lime it is desirable to have 8-30% of clay. It retards slaking when present in small quantity, arrests slaking when it is in excess. Clay makes lime insoluble in water.

Soluble silica:.

Magnesium carbonate:

Alkalies & metallic oxides:

Sulphates:

Iron compounds:

Carbonaceous matter

Types

❖**Fat lime (Rich, pure lime)**

❖ It is lime which has high CaO & is depended for setting & hardening on the absorption of CO2 from atmosphere.

❖ It contains about 93% CaO & less than 5% impurities such as silica, alumina etc.

Poor or lean lime

❖ It consists of impurities of about more than 5% in the form of silica, alumina. It takes longer time to slake than fat lime. It sets & hardens slowly.

Hydraulic lime:

❖ Hydraulic lime sets by absorbing CO2 from atmosphere. This lime sets under water. It is used in building works when strength is required.

Types

❖**Fat lime (Rich, pure lime)**

- ❖ It is lime which has high CaO & is depended for setting & hardening on the absorption of CO2 from atmosphere.
- ❖ It contains about 93% CaO & less than 5% impurities such as silica, alumina etc.
- ❖ It slakes actively with hissing sound & lot of heat generated during slaking.
- ❖ It **swells 2-3 times of original volume** after slaking.

- **Poor or lean lime**
- ❖ It consists of impurities of about more than 5% in the form of silica, alumina. It takes longer time to slake than fat lime. It sets & hardens slowly.
- ❖ It has poor binding properties.
- ❖ It forms a thin paste with water.

- **Hydraulic lime:**
- ❖ Hydraulic lime sets by absorbing CO2 from atmosphere. This lime sets under water. It is used in building works when strength is required.

1. Feebly hydraulic lime:

- It contains 15% silica & alumina. Increased in volume is small. Rate of slaking is very slow.

2. Moderately hydraulic lime:

- It contains 15-25% silica & alumina. Increased in volume is small.

3. Eminently hydraulic lime:

- It contains 25-30% silica & alumina. It gives stronger mortar. It is used as cement.

1.For the manufacture of Portland cement, the proportions of raw materials used, are

a) lime 63% ; silica 22% ; other ingredients 15%

b) lime 22% ; silica 63% ; other ingredients 15%

c) silica 40% ; lime 40% ; other ingredients 20%

d) silica 70% ; lime 20% ; other ingredients 10%.

- The apparatus used in consistency test of cement is:

a) Vicats needle

b) Vicats plunger

c) Vicats needle with annular collar

d) Le Chatliers apparatus

- Initial setting time for OPC cement should not be less than:

a) 45 mins

b) 600 mins

c) 40 mins

d) 30 mins

- The apparatus used for soundness test of cement is:

a) Vicats apparatus
b) compression testing machine
c) Le chatlier’s apparatus
d) Soundness apparatus

The initial setting time of lime-pozzolana, is

a) 30 minutes
b) 60 minutes
c) 90 minutes
d) 120 minutes.

- The apparatus used for initial setting time of cement is:

a) Vicats needle
b) Vicats plunger
c) Vicats needle with annular collar
d) Le Chatliers apparatus

- The apparatus used for final setting time of cement is:

a) Vicats needle
b) Vicats plunger
c) Vicats needle with annular collar
d) Le Chatliers apparatus

According to IS standard, maximum setting time for OPC should be

a) 30 minutes
b) 1 hour
c) 6 hours
d) 10 hours

The standard consist of cement is the condition when

a) Plunger penetrates to 5-7 mm from bottom of mould
b) Plunger penetrates to 5-7 mm from top of mould
c) Plunger penetrates to 50-70 mm from top of mould
d) Plunger penetrates to 25-30 mm from bottom of mould

Timber

Wood suitable for use as an engineering purpose is called timber.

❖According to various stages of which timber is found, it is named as:

- ❖Standing timber – part of living tree
- ❖Rough timber – when the tree felt.
- ❖Converted timber – rough timber is further sown & converted to market forms such as beams, planks etc.

❖**Types of wood:**

❖Depending upon the mode of growth; trees are:

❖Endogenous

❖Endogenous trees grow inward in a longitudinal fibrous mass such as banana, bamboo, cane.

❖**It is not suitable for engineering purposes with exceptional bamboo.**

❖Exogenous

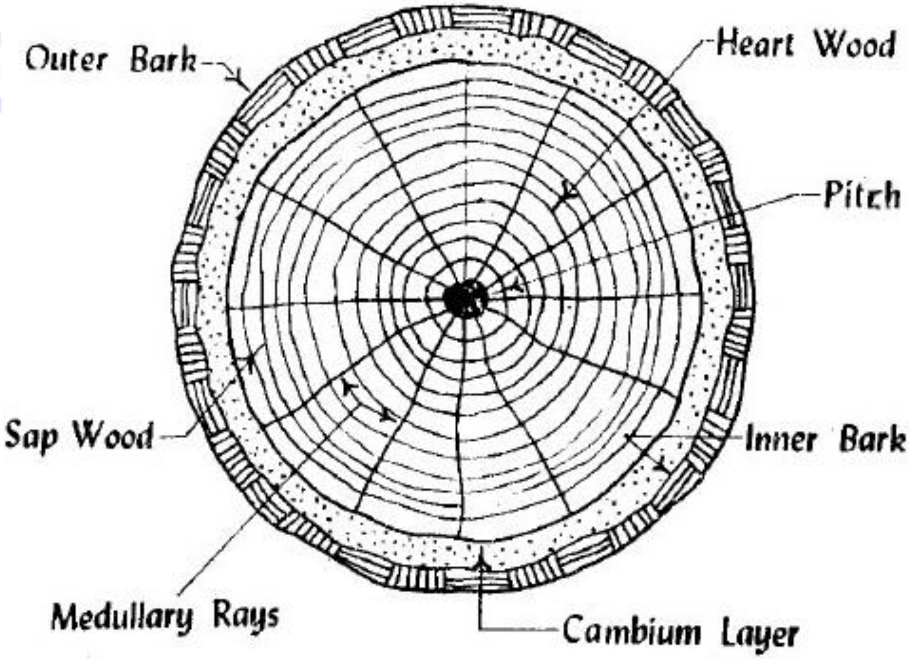
❖Exogenous trees are those that grow outwards with the addition of the ring every year known as annual ring.

❖Thus number of annual ring show the age of the tree.

❖**The timber obtained from this class of trees is extensively used in engineering works.**

❖**<u>Conifer or evergreen yielding soft wood:</u>**E.g. Deodar, pine, chir etc.

❖**<u>Deciduous yielding hard wood:</u>**



Characteristics of good timber

- It should have straight and close fibres.
- Uniform colour.
- **Give clear ringing sound when struck.** Dulls heavy sound is the sign of internal decay.
- It should have regular annual rings.
- Timbers with narrow annual rings are generally strongest.
- **Teeth of saw shouldn’t get clogged while sawing.**
- It should have bright & smooth surface when planned, dull appearance is a sign of defective timber.
- Darker & heavier pieces are strong.
- **It should be free from knots, shakes for other defects.**
- It should have compact medullary rays.

Metal and alloys

Classification:

- Ferrous metal:
  - The metal where iron is main constituent.
- Non-ferrous metal:
  - The metal where iron is not main constituent.

- **Occurrence of iron:**
  - **Magnetite (70-75% iron)**
  - **Haematite (70% iron)**
  - **Iron pyrite (47% iron)**
  - **Siderite (40% iron)**
- Pig iron is the crudest form of iron. All the various forms of iron & steel are then obtained by suitably purifying & adjusting the composition of pig iron.

Type, properties and uses of iron

- **Pig iron:**
  - In order to remove impurities from the iron ore, carbon & flux are added while melting it. The refined product so obtained is the crudest form of iron & is called pig iron. Then it is cast into raw parts called pigs.
- **Cast iron:**
  - Pig iron is remelted with limestone & coke in a furnace & poured into moulds of desired shapes & sizes to get pure product known as cast iron. Carbon contain in cast iron vary from 2-4.5%. It contains impurities like manganese, phosphorous, silicon etc.
- **Wrought iron:**
- In wrought iron, nearly all the carbon & other elements in pig iron are oxidized & left with 0.25% of carbon obtained wrought iron. It is the purest form of iron in which the total impurities don't exceed 0.5%.

Characteristics:

- It is hard, brittle & easily fusible with 1250ºC of melting temperature.
- It doesn't burst& can't be magnetized.
- It can be harden by heating & sudden cooling.
- It can't be tempered.
- It shrinks on cooling.
- It is strong in compression but weak in tension.
- It can't be riveted or welded.
- It is used for rainwater pipes, sewer pipe, gutters etc.

Composition and properties of steel

Carbon steel types:

- ❖ Dead carbon steel (Carbon < 0.15%)
- ❖ Mild carbon steel (Carbon 0.15 – 0.25%)
- ❖ Medium carbon steel (Carbon 0.25 – 0.70%)
- ❖ High carbon steel (Carbon 0.70 – 1.5%)

Heat Treatment Process

Annealing: (Cool in sand, ash, lime)

- ❖ Annealing may be defined as heating the steel to austenite phase & then cooling slowly through the transformation range

Quenching/Hardening:

- ❖ Quenching may be defined as rapid cooling of steel from the austenite phase. The rapid cooling is obtained by immersion of steel in a liquid bath such as water or oil & sometimes forced air can also be used.

Normalizing: (become brittle & crack)

- ❖ Normalizing may be defined as heating the steel to austenite phase & cooling it in air. It is done to achieve machinability.

Case hardening/Surface hardening:

- ❖ Surface hardening may be defined as a process of hardening a ferrous material in such a manner that the surface layer (case) is substantially harder than the remaining material (core).

Properties:

- ❖It is a mid way between cast iron & wrought iron.
- ❖It has a granular structure.
- ❖Its MP is between 1300 – 1400^{o}C
- ❖It can be hardened & tempered.
- ❖It absorbs socks.
- ❖It rusts easily.
- ❖It is tough, malleable & ductile.
- ❖It is strong in compression as well as tension.
- ❖It can be magnetite.
- ❖It can be rapidly forged & welded.
- ❖Used as reinforcement in RCC works, drill, bridges, steel column & beams, machine tools etc.

Bitumen:

- **It is defined as non crystalline solid or viscous hydrocarbon material having adhesive properties & derived from petroleum either by natural or refining process.**

Properties:

- It is solid or semi-solid, black in colour & is sticky.
- It melts or softens as application of heat.
- It is completely soluble in carbon-disulphide.
- It is binder in all types of asphalt.

Uses:

- Used as road making materials.
- Used in damp proof coarse (DPC).
- Since it forms good expansion joint, it is used for filling up the joints in leaky roof.
- It is employed in manufacture of water proofing materials, paints etc.

- **Cut-back bitumen:**
- Cut back is defined as a bitumen **whose viscosity is maintained by addition of volatile diluents such as gasoline, kerosene etc.** Cut backs are manufactured in three groups from rapid curing, medium curing, and slow curing.
- **Emulsion:**
- **Emulsion is combination of water, bitumen & emulsifying agent. To prevent bitumen spheres from coagulation, an emulsifying agent is added. Mostly soap is used as an emulsifying agent.**

Emulsion may be classified as rapid setting, medium setting & slow setting.

- Rapid setting (10-30 mins)
- Medium setting (30-60 mins)
- Slow setting (2-24 hrs.)

Tar:

- Tar is one of the bituminous material obtained during the destructive distillation of coal, peat, wood or other organic material.

Paint and Varnishes

- **Paint** is any liquid, liquefiable, or mastic composition(resin) that, after application to a substrate in a thin layer, converts to a solid film.
- It is most commonly used to protect, **color, or provide texture** to objects.

Components of Paint

1. Binder (or film former)

- The binder, commonly called the vehicle, is the film-forming component of paint.
- It is the only component that **must be present.** Other components are included optionally, depending on the desired properties of the cured film.
- The binder imparts **adhesion** and strongly influences properties such as gloss, durability, flexibility, and toughness.

2. Diluent or Solvent

- The main purposes of the diluent are to dissolve the polymer and adjust the viscosity of the paint.
- **It is volatile and does not become part of the paint film**. It also controls flow and application properties, and in some cases can affect the stability of the paint while in liquid state.
- Its main function is as the carrier for the non volatile components.

3. Pigment and Filler

- Pigments are granular solids incorporated in the paint to contribute **color**.

4. Additives

- Besides the three main categories of ingredients, paint can have a wide variety of miscellaneous additives, which are usually added in small amounts, yet provide a significant effect on the product.

Types of Paint

1. Whitewash:low-cost paint made from mixture of slaked lime or powdered chalk, size and water used for whitening walls

2. Oil Paint:slow drying paints which consist of particles of pigment suspended in a drying oil or oil varnish.

3. Emulsion Paint:

- Emulsions are defined as a mix of two liquids that don't mix well.

4. Cement Based Paint:

- Cement-based paints are water based paint in which cement forms the base.

5. Enamel Paint:

- Enamel paints are oil based paints and with a considerably glossy finish. Enamel Paints consists of white lead, zinc white, resinous matter and petroleum spirit. Enamel paints are more durable and have hard strong finish.

6. Bituminous paint 7. Lead Paint 8: Rubber paint 8.Metallic Paint

Varnishes

- **Varnish** is a transparent, hard, protective finish or film primarily used in wood finishing but also for other materials.
- Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent.
- Varnish finishes are usually glossy but may be designed to produce satin or semi-gloss sheens by the addition of "flatting" agents.
- Varnish has little or no color, is transparent, and has no added pigment, as opposed to paints or wood stains, which contain pigment and generally range from opaque to translucent.

Components of Varnish

1. Drying oil

- There are many different types of drying oils, including linseed oil, tung oil, and walnut oil.

2. Resin

3. Solvent (traditionally turpentine)

Distemper

- **Distemper** is a term with a variety of meanings for paints used in decorating and as a historical medium for painting pictures, and contrasted with tempera. The binding element may be some form of glue or oil; these are known in decorating respectively as
  - soft distemper and
  - oil bound distemper.

- 1. Bitumen is obtained from __________
  a) Wood
  b) Petroleum
  c) Coal
  d) Kerosene

- The distance between two samples in penetration test should be __________
  a) 10mm
  b) 15mm
  c) 20mm
  d) 25mm

- The bitumen is completely soluble in __________(IMP)
  a) Carbon monoxide
  b) Carbon dioxide
  c) Carbon sulfide
  d) Carbon disulfide

- Which bitumen does not need heating?
  a) Paving grade
  b) Cut back
  c) Modified
  d) Bitumen emulsion

- Which of the following grade of bitumen is harder?
  a) 30/40
  b) 60/70
  c) 80/100
  d) All are equal

1.2 Tests on civil Engineering Materials and IS and NS standards

- tests of brick (water absorption and compressive tests),
- tests of cement (consistency, setting time, soundness, and compressive strength);
- test of aggregate (bulking of sand);
- test of rebar (tensile test).

STANDARD TESTS ON BRICKS

Compressive strength test on brick

Step 1: brick specimen immersed in water for 24 hrs
Step 2: frog of brick is filled with 1:3 mortar and is stored under damp jute bags for 24 hrs followed by immersion in clean water for three days.
Step 3: place the specimen between the plates of the compression testing machine
Step 4: apply load axially at a uniform rate (14 N/mm^2) and maximum load at the specimen fails is noted

Compressive strength = $\frac{maximum\ load\ at\ failure}{loaded\ area\ of\ brick}$

Crushing or compressive strength of common building brick should not be less than 3.5 N/mm^2

Efflorescence test

- Step 1: Immerse the brick specimen for 24 hrs.
- Step 2: Take out and allow the specimen to dry in shade.
- Step 3: Check the availability of grey or white deposit on its surface which indicate the presence of soluble salt
- Presence of white deposit about 10% of surface -> said to be slight & consider as moderate
- Presence of white deposit about 50% of surface -> said to be heavy & considered as serious

- In absorption test on brick, how many hours it has to be soaked in cold water?
  a) 19 hours
  b) 5 hours
  c) 6 hours
  d) 24 hours

- What is the loading rate used in compressive strength test?
  a) 14 N/mm^2 per hour
  b) 14 N/mm^2 per minute
  c) 20 N/mm^2 per minute
  d) 40 N/mm^2 per hour

- When observed efflorescence is more than 10% but less than 50% of the exposed area, it is:
  a) Moderate efflorescence
  b) Serious efflorescence
  c) Heavy efflorescence
  d) Light efflorescence

- _________ is used for skirting around bathtubs and mosaics?
  a) Sandstone
  b) Travertine
  c) Granite
  d) Onyx

- How is the hardness of brick tested?
  a) Using finger nail
  b) Using hardness apparatus
  c) Using hammer
  d) Using chisel

- What is the maximum permissible tolerance for length and width respectively?
  a) ± 3mm and ± 6mm
  b) ± 6mm and ± 3mm
  c) ± 3cm and ± 6cm
  d) ± 6cm and ± 3cm

- Which of the following is not a feature of second class bricks?
  a) Have small irregularities
  b) Water absorption is between 20-25%
  c) Rectangular in shape
  d) Free from cracks

- The compressive strength of the brick should be:
  a) Minimum 3.5 kN/m^2
  b) Maximum 3.5 kN/m^2
  c) Minimum 3.5 N/mm^2
  d) Maximum 3.5 N/mm^2

- What does M_1 indicate in the formula:
  % water absorption = $\frac{M_2 - M_1}{M_2} \times 100$
  a) Oven dried mass of brick
  b) Oven dried and cooled mass of brick
  c) Mass of water absorbed brick
  d) Mass of water absorbed and dried brick

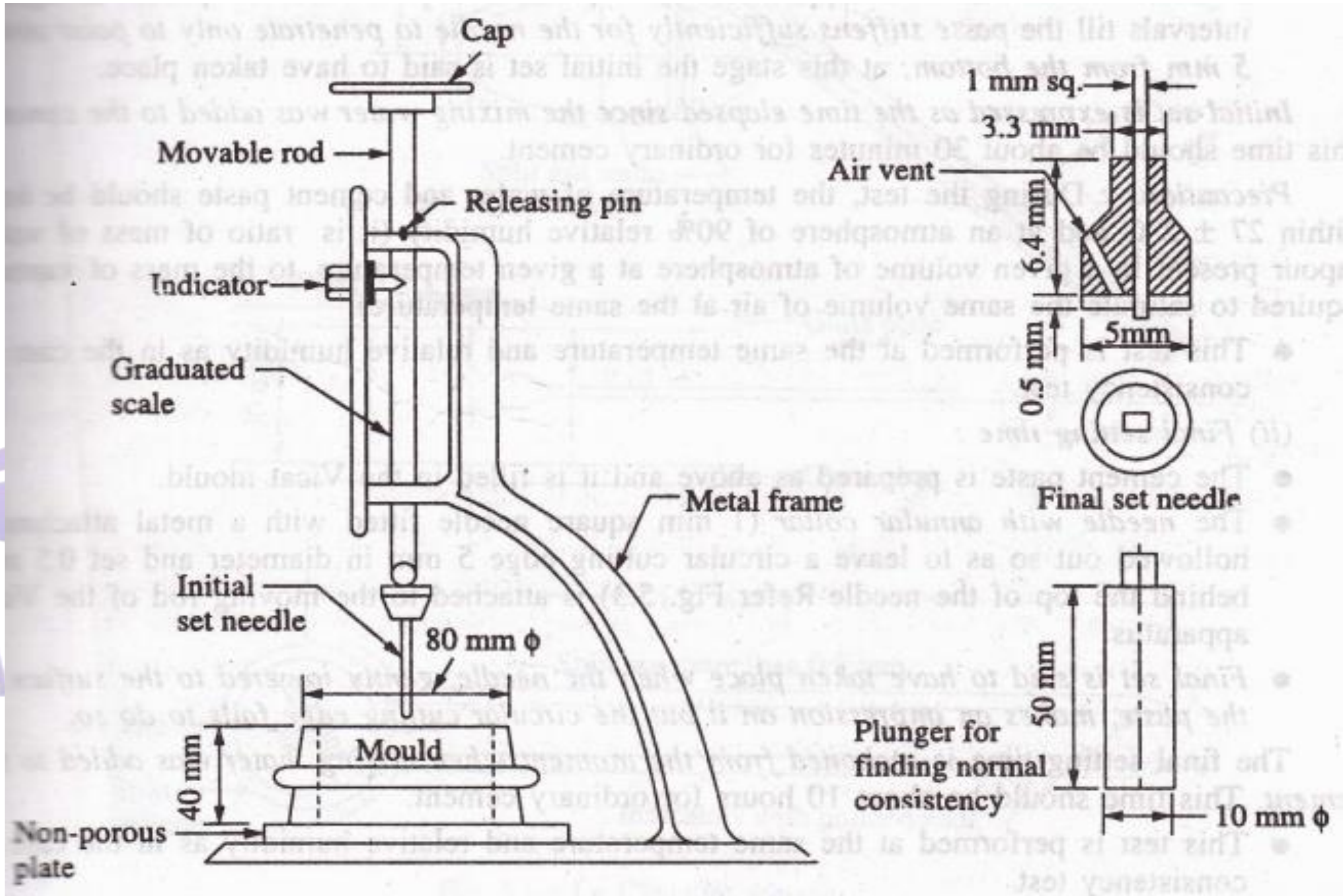
- Quarry tile is also called:
  a) Granite tile
  b) Unglazed ceramic tile
  c) Stone tile
  d) Workshop tiles

- Type of tile commonly used in roofs
  a) Porcelain
  b) Shale
  c) Slate
  d) Granite

Tests on Cements

Consistency Test of Cement

- 300gm of cement is taken with 25 to 30% water
- Fill the mould **of Vicat's apparatus**
- The interval between the addition of water to the commencement of filling of mould is known as the time of *gauging* and it should be $3^{3/4}$ to $4^{1/4}$ minutes
- Vicat's apparatus is attached with plunger having diameter and length as 10 mm and 50 mm respectively
- **Square needle(1mm*1mm) for initial setting time, plunger for consistency test, needle with annular collar for final setting time**
- Settlement of plunger is noted and if the penetration is between **5mm to 7mm** from bottom of mould, the water added is correct.



Initial Setting Time Test

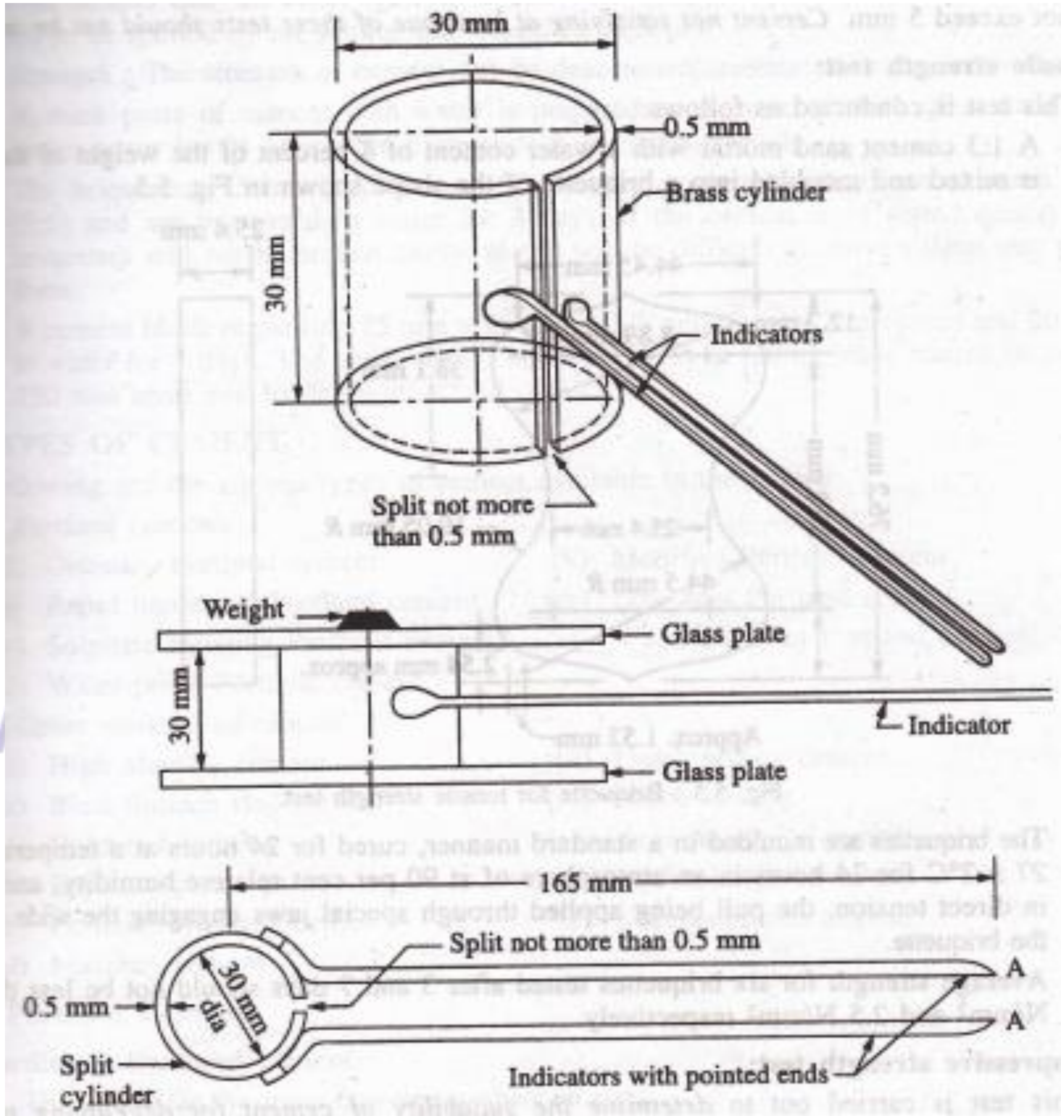
- Take a cement sample of 300 gm and mixed with water (quantity from consistency test)
- Fill the Vicat's mould with the cement paste
- Using the square needle **of 1mm*1mm or 1mm^2 X-sectional area** try to find the penetration of **about 5 mm from** bottom of the mould
- The initial setting time is the interval between the addition of water to cement and the stage when the needle ceases to penetrate completely. This time is to be **minimum 30 minutes** for OPC.

Final Setting Time Test

- Cement paste is prepared as above and it is filled in the Vicat's mould as previously done.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus. This needle has a sharp point projecting in the centre with annular collar.
- The needle is gently released. The time at which the **needle makes an impression on the test block and the collar fails to do so is noted**.
- The final setting time is the difference between the time at which **water was added to cement and time as recorded when needle only penetrates the paste**. This time should be about **10 hrs** for OPC.

Soundness Test of Cement

- Performed to detect the presence of **uncombined lime and magnesia in cement**
- **Use Le Chatelier apparatus**
- Procedure:
- The cement paste is prepared (as mentioned in consistency test)
- The cylinder is placed on glass plate and it is filled with cement paste and is covered by another glass plate with small weight on it
- The whole assembly is immersed in water at $24^{o}C$ to $35^{o}C$ for 24 hrs. At the end of that period the distance between the indicators is measured.
- The mould is immersed in water again and brought to boil in 30 minutes, after boiling for one hour the mould is removed and cooled then the distance between the indicators is again measured.
- Increase in this distance represents the expansion of cement and according to IS specification, **it should not exceed 10mm for any type of Portland cement.**



Compressive Strength Test of Cement

% of water by wt of cement **= (P/4 +3) %,**

P= % of water for normal consistency

3 Moulds of either cube size **70.6mm x 70.6mm x 70.6mm**

Dry mix cement and sand (1:3) then mix with water for uniform colour with in 3-4 mintues

Rod the mortar placed in mould **20 times in about 8 secs** for full compaction

Store specimen of cubes for 24 hours in place of relative humidity 90 % and temperature 27 +_ $2^{O}C$.

Cubes are tested in compression testing machine at end of 3 days,7 days and 28 days

Load is applied uniformly at the rate of $350kg/cm^2$

Average of 3 moulds give compressive strength

Tensile Strength Test of Cement

% of water by wt of cement= (P * 0.2 +2.5),

P= % of water for normal consistency

12 standard briquettes are prepared

Six briquettes are tested after 3 days ,7 days and days . Rate of loading $35kg/cm^2$

X-sectional of briquette at least section is $6.45cm^2$

Ultimate tensile stress = failing load/6.45

At 3 days T.S>$20kg/cm^2$, at 7 days T.S>$25kg/cm^2$

Tests on Aggregate,Bulking of Sand

Bulking of sand refers to an increase in the volume of sand due to the presence of moisture. When dry sand absorbs water, the water coats the sand particles and fills the voids between them, causing the sand to expand. This phenomenon is important to consider in construction, especially in applications where accurate volume measurements are crucial, such as concrete mixtures.

Causes of Bulking:

1.Surface Tension: Water adheres to the surface of sand particles due to surface tension, causing the sand particles to repel each other and increase the volume.

2.Capillary Action: Water is drawn into the spaces between sand particles through capillary action, leading to an increase in volume.

3.Film of Water: A film of water forms around each sand particle, separating them and causing expansion.

Effects of Bulking:

1.Reduced Yield: Bulking of sand results in an apparent increase in volume, which can lead to a decrease in the amount of sand available for a given weight or volume.

2.Inaccurate Measurements: Bulking can cause inaccuracies in volume measurements, affecting the proportioning of materials in concrete mixtures and other applications.

Procedure:

Selection of Sand Sample:

Obtain a representative sample of the sand to be tested. Ensure that the sample is free from contaminants and large particles.

Initial Volume Measurement:

Fill the graduated cylinder or container with a known volume of dry sand, ensuring that it is compacted and leveled off to eliminate any voids or air pockets. Record the initial volume (V1) of sand.

Wetting of Sand:

Slowly add a measured quantity of water to the sand sample in the mixing bowl, ensuring thorough mixing to achieve uniform moisture distribution. The amount of water added should be sufficient to fully wet the sand but avoid excessive saturation.

Final Volume Measurement:

Transfer the wetted sand back into the graduated cylinder or container, filling it to the same level as before. Tap the container gently to settle the sand and remove any trapped air bubbles. Record the final volume (V2) of sand.

Calculation:

Calculate the bulking factor using the formula:

Bulking Factor=$V2/V1 \times 100\%$

Results Analysis:

Analyze the bulking factor obtained and compare it with known values or specifications for the sand type. Bulking factors can vary depending on factors such as sand particle shape, gradation, and moisture content.

1.For the manufacture of Portland cement, the proportions of raw materials used, are

a) lime 63% ; silica 22% ; other ingredients 15%

b) lime 22% ; silica 63% ; other ingredients 15%

c) silica 40% ; lime 40% ; other ingredients 20%

d) silica 70% ; lime 20% ; other ingredients 10%.

- The attachment used in consistency test of cement is:

a) Vicats needle

b) Vicats plunger

c) Vicats needle with annular collar

d) Le Chatliers apparatus

- Initial setting time for OPC cement should not be less than:

a) 45 mins

b) 600 mins

c) 40 mins

d) 30 mins

- The apparatus used for soundness test of cement is:

a) Vicats apparatus

b) compression testing machine

c) Le chatlier’s apparatus

d) Soundness apparatus

The initial setting time of lime-pozzolana, is

a) 30 minutes

b) 60 minutes

c) 90 minutes

d) 120 minutes.

- The attachment used for initial setting time of cement is:

a) Vicats needle

b) Vicats plunger

c) Vicats needle with annular collar

d) Le Chatliers apparatus

- The apparatus used for final setting time of cement is:

a) Vicats needle

b) Vicats plunger

c) Vicats needle with annular collar

d) Le Chatliers apparatus

According to IS standard, maximum setting time for OPC should be

a) 30 minutes

b) 1 hour

c) 6 hours

d) 10 hours

The standard consist of cement is the condition when

a) Plunger penetrates to 5-7 mm from bottom of mould

b) Plunger penetrates to 5-7 mm from top of mould

c) Plunger penetrates to 50-70 mm from top of mould

d) Plunger penetrates to 25-30 mm from bottom of mould

Area of plunger used in consistency test of cement is:

a) 1.8 cm2
b) 1 cm2
c) 1.5 cm2
d) 2 cm2

Two consecutive readings for initial setting time of cement mustnot be less than

a) 1 cm
b) 1.9 cm
c) 1.5 cm
d) 1.8 cm

Standards for Cement

NS Code

1. NS 49:2041 Ordinary Portland Cement
2. NS 384:2054 Portland Slag Cement
3. NS 385:2054 Portland Pozzolana Cement

IS Code:

1. IS 269: Ordinary Portland Cement
2. IS 8112: High Strength Portland Cement
3. IS 12269: Portland Slag Cement
4. IS 1489: Portland Pozzolana Cement

NS 572:2076 Specification for 43 grade and 53 Grade OPC

- The **minimum amount of clinker** shall be **95%** by mass of OPC
- No materials shall be added to clinker other than gypsum (natural, mineral or chemical), water and not more than (a total of 1.0% of air entraining agents or other agents including coloring agents, which have proved not to be harmful. Such additions shall be made before grinding.
- The net quantity of OPC per bag shall be 50 kg or 25 kg or 10 kg or 5 kg. the quantity of OPC in any of bags shall be ±1% of the market net quantity.

- The cement can be packed in
  - Jute Sacking bag
  - Multi-Wall paper sacks
  - Light weight jute
  - HDPE/PP Woven Sacks
  - Jute Synthetic Union Bags
  - Any approved composite bag
- Marking of each bag of cement should contain:
  - Manufacturer's Name and his registered trade mark
  - The name and designated grade of the ordinary Portland cement
  - Net quantity in kg
  - Batch No/Code number in terms of week, month and year of packing
  - Best before date (that is, not more than 3 months from the date of packing)
  - Need for testing of cement more than 3 months old to check conformity beforfe its use
  - Nepal standard certification mark with applicabe number and year.
  - Address of the manufacturer

Standards for Cement

- **Physical Requirements for OPC 43 Grade:**
- **Fineness**: The cement should have a specific surface area (Blaine) not less than 225 m^2/kg.
- **Setting Time**: The initial setting time of cement should not be less than 30 minutes, and the final setting time should not be more than 600 minutes.
- **Soundness**: The ***autoclave expansion*** of the cement should not exceed 0.8%. And when measure with ***Le-Chatliers Appratus*** the cement should not go expansion more than 10mm.
- **Compressive Strength**: The compressive strength of OPC 43 Grade at various ages should meet the following requirements:
  - 3 Days: Not less than 23 MPa
  - 7 Days: Not less than 33 MPa
  - 28 Days: Not less than 43 MPa
- **Loss on Ignition (LOI)**: The loss on ignition of the cement should not exceed 5%.
- **Specific Gravity**: The specific gravity of cement should be between 3.10 to 3.20.

- **Physical Requirements for OPC 43 Grade:**
- **Fineness**: The cement should have a specific surface area (Blaine) typically not less than 325 m^2/kg.
- **Setting Time**:
  - Initial setting time: Not less than 30 minutes.
  - Final setting time: Not more than 600 minutes.
- **Soundness**: The ***autoclave*** expansion of the cement should not exceed 0.8% and the expansion measure using ***Le-Chatliers*** should not exceed 5mm.
- **Compressive Strength**:
  - 3 Days: Not less than 27 MPa
  - 7 Days: Not less than 37 MPa
  - 28 Days: Not less than 53 MPa
- **Loss on Ignition (LOI)**: The loss on ignition of the cement should not exceed 3%.
- **Specific Gravity**: The specific gravity of cement should typically be between 3.10 to 3.20.

Note: The aeration shall be done by spreading out the sample to a depth of 75mm at a relative humidity of 50 to 80% for a Total period of 7 days. The expansion of OPC so aerated shall be not more than 5mm and 0.6% when tested Le-Chatelier Method and autoclave test respectively

Standards for Cement

S.No	Characteristics	Requirements	
		OPC 43	OPC 53
1	Lime saturation factor(ratio of percentage of lime to percentage of silica, alumina and iron oxide	0.66-1.02	0.8-1.08
2	Ratio of percentage of alumina to that of iron oxide	0.66 minimum	0.66 minimum
3	Insoluble residue, percent by mass,	2 max	2max
4	Magnesia, percent by mass,	5.0 max	5.0 max
5	Total sulphur content calculated as sulphuric anhydrid present by mass		
	case a. content of C3A <5%	2.5 max	2.5max
	case b. content of C3A >5%	3.0 max	3.0 max
6	Loss on ignition, percentage by mass	4 max	4 max

Standards of Rebar

- NS 84:2042 Mild Steel Rod
- NS 191:2046 Deformed steel bars and wires for concrete reinforcement
- IS 1786: High Strength Deformed steel bars and wires for concrete Reinforcement Specimen

Note: mild steel: Fe 250

Tor(Toristeg Steel Corporation) ***Steel: Fe 415***

TMT: Fe 500

- Nominal Size of bars: 4,5, 6,8,10,12,16,20,25,28,32,36,40,45,50 mm

Types of Rebar:

1.Mild Steel Rebar (MSR): Also known as "black bar," mild steel rebar is the traditional type of rebar used in construction projects. It is primarily composed of carbon steel and is easily weldable.

2.High-Strength Reinforcement Steel (HSRS): This includes rebar with higher yield strength than traditional mild steel rebar. Examples include Fe 415, Fe 500, Fe 550, and Fe 600 grades.

3.Corrosion-Resistant Rebar: Rebar coated with epoxy or other corrosion-resistant coatings to protect against rust and corrosion in aggressive environments, such as coastal areas or structures exposed to chemicals.

4.Stainless Steel Rebar: Stainless steel rebar offers excellent corrosion resistance and durability, making it suitable for use in corrosive environments or where aesthetic considerations are important.

5.Galvanized Rebar: Rebar coated with a layer of zinc to provide corrosion protection. Galvanized rebar is commonly used in projects where exposure to moisture and chemicals is a concern.

Tensile Test on Rebar

- To determine yield stress, strain and ultimate tensile strength
- Apparatus: UTM, Extensometer, Vernier Calipers, Punching tool

Notes:

- The Stress upto the point where the material loses its elasticity and goes into plastic deformation is called a yield point/yield stress
- At this very point, we can experience that the specimen is getting narrow and thin. We can even experience a sudden drop in the curve
- After this, the bar goes into plastic deformation where specimen starts getting thin from center point and the metal specimen goes upto ultimate tensile stress which is the highest point.
- When the specimen reaches maximum stress it experiences “necking "process which is known as Ultimate tensile stress
- After this , the bar goes into more deformation and finally arrives at a fracture point where the metal breaks.
- Stiffness= Young’s modulus (Slope of stress-strain curve)
- Strength= Yield Stress
- Young's modulus can be calculated using the following formula:

    E= Stress/Strain

    Where:

    E = Young's modulus of elasticity (in Pascals, Pa)

    Stress = Force (in Newtons, N) applied to the material divided by the original cross-sectional area (in square meters, m²) of the material

    Strain = Change in length of the material (in meters, m) divided by the original length (in meters, m) of the material

Standards for Aggregate

- Ns 297: 2050 Aggregate
- NS 298: 2050 Sampling Method for aggregates
- NS 305:2050 Methods of test for aggregates for Concrete
- IS 383:1970 Specifications for fine and Coarse aggregate

Class A	Consist of Igneous or quartzite rock from an approved source
Class B	Consist of Crushed quarry rock other than Class A from an approved source
Class C	consist of natural or partly crushed gravel, pebbles obtained from approved gravel deposit
Class D	consist of crushed gravel
Class E	consist of an artificial mixture of any of the above classes

Types of Aggregates:

1.Natural Aggregates:

1. **Sand**: Fine granular material, typically composed of particles ranging from 0.075mm to 4.75mm in size.
2. **Gravel**: Coarse granular material consisting of particles larger than sand, typically ranging from 4.75mm to 75mm in size.
3. **Crushed Stone**: Stone aggregates produced by crushing larger rocks, available in various sizes.

2.Manufactured Aggregates:

1. **Recycled Concrete Aggregate (RCA)**: Produced from demolished concrete, used as a sustainable alternative to natural aggregates.
2. **Slag Aggregates**: Byproducts of industrial processes, such as blast furnace slag or steel slag, used in construction.

Characteristics of Aggregates:

- **Shape**: Influences workability, strength, and durability of concrete. Angular and rough-textured aggregates provide better interlocking, while rounded aggregates reduce water demand.
- **Size Gradation**: Refers to the distribution of particle sizes within an aggregate sample, affecting the workability and strength of concrete.
- **Cleanliness**: Presence of contaminants like clay, silt, or organic matter can affect the performance and durability of concrete.
- **Specific Gravity**: Indicates the density of aggregates relative to water and influences the density and strength of concrete.
- **Absorption**: Measures the porosity of aggregates and affects the water-cement ratio in concrete mixtures.

Standards for aggregate

Composition of Aggregates:

1.Minerals: Aggregates primarily consist of mineral materials such as **quartz, feldspar, limestone, granite, or basalt.**

2.Particle Size Distribution: Aggregates are classified based on particle sizes, including coarse aggregates (gravel and crushed stone) and fine aggregates (sand).

Selection Criteria:

Application: Consider the intended use of aggregates, whether for concrete, asphalt, base course, or drainage.

Gradation: Ensure proper particle size distribution for optimal concrete workability, strength, and durability.

Quality: Assess cleanliness, grading, and absence of deleterious materials to meet project specifications and performance requirements.

Availability: Consider local availability and sourcing of aggregates to minimize transportation costs and environmental impact.

Cost: Balance quality requirements with budget constraints when selecting aggregates for construction projects.

Usage of Aggregates:

Concrete Production: Aggregates constitute the bulk of concrete mixtures, providing strength, durability, and volume stability.

Asphalt Mixtures: Aggregates are used as the main component in asphalt concrete for road construction and pavement.

Base Course Material: Aggregates serve as the foundation material for roads, railway tracks, and airport runways.

Drainage Systems: Coarse aggregates are used in drainage systems to facilitate water flow and prevent soil erosion.

Landscaping: Decorative aggregates are used in landscaping projects for pathways, gardens, and decorative features.

Testing Methods for Aggregates:

Gradation Analysis: Determines the particle size distribution of aggregates using sieving techniques.

Specific Gravity and Absorption: Measures the density and porosity of aggregates relative to water.

Particle Shape Analysis: Assesses the shape characteristics of aggregates using visual or mechanical methods.

Cleanliness Test: Determines the presence of contaminants such as clay, silt, or organic matter in aggregates.

Aggregate Crushing Value (ACV): Measures the resistance of aggregates to crushing under compressive loads.

Bulking of Sand

Bulking of sand refers to an increase in the volume of sand due to the presence of moisture. When dry sand absorbs water, the water coats the sand particles and fills the voids between them, causing the sand to expand. This phenomenon is important to consider in construction, especially in applications where accurate volume measurements are crucial, such as concrete mixtures.

Causes of Bulking:

1.Surface Tension: Water adheres to the surface of sand particles due to surface tension, causing the sand particles to repel each other and increase the volume.

2.Capillary Action: Water is drawn into the spaces between sand particles through capillary action, leading to an increase in volume.

3.Film of Water: A film of water forms around each sand particle, separating them and causing expansion.

Effects of Bulking:

1.Reduced Yield: Bulking of sand results in an apparent increase in volume, which can lead to a decrease in the amount of sand available for a given weight or volume.

2.Inaccurate Measurements: Bulking can cause inaccuracies in volume measurements, affecting the proportioning of materials in concrete mixtures and other applications.

Procedure:

Selection of Sand Sample:

Obtain a representative sample of the sand to be tested. Ensure that the sample is free from contaminants and large particles.

Initial Volume Measurement:

Fill the graduated cylinder or container with a known volume of dry sand, ensuring that it is compacted and leveled off to eliminate any voids or air pockets. Record the initial volume (V1) of sand.

Wetting of Sand:

Slowly add a measured quantity of water to the sand sample in the mixing bowl, ensuring thorough mixing to achieve uniform moisture distribution. The amount of water added should be sufficient to fully wet the sand but avoid excessive saturation.

Final Volume Measurement:

Transfer the wetted sand back into the graduated cylinder or container, filling it to the same level as before. Tap the container gently to settle the sand and remove any trapped air bubbles. Record the final volume (V2) of sand.

Calculation:

Calculate the bulking factor using the formula:

Bulking Factor=$V2/V1\times100\%$

Results Analysis:

Analyze the bulking factor obtained and compare it with known values or specifications for the sand type. Bulking factors can vary depending on factors such as sand particle shape, gradation, and moisture content.