INTERMEDIATE
Vocational Course
First Year

Construction Materials Laboratory Manual

For the Course of Construction Technology

AUTHOR

B.HARINATH REDDY

B.Tech, MBA

JUNIOR LECTURER IN CIVIL ENGG.

NEW GOVT. JR. COLLEGE,

MALAKPET, HYDERABAD

CONTENTS

****

1
IDENTIFICATION OF VARIOUS CONSTRUCTION MATERIALS AND THEIR APPLICATIONS

1.1 Identification of various types of stones and their applications

Aim: To identify various types of stones available with their usage

Materials: Various types of stone blocks

Observations: The building stones are obtained from the rocks. A rock represents a definite portion of earth's surface. It is not homogeneous. Rocks contain many minerals. These minerals have different distinctive characteristics. The following building stones which are commonly used in India for construction works.

a) Granite: This is igneous rock. It is hard, durable and available in different colours. It is highly resistant to natural forces and can take nice polish. Its specific gravity various from 2.6 to 2.7 and compressive strength vary from 75 to 127 N/mm2. Its weight is about 26 to 27 KN per cubic metre.

It is used in construction of steps, sills, facing work, walls, bridges, piers, columns, road metal, ballast etc. It is unsuitable for carving.

Granite is available in many places like Kashmir, Punjab, Rajasthan, UP, MP, Mysore, Maharashtra, Assam, Bengal, Bihar, Orissa, etc.

b) Sand stone: It is sedimentary rock. It consists of quartz and other minerals. It is easy to dress and work with this stone. It is available in different colours. Its specific gravity varies from 2.65 to 2.95 and compressive strength is 64N/mm2 its weight is about 20 to 22 KN/mm3

It is used in construction of steps, facing work, columns, flooring, walls road metal, ornamental carving etc.

It is available in AP, MP, Rajasthan, Punjab, Maharashtra, Andaman Island, UP, HP, etc.

c) Marble: It is metamorphic rock. It can take good polish and available in different colours. Its specific gravity is 2.65 and compressive strength is 71 N/mm2. It is mostly used for flooring, facing work, Ornamental work, steps etc. It can take nice polish. It can easily be sawn and carked. It is mostly available in Rajasthan, Maharashtra, Gujarat, AP, MP and UP

d) Lime stone: It is sedimentary rock. It consists of carbonate of time. It is easy to work with limestone. Its specific gravity varies from 2 to 2.75 and compressive strength is 54 N/mm2. It is used in construction of floors, Steps, walls, road metal etc.

It is available in Rajasthan, Maharashtra, Punjab, Bihar, AP, MP, Bengal, UP

e) Slate: It is metamorphic rock. It is in black colour and splits along natural bedding planes. It is not absorbent. Its specific gravity is 2.89 and compressive strength varies from 75 to 207 N/mm2. It is used in roofing work, sills, damp – proof courses etc.

It is available in UP, MP, Bihar, Rajasthan, and Mysore.

f) Basalt: It is igneous rock. It is hard and tough. It is difficult to work with this rock. Its specific gravity is 3 and compressive strength varies from 150 to 185 N/mm^2. Its weight varies from 18 to 29 KN per m^3. It is mainly used in road metal, rubble masonry, foundation work etc.

It is mostly available in Maharashtra, Bihar, Gujarat, Bengal and MP.

Table : 1.1

Sl No.	Type of Stone	Observations (Qualities & Uses)	Remarks

1.2 Identification of various types of bricks and clay products

Aim: To identify various types of bricks and clay products with their qualities and uses.

Material: Various types of bricks and clay products.

Observations: Bricks are widely used as a building material because of its durability, Strength, Low cost, Easy availability, etc. Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks.

a) Country Bricks:

i) The good bricks should be table moulded, well burnt in kilns, copper coloured, free from cracks and with sharp and square edges

ii) The bricks should be uniform in shape and of standard size.

iii) The bricks should give a clear metallic ringing sound when struck with each other.

iv) The bricks when broken should show a bright homogeneous and uniform structure and free from voids.

v) The brick when it is scratched with fingernail no impression should be left on brick surface.

vi) The bricks should not break into pieces when dropped flat on hard ground from a height of about one metre.

b) Special purpose bricks: These bricks are made to meet certain purposes such as in construction of arches, columns, jambs of doors and windows etc. the ornamental bricks are prepared for corbels, cornices, etc. These bricks are made from specially selected earth and used in constructions where high durability, compression strength and adequate resistance to sudden shocks are required. The following are various forms of purpose made bricks:

i) **Soap bricks:** The recommended size is 19 x 41/2 x 9 cm. These are used as queen closers.
ii) **Plinth bricks:** These are made into a number of shapes depending upon their use as headers, stretchers, and for angles.
iii) **Coping bricks:** These bricks are made in different sizes and sections so as to suit walls with different thickness.
iv) **Round end bricks:** These are the bricks with round corners and edges. These are used at corners in walls, cornices, columns etc.
v) **Cant bricks:** These are leveled off on one or many sides and used on the outer side of walls, on pillars, on doors and window jambs.
vi) **Gutter bricks:** Used to send water and wastewater from houses.

c) Earthen ware: This is manufactured by the burning of ordinary clay. The clay is mixed with sand and crushed pottery, burnt at low temperature and gradually cooled.

The earthenwares are generally soft and porous. On glazing, this gets a better appearance and becomes impervious to water and resists the acids and atmospheric agencies. The earthenware is used for making ordinary drain pipes, electrical cable conduits, partition blocks, etc.

d) Stoneware: Stoneware is made from refractory clays, which are mixed stone and crushed pottery. This mixture is burnt at high temperature and cooled.

Stoneware is strong, impervious, durable and resistant to corrosion. They produce clear and sharp ringing sound when struck with each other. The stonewares can be cleaned easily and mostly used in sanitary fittings like washbasins, sewer pipes, glazed tiles, water closets, etc. They are also used as jars to store the chemicals.

e) Tiles: The tiles are thin slabs of bricks, which are burnt in kiln. The tiles are generally classified into

(i) Common tiles – These tiles have different shapes and sizes. They are mainly used for paving, flooring and roofing.
(ii) Encaustic tiles – These tiles are used for decorative purposes in floors, walls, ceilings and roofs.

The tiles should have the following characteristics: -

(i) Tiles should be free from any cracks, bends.
(ii) Tiles should have standard shape and size.
(iii) Tiles should be well burnt, hard and durable.
(iv) Tiles should give a clear ringing sound when struck with each other. It should have uniform colour.

Table 1.2

Sl No.	Type of Brick	Observations (Qualities & Uses)	Remarks

1.3 Identification of various types of metals and their applications.

Aim: To identify various types of metals and study of their uses.

Materials: Various types of metals.
Observations: The metals are used in construction of structural members, roofing materials, pipes, tanks, doors, windows, etc. Metals are mainly grouped into two categories.

(i) Ferrous Metals – The main constituent present in ferrous metals is iron. The important ferrous metals are cast – Iron, wrought Iron and steel.
(ii) Non-Ferrous metals – These metals do not contain iron as their main constituent. The important non-ferrous metals are aluminum, copper etc.

a) Cast Iron – The cast iron is manufactured by remelting pig iron with coke and limestone in a cupolar furnace. The cast iron contains about 2 to 4 percent of carbon and other impurities like manganese, Phosphorus, silicon and sulphur. The main characteristics of cast iron are:

i) Its structure is crystalline and granular having specific gravity 7.5
ii) When it is placed in salt water, it softens.
iii) It can’t be magnetized and does not rust easily.
iv) It is weak in tension and strong in compression. Its tensile and compressive strengths of average quality are 150 N/mm2 and 600 N/mm2 respectively.
v) Cast Iron cannot be connected by riveting or welding. They are connected only by nuts and bolts.

Cast iron is mainly used in making cisterns, water pipes, gas and sewer pipes, manhole covers. It can also be used in making ornamental designs like lamp sets, gates, geometrical staircases etc.

b) Wrought Iron: It is almost pure iron (nearly 98%) and having lowest carbon content containing 0.05 to 0.15%. It is having the following characteristics

i) It can be easily forged and welded.
ii) It is ductile, malleable and tough.
iii) Its ultimate tensile and compressive strengths are about 400 N/mm^2 and 200 N/mm^2 respectively.
iv) It does not soften in salt water and resists corrosion.
v) Its melting point is about 1500^0c and specific gravity is about 7.8

Wrought Iron can be used for making rivets, chains, railway couplings, boiler tubes, roofing sheets, etc.

c) Steel: Steel is an important building material suitable for all constructions works Based on carbon content, steel is classified as mild steel, medium carbon steel and high carbon steel. The following are the properties of mild steel.

i) It can be welded and forged easily.
ii) It is ductile and malleable, rusts easily
iii) Its melting point is about 1400^0c and specific gravity is 7.80.
iv) It has a fibrous structure and can be magnetized permanently.

Mild steel can be used in manufacture of rails, roofing sheets, rivets, bolts, wire ropes, power transmission towers, RCC works etc.

d) Aluminum: The aluminum is non-ferrous metal, produced mainly from bauxite ores. The following are the properties of aluminum:

i) It is light in weight and very soft.
ii) It is a good conductor of heat and electricity.
iii) It is a silvery white metal and resist corrosion
iv) It dissolves in Hydrochloric acid
v) It is having more toughness and tensile strength.

Aluminum is mostly used in manufacture of cooking utensils, surgical instruments automobile parts, parts of aeroplane, corrugated sheets. Etc.

e) Copper: The copper is also an important metal widely used. The following are the properties of copper.

i) It is in reddish brown colour and good conductor of heat and electricity.
ii) It is soft, malleable and ductile material.

iii) It can't be welded but workable in both hot and cold conditions.
iv) It melts at 1083^0 c and specific gravity is 8.90

It is mostly used in making electric cables, alloys for lining boilers and tanks etc.

f) Lead: It occurs mainly in combined form such as sulphide, the ore is called as Galena pbs. It contains about 86% lead and 14% sulpur.

Following are the properties of lead:

i) It can be cut with knife and makes impression on paper.
ii) It is soft, plastic with bluish grey colour
iii) It's specific gravity is 11.36 and melts at 327.5 c

The lead is widely used for making bullets waterproof and acid proof chambers, gas pipes roof gutters etc.

Table 1.3

Sl No.	Type of Metal	Observations (Qualities & Uses)	Remarks

1.4 Identification of various types of timber and wood products

Aim: To identify various types of timber and wood products and study of its uses.

Material: Various types of timber

Observations: Timber may be defined as the wood, which is suitable for building, carpentry and other engineering purposes.

The following are the various types of timber trees used for the purposes in India.

a) Teak: Its colour is deep yellow to dark brown. It is moderately hard, durable and fire resistant. It can be easily seasoned and worked. It can be polished well and can't be attacked by white ants. It is costly material and used only for superior and important works. It is mostly available in central India and southern India.

b) Sal wood: It is hard, Fibrous and brown in colour. It does not take up good polish but durable under ground and water. It is mostly available in A.P., UP, MP, Orissa and Maharashtra. It is used for making railway sleepers, foundation piles, bridges etc.

c) Babul: It is whitish red in colour and takes good polish. It is strong, hard and durable. It is available in AP, MP, UP, Bengal, Maharashtra and Gujarat. It is mostly used for making bodies and wheels of bullock carts, agricultural instruments. Tool handles etc.

d) Veneers: These are thin sheets or slices of wood of good quality. The thickness of veneers varies from 0.40 mm to 6 mm. They are obtained by rotating a log of wood on a sharp knife of rotary cutter. The veneers thus obtained are dried in kilns to remove moisture. Mahogany, oak, rose wood, teak etc. are most suitable for making veneers.

The veneers are used to make decorative sheets, plywood, batten boards, etc. the veneers are glued with suitable adhesives on the surface of wood to make it good appearance.

e) Ply wood: The plywood are boards which are prepared by placing thin layers of wood or veneers one above the other and held in position by applying adhesives. The plywood is pressed under hot or cold pressure. The plywood is commonly used for ceilings, doors, furniture, partitions, railway coaches etc.

f) Lamin and other boards: The plywood are available in various forms like lamin boards, batten boards, metal-faced plywood, multi-ply.

The laminboard is a solid block with the core is made of multiply veneers. The thickness of each veneer does not exceed 6 mm and total thickness of board is about 50 mm. The outer ply sheets are firmly glued with core to form a solid block. These boards are widely used for making partition walls, packing cases, furniture pieces, ceilings, shutters of doors and windows etc.

The batten is similar to lamin board with core thickness is about 20 mm to 25 mm and total thickness of board is about 50 mm. These boards are light and strong.

In metal faced plywood, the core is covered by a thin sheet of aluminum, copper, bronze, steel etc.

In multi-ply board more than three plies are placed. The thickness may vary from 6 mm to 25 mm or more.

Tabe 1.4

Sl No.	Type of Wood	Observations (Qualities & Uses)	Remarks

1.5 Identification of other miscellaneous materials

Aim: To identify and study the characteristics of other miscellaneous materials.

Material: Miscellaneous materials like Glass, Bitumen, Asbestos, plastics etc.

Observations:

a) Glass: The Glass is a mixture of a number of metallic silicates. It is amorphous and transparent. Because of good progress in glass industry, its use has increased greatly in various engineering and industrial works. The following are the characteristics of glass.

i) It absorbs, reflects and transmits light.
ii) It can't be affected by air, water and chemicals.
iii) It is good heat, electric and sound insulator.
iv) It can be welded and made bullet proof.

b) Bitumen: Bitumen is a binding material obtained by partial distillation of crude petroleum. The following are the characteristics of bitumen.

i) It is in the form of solid or semi solid
ii) It is block or brown in colour and good insulator of electricity heat and sound.

Bitumen can be used for various engineering purposes like DPC waterproofing, constructing roads and pavements etc.

c) Asbestos: The asbestos is a fibrous material available in nature. It consists of hydrous silicates of calcium and magnesium ($Casio_3$, 3 Mg sio_3) the following are properties of asbestos:

i) It is soft and smooth can be cut into pieces.
ii) It is fire proof and acid proof.
iii) Its colour is brown, grey or white and act as insulator for heat and electricity.
iv) The holes can be made and screws can be fitted into asbestos surface.

Asbestos can be used as covering material, preparing asbestos cement products like sheets and pipes, damp proof layer, etc.

d) Plastics: Plastic is an organic material consists of natural or synthetic carbon compounds. The following are the properties

i) Plastics are in lightweight, hard and durable.
ii) Plastics give more resistance to moisture, chemicals and corrosion.
iii) Plastics are good electrical and heat insulators.
iv) Plastics are easily fabricated into desired shapes.

The plastics are used as bath and sink units, roofing and flooring material, electrical insulators, over head tanks etc.

e) Rubber: It is an important material available in two forms

1) Natural rubber 2) Synthetic rubber

Natural rubber is obtained from latex tapped from rubber trees. Synthetic rubber is an artificial rubber obtained as a polymer.

The following are properties of rubber

i) It can contain liquids and gases, undergoes deformation due to external loads.
ii) It can absorb shocks due to impact loads.
iii) It can be moulded into desired shapes
iv) The synthetic rubber offers more resistance to acids, petroleum, products etc.

Rubber is used in manufacture of tyres, gaskets, hosepipes etc.

Table 1.5

Sl No.	Type of Other Materials	Observations (Qualities & Uses)	Remarks

2
TESTS ON BRICKS

2.1 Field tests on bricks

Aim: To conduct field tests on bricks.

Material: Bricks taken from the stack.

Procedure: Bricks are widely used material in construction work. The following are the field tests to be conducted on bricks.

1) **Hardness:** A scratch is made on brick surface with a fingernail, no impression should be left on the surface. Now the brick is assumed to be hard.

2) **Shape and size:** The brick should be of standard size and its shape should be truly rectangular with sharp edges. Take 20 bricks of standard size (19 x 9 x 9 cm) at random from the stack, placed along length wise, along the width and along the height. For good quality of bricks, the results should be with in the following limits.

Length:	3680 mm	to	3920 mm
Width:	1740 mm	to	1860 mm
Height:	1740 mm	to	1860 mm

3) **Soundness:** The bricks should not break and give a clear ringing sound when they struck with each other.

4) **Colour and appearance:** The well-burnt brick should have copper red colour and free from cracks. The colour should be uniform and bright. The bricks when broken should show a bright homogeneous and uniform structure, free from voids.

5) **Strength:** The brick should not break when dropped on a hard ground from a height of about 1 m.

Result: Based on filed tests the bricks are suitable / not suitable for the construction work.

Table 2.1

Sl No.	Type of Field Test	Observations	Remarks

2. 2 Water absorption test on bricks

Aim: To find the amount of water absorbed by the bricks

Apparatus: i) Electric oven ii) Weighing balance

Procedure: At least 4 to 5 brick samples are selected randomly from the stack and marked with numbers. They are dried in an Electric oven at 105^0 c to 115^0c. The bricks are taken out from oven and brought to room temperature. The bricks are weighed accurately and immersed in water for 24 hours at a temperature of 27^0c $\pm$ 3^0 c.

After this period, each brick is taken out of water and cleaned with dry cloth. The bricks are again weighed accurately. The Difference in weight gives the amount of water absorbed by the brick. The bricks should not absorb water more than 20% by weight for first class bricks and 22% by weight for second-class bricks.

Table 2.2

Sl. No.	Weight of dry brick (W1)	Weight of brick immersed in water, after 24 hours (W2)	% of water absorption $\frac{W2-W1}{W1} \times 100$	Remarks

Result: Based on the results of water absorption test, the bricks are suitable/not suitable for the construction work.

2.3 Crushing strength of bricks

Aim: To find the crushing strength of bricks.

Apparatus: compression testing machine, trowel, container, steel rule.

Material: Bricks, cement, fine sand.

Theory: Bricks used in construction are generally subjected to compressive loads. Hence it is necessary to find the compressive strength of bricks. Compressive strength is the ratio of load at failure to surface area of brick. As per BIS: 1077-1957, the minimum crushing strength of bricks is 3.50 N/ mm^2. The bricks with crushing strength of 7 to 14 N/mm^2 are graded as AA.

Procedure: Select 5 bricks of standard size at random from the stack. Immerse the bricks in water for 24 hours at room temperature. Then the bricks are taken out from water and wipe off the surfaces with dry cloth. Apply cement mortar 1:1 on their faces and fill up the frogs also. Ensure that the loading faces are smooth and level. Now the bricks are kept under damp jute bags for 24 hours and there – after immersed in water for 3 days.

Now the bricks are taken out and wipe off the surfaces with dry cloth. Measure the dimensions of the bricks. Place the bricks with flat faces horizontal and the mortar field frog face upwards between the two 3mm ply wood sheets in compression testing machine. The bricks should be kept in such a position that the loading should be axial.

Now load is applied gradually at the rate of 14 N/mm2 per minute till failure occurs. The maximum load at failure is noted which is the crushing strength of the bricks. Repeat the procedure for remaining bricks. Calculate the average compressive strength.

Table 2.3

Brick No.	Dimension of Brick	Surface area	Load at failure	Crushing strength Load/area N/mm2

Result: Average compressive strength =

3
TESTS ON CEMENT

3.1 Field tests of cement

Aim: Conduct field tests on cement to find roughly the quality of cement.

Material: Cement samples.

Procedure: The following field tests may be carried out to find roughly the quality of cement.

(i) Colour: The colour of cement should be greenish grey colour. The colour of cement should be uniform. This test gives a rough idea of excess lime or clay and the degree of burning.

(ii) Physical properties: The cement should be smooth when touched or rubbed in between fingers. It should give a cool feeling when hand is inserted in a cement bag. When a small quantity of cement is thrown in a bucket of water, the cement should float for a few minutes before it sinks. If it sinks immediately, it indicates some impurities present in cement.

(iii) Presence of lumps: Hard lumps should not be present in cement. Such lumps are formed by the absorption of moisture from the atmosphere.

(iv) Strength: Strength of cement is roughly determined by making briquettes with a lean mortar. The size may be 75mm x 25mm x 12mm, with a cement mortar (1:6). The briquettes are immersed in water for a period of 3 days. If the cement is of good quality, such briquettes will not be broken easily and it will be difficult to convert then into powder form.

Table - 3.1

Sl. No.	Type of Field Test	Observations	Remarks

Result: Based on the observations, the cement is of good / bad quality.

3.2 Fineness of Cement

Aim: To find the fineness of cement by sieve method.

Apparatus: I.S. Sieve No. 9, Weighing balance, tray

Material: Cement Sample

Procedure: This test is carried out to check proper grinding of cement. The finer cement will have fast chemical reaction with water and thus gives early strength. The cement weighing 100 gm is taken and placed in I.S. Sieve No. 9 and sieved continuously for a period of 15 minutes. The residue is then weighed. The residue by weight should not be more than 10% of original weight.

Table 3.2

Sl. No.	Weght of Cement Sample W1	Weight of residue W2	% of residue by weight $\frac{W2}{W1} \times 100$

Result: The average % of residual weight of cement =

3.3 Normal consistency test

Aim: To determine the percentage of water required for preparing cement paste of standard consistency, used for other tests.

Apparatus: Vicat apparatus with plunger, I.S. Sieve No. 9, measuring jar, weighing balance

Procedure: The vicat apparatus consists of a D- frame with movable rod. An indicator is attached to the movable rod, which gives the penetration on a vertical scale. A plunger of 10 mm diameter, 50 mm long is attached to the movable rod to find out normal consistency of cement.

Take 300 gm of cement sieved through I.S. Sieve No. 9 and add 30% by weight (90 ml) water to it. Mix water and cement on a non-porous surface thoroughly with in 3 to 4 minutes. The cement paste is filled in the vicat mould and top surface is leveled with a trowel. The filled up mould shall be placed along with its bottom non-porous plate on the base plate of the vicat apparatus centrally below the movable rod.

The plunger is quickly released into the paste. The settlement of plunger is noted. If the penetration is between 33 mm to 35 mm from top (or) 5 mm to 7 mm from the bottom, the water added is correct. If the penetration is less than required, the process is repeated with different percentages of water till the desired penetration is obtained.

Table 3.3

Sl. No.	Amount of Water Mixed	Penetration of Plunger from top	Remarks

Result: The normal consistency of cement =

3.4 Initial and final setting times of cement

Aim: To find initial and final setting times of cement.

Apparatus: Vicat apparatus with mould, I.S. sieve No. 9, Initial and final setting time needles, measuring jar, weighing balance, etc.

Procedure:

Initial setting time:

Initial setting time is defined as the time elapsed between the moment that the water is added to the cement, to the time that the paste starts loosing its plasticity i.e. the initial setting time needle fails to penetrate the cement paste kept in the mould by about 33-35 mm from the top or 5-7 mm from bottom of the indicator is called initial setting time.

Take a cement sample weighing 300 gm, sieved through I.S. sieve No. 9 and mixed with percentage of water as determined in normal consistency test. Stopwatch should be started at the instant when water is added to the cement. Now the prepared cement paste is filled in vicats mould and leveled with trowel. This mould filled with cement paste kept on the non porous plate is now placed under the movable rod with initial setting time needle of cross section 1mm x 1mm

The needle is quickly released and it is allowed to penetrate the cement paste. In the beginning the needle penetrates completely. It is then taken out and dropped at a fresh place. This procedure is repeated at regular intervals till the needle does not penetrate the block for about 5 mm measured from the bottom of indicator. Note the time for initial setting of cement. The initial setting time of an ordinary Portland cement shall not be less than 30 minutes.

Final setting time:

After noting the time for initial setting of cement, the needle shall be replaced by the final setting time needle. The movable rod is slowly released on to the cement paste. In the initial stages the needle and collar may pierce through the paste. But after some time the same procedure is followed. Such trials shall be carried out until the needle only makes as impression on the top surface of the cement paste and the collar of the needle fails to do so. Note the time for final setting time of cement. The final setting time of an ordinary Portland cement shall not be more than 10 hours.

Result: 1. Initial setting time of cement=
2. Final setting time of cement=

4
TESTS ON AGGREGATES

4.1 Bulking of sand

Aim: - To determine the percentage of bulking of sand.

Material: - Fine aggregate, water

Apparatus: - Measuring glass jar, Non-absorbent mixing pan, and trowel.

Theory: - The bulking of sand is an apparent increase in volume of sand due to the presence of moisture. It is caused by the films of water, which push the particles apart due to surface tension. It increases with increase of moisture content up to certain limit and beyond that further increase of moisture content results in the decrease in volume. It is observed that if the % of moisture content is increased beyond 10% bulking of sand starts decreasing. When the sand is completely flooded with water its volume is equal to that of dry sand. In mixing of mortar or concrete, extra volume of sand should be added due to bulkage of sand.

PROCEDURE: -

A measuring jar of 500ml capacity is taken and the given sample of sand is poured into the jar upto 250ml mark. Now the sand is removed from the jar and pour it in mixing pan. Add 2% of water (5 ml) by volume to sand and mix it thoroughly. Place this sand in the measuring jar and note the graduation carefully. This will be slightly more than the initial volume.

Repeat the procedure by adding more water (4%, 6%, etc.) and note down the readings. It can be observed that increase in moisture content shall make the sand to increase in volume up to certain limit. Thereafter, further increase in moisture content decreases the volume of sand. The addition of water at uniform rate that is 2% (equal to 5 ml) will be continued until the original volume of 250 ml mark is obtained.

OBSERVATIONS: -

S.No.	Original volume of sand in ml	Percentage of water added	Corresponding volume of sand	Increase or decrease in volume	Percentage of bulking or decrease

CALCULATIONS: -

Let $V1$=Initial volume of sand
‘ $V2$= Final volume of sand

$$\% \text{ Of bulking} = \frac{V2-V1}{V1} \times 100$$

GRAPH: - The variation of bulking of sand with the variation of moisture content will be shown on graph paper taking % moisture content on x-axis and % of bulking on y-axis.

RESULT: % Of bulking of sand =

4.2 Standard Proctor Compaction Test

Aim: - To determine the optimum Moisture content and maximum dry density of soil.

Material: - Soil sample, water

Apparatus: -

1) Proctors compaction mould
2) Rammer
3) I.S Sieve 4.75 mm
4) Balance
5) Measuring jar
6) Steel straight edge
7) Mixing pan
8) Spatula

Theory: - Compaction is a process by which the soil particles are packed together into a closer state of contact. The degree of compaction of a soil is measured in terms of dry density. The degree of compaction mainly depends upon its moisture content, compaction energy and type of soil. The soil attains maximum dry density at a particular water content is known as "optimum moisture content."

DESCRIPTION OF EQUIPMENT: -

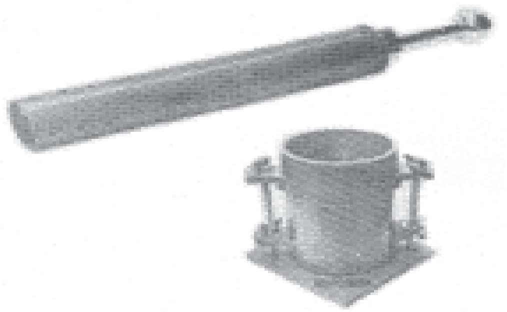
1) A cylindrical mould of non-corrodible material with 100 mm internal diameter, internal effective height 127.3 mm, having a capacity of 1000 cc (cm3). Each mould will have detachable base plate and a removable extension collar of approximately 60 mm height.
2) Metal rammer, 50 mm diameter, weighing 2.6 kg housed in a casing tube to give a free fall of 310mm.

PROCEDURE: - An air-dried soil sample of 20 kg is taken. Sieve this soil through 4.75 mm IS sieve. Take the soil that passes through 4.75mm sieve. Take about 2.5 kg soil and add water to bring its moisture content to about 4% coarse-grained soil and 6% for fine-grained soil.

The cylindrical mould and base plate are cleaned and slightly greased. Weight the mould with base plate. Attach the collar to the mould. Place the wet soil in the mould in three equal layers and each layer is rammed by using rammer with 25 evenly distributed blows in each layer.

Now remove the collar and excess soil is removed with the help of straight edge. In removing the collar rotate it to break the bond between it and soil before lifting it off the mould. All the loose soil from outside and base of the mould shall be cleaned and weight of the mould containing compacted soil with base plate shall be taken.

Fig 4.2 : PROCTER MOULD



Remove the soil from the mould and a small amount of soil sample shall be taken from the center of the compacted soil and kept in a drying crucible and the weight of crucible with soil sample shall be taken to the nearest 0.01 gm. Then this crucible is kept in an oven for its water content determination. Identification number should be marked on the crucibles.

Repeat the procedure with 8,12,16,20% of water content on coarse-grained soil sample and 10,14,18,22 and 26% of water content on fine-grained fresh soil samples i.e. with 4% increments in moisture content.

The crucibles are taken out of oven after 24 hours when the soil samples become dry and the weight of crucibles with dry soil and also the weight of empty crucibles shall be taken.

OBSERVATIONS AND CALCULATIONS:

Diameter of mould (d) =
Height of Mould (h) =
Volume of mould (v) = 1000cc
Weight of the mould (w) =
Weight of empty mould with base plate = W1
Weight of mould + Compacted soil = W2
Weight of compacted soil = W2 – W1
Wet density or bulk density (γ) = $\frac{W2 - W1}{V}$
Weight of empty crucible = W3
Weight of crucible + wet soil = W4
Weight of crucible + dry soil = W5

Weight of water content = W4 – W5
Weight of dry soil = W5 – W3

$$\% \text{ Of water content } (\omega) = \frac{W4 - W5}{W5 - W3} \times 100$$

$$\text{Dry density } (\gamma_d) = \frac{\text{Wet density or bulk density}}{1 + \% \text{ of water content}}$$

$$\therefore \gamma_d = \gamma / (1+\omega)$$

The observations are tabulated for different water contents:

Table 4.2

Data	Trial No. 1	2	3	4	5
W1					
W2					
W2-W1					
V					
(W2-W1) / V					
W3					
W4					
W5					
W4-W5					
W5-W3					
ω					
γ_d					

GRAPH: - A graph is drawn taking water content percentage on X-axis and dry density on Y-axis. From graph, the water content percentage for maximum dry density is computed, which is called as optimum water content.

RESULT: - Maximum dry density = gm/cc
Optimum moisture content = %

4.3 Percentage of voids in course aggregate

Aim: - To determine the percentage of voids in coarse aggregate.

Material: - Coarse aggregate, water

Apparatus: - 1) Balance 2) Measuring jars 3) Bucket.

Theory:- Voids ratio is the ratio of volume of voids to volume of solids. Voids ratio is very important parameter in proportioning the ingredients of a concrete to produce dense concrete. Dense concrete is durable and permeability is reduced to greater extent. This can be achieved by filling the voids in coarse aggregate by fine aggregate and cement fills the voids in fine aggregate. The amount of empty spaces (voids) depends on size and shape of aggregate particles. So it is necessary to determine the percentage of voids in aggregate to produce dense mix.

PROCEDURE:

i) **Weight method:** An empty bucket is weighed with balance and let it is W1. The bucket is filled with the given sample of coarse aggregate up to its brim without compacting the aggregate. The weight of this bucket with aggregate shall be weighed and let it be W2. Now water is slowly poured into the bucket such that water will occupy all the voids. Care should be taken so that excess water should not be present on the top surface of aggregate. Take the weight as W3.

OBSERVATIONS & CALCULATIONS: -

Weight of empty bucket = W1 =
Weight of bucket + aggregate = W2 =
Weight of bucket + aggregate + water = W3 =
Weight of aggregate = W4 = (W2-W1) =
Weight of water = W5 = (W3-W2) =

Percentage of voids in the coarse aggregate = $\frac{W5}{W4} \times 100$ =

ii) Volume Method: - Take the sample of coarse aggregate in the bucket. Let the volume of coarse aggregate is V1. Now water is added slowly with a measuring jar to the aggregate until the water fills all the voids. Care should be taken so that excess water should not be present on the top surface of aggregate. Let the volume of water added is V2.

OBSERVATIONS AND CALCULATIONS:

Volume of coarse aggregate = V1 = ml
Volume of water added = V2 = ml
Percentage of voids in coarse aggregate = $\frac{V2}{V1} \times 100$ =

RESULT: -

1) Percentage of voids in coarse aggregate (by weight method) =

2) Percentage of voids in coarse aggregate (by volume method) =

4.4 Percentage of voids in fine aggregate

Aim: - To determine the percentage of voids in fine aggregate (sound).

Material: - Fine aggregate, water

Apparatus: - 1.Balance 2.Measuring Jar 3. Bucket

Procedure: -

1) Weight method: - Take a small empty bucket and find its weight. Let it is W1. The bucket is filled with the given sample of sand up to the brim without compacting and find its weight. Let it is W2. Now water is added slowly till the voids are completely filled up. Care should be taken not to pour any excess water over the sand. Find the weight of bucket containing sand and water. Let it is W3.

OBSERVATIONS AND CALCULATIONS:

Weight of sand = W4 = W2 – W1 =
Weight of water added = W5 = W3 – W2 =
Percentage of voids in the given sample of
fine aggregate = $\frac{W5}{W4} \times 100$ =

2) Volume Method:

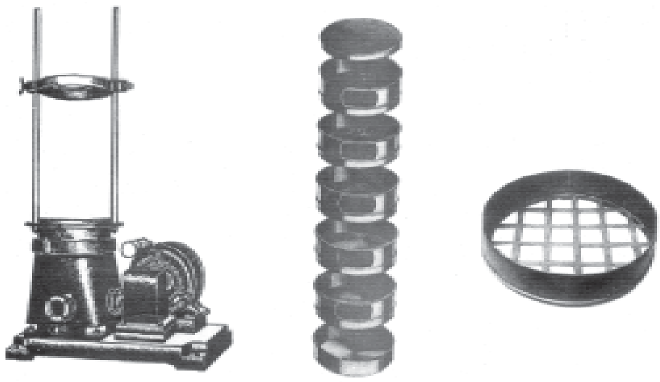
A glass-measuring jar of capacity 500 ml is taken and filled with fine aggregate up to 250 or 300 ml. Let it be V1ml. water is added slowly to fill the voids in the sand. Care should be taken not to pour excess water in the sand. For this burette is used to pour the exact quantity of water. The difference of initial and final readings of burette gives the volume of water added to fill the voids in sand. Let it be V2 ml.

OBSERVATIONS AND CALCULATIONS:

Volume of fine aggregate = V1 =
Volume of water added = V2 =
Percentage of voids in the given sample of
fine aggregate = $\frac{V2}{V1} \times 100$

RESULT: - Percentage of voids in fine aggregate
1) By weight method=
2) By Volume method=

FIG 4.4 : SET OF SIEVES



4.5 Fineness Modulus of coarse aggregate by sieve analysis

Aim: To determine the fineness modulus of given sample of coarse aggregate by sieve analysis.

Apparatus:

1. The sieves used for sieve analysis are as per IS 2386 - 1963. (Shown in Table).
2. Balance 3. Sieve Shaker.

Theory:
The fineness modulus is a numerical index of fineness equal to the sum of cumulative percentages of material retained on set of ten sieves divided by 100. This will give some idea of the mean size of the particles present in the sample. The aggregate passing through 4.75mm sieve is called fine aggregate and retained on 4.75mm sieve is called coarse aggregate. It is necessary to find fineness modulus, to grade the given aggregate for the most economical mix and to get required strength and workability with minimum quantity of cement.

PROCEDURE:

The sieves mentioned in the table are taken and cleaned before use. The sieves are arranged with 80mm sieve at top and 150 microns sieve at bottom. Top sieve is covered with a lid and a receiver shall be placed below the last sieve.

The sample of aggregate shall be brought to a dry condition before weighing and sieving. Weigh 2 kg of coarse aggregate and place in the top most sieve of the set. The sieves are shaken either manually or mechanically. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise so that the material is kept moving over the surface in frequently changing directions. This can be continued for a period of 2 minutes or more. In mechanical sieving, sieving, sieving shall be continued for not less than 10 minutes.

On completion of sieving, the material retained on each sieve shall be weighed. The readings are tabulated. Calculate the cumulative percentages retained divided by 100. The value of fineness modulus is higher for coarse aggregate.

OBSERVATIONS AND CALCULATIONS:

Weight of Sample taken = kg.

TABLE 4.5

	Coarse aggregate		
I.S. Sieve size	Weight retained	Cumulative weight retained	Cumulative % retained
80mm 40mm 20mm 10mm 4.75mm			

Result:

1. Fineness modulus of coarse aggregate

$$= \frac{\text{Sum of Cumulative percentage retained}}{100}$$

=

4.6 Fineness modulus of fine aggregate by sieve analysis

Aim: To determine the fineness modulus of given sample of find aggregate by sieve analysis.

Apparatus: 1. The sieves used for sieve analysis are as per IS 2386 – 1963 (Shown in Table)2. Balance 3. Sieve shaker

PROCEDURE:

The sieves mentioned in the table are taken and cleaned before use. The sieves are arranged with 80mm sieve at top and 150 microns sieve at bottom. Top sieve is covered with a lid and a receiver shall be placed below the last sieve.

TABLE 4.6

	Fine aggregate		
I.S. Sieve size	Weight retained	Cumulative weight retained	Cumulative % retained
4.75mm 2.36mm 1.18mm 600micron 300micron 150micron			

The sample of aggregate shall be brought to a dry condition before weighing and sieving. Weigh 1 kg of fine aggregate and place in the top most sieve of the set. The sieves are shaken either manually or mechanically. The shaking shall be done with a varied motion, backwards and forwards, left to right, circular clockwise and anti-clockwise so that the material is kept moving over the surface in frequently changing directions. This can be continued for a period of 2 minutes or more. In mechanical sieving, sieving shall be continued for not less than 10 minutes.

On completion of sieving, the material retained on each sieve shall be weighed. The readings are tabulated. Calculate the cumulative percentages retained divided by 100.

OBSERVATIONS AND CALCULATIONS

Weight of sample taken=

Result:

1. Fineness modulus of fine aggregate

$$= \frac{\text{Sum of cumulative percentage retained}}{100}$$

Note:

Generally the fineness modulus of fine aggregate varies from 2.0 to 3.5 and for coarse aggregate varies from 5.0 to 8.0. The sieves adopted for all in aggregates, coarse aggregates and fine aggregates are:

1) For all in aggregates: 80mm, 40mm, 10mm, 4.75mm, 2.36mm, 1.18mm, and 600 micron, 300 micron and 150 micron.

2) For coarse aggregate: 80mm, 40mm, 10mm, and 4.75mm

3) For fine aggregate: 4.75mm, 2.36mm, 1.18mm, 600, 300,150 micron.

5
TESTS ON METALS

5.1 Tension test on mild steel

Aim: To conduct tension test on the given mild steel specimen to determine:

1 yield strength
2 ultimate strength
3 Breaking strength
4 Percentage elongation
5 Percentage reduction in area
6 Young's modulus

Materials: Test specimen of mild steel

Apparatus: Universal testing machine (U.T.M.), Vernier calipers/ micro meter, scale, Dot punch, Hammer

Description of equipment: U.T.M. can be used to conduct tension, compression, bending and shear tests. This machine mainly consists of testing unit and control unit. Testing unit consists of four cross heads (lower, middle, Upper and top guide cross heads) and a deformation-measuring device. Control unit consists of a hydraulic system, load measuring device and an automatic diagram recorder.

Theory: Mild steel bars are commonly used as reinforcement in concrete structures to with stand tensile stresses. So it is necessary to test for tensile strength of mild steel bars. The following properties are determined in this test.

1. Yield stress: The point at which the stress remains constant with increase in strain.

2. Ultimate stress: This is the maximum stress the material has attained. At this point reduction in cross sectional area takes place in the specimen. It leads to reduction in the load carrying capacity.

3. Breaking stress: The stress at which the specimen breaks down.

4. Percentage Elongation: It is the ratio of final elongation to its original gauge length.

$$\% \text{ Elongation} = \frac{L2 - L1}{L1} \times 100$$

Where L1 = Initial gauge length
L2 = Final gauge length at fracture

5. Percentage reduction in area: It is the ratio of decrease in area to the original area of cross section.

6. Young's modulus: It is defined as the ratio of stress to strain with in the elastic limit.

A - Limit of proportionality
B - Elastic limit
C - Upper yield
D, E - Lower yield
F - Ultimate load
G - Breaking load

Procedure: Measure the diameter the of the given mild steel specimen at three different places with the help of vernier calipers or micrometer. Find the average diameter (D) of the specimen. Calculate the gauge length (Lo) of the specimen by $L_o = 5.65 \sqrt{S_o}$ where S_o = Cross Sectional area in mm^2. Mark center point on the specimen and mark the gauge length.

Fix the specimen in the grips of movable and fixed cross heads of UTM. Fix extensometer to the rod over the gauge length to get accurate value of extension. Note the reading of extensometer to measure the elongation up to yield point. A suitable load range is selected depending upon the type of specimen. Switch on the hydraulic system, apply load at a steady and uniform rate by turning the loading wheel slowly.

The tension cross head moves up and the middle cross head remains fixed thus exerting tension on the test specimen. A graph sheet shall also be fixed in the recording unit, which plots stress strain curve.

Apply the load slowly so as to note down the loading and corresponding elongation from the scale or extensometer, without stopping the machine. The tension is proportional to elongation up to a limit called as limit of proportionality. If the load is continued, the elongation of the bar increases very speedily at almost slight increase of load. This can be identified by a downward kink in the stress strain curve. The stress, at which the down ward kink starts, is taken as yield stress. From the load dial, the load at yield point can be noted when the needle just stops and slightly comes back.

Apply the load continuously, when the load reaches maximum value, a crack is initiated in the specimen and the needle that shows the load comes back. This maximum load is called as ultimate load. Now the diameter of the specimen decreases and a neck formation starts. Finally the specimen breaks at a load called breaking load, which is slightly less than the ultimate load. Breaking load shall be recorded.

After breaking, remove the specimen from the UTM, measure the final gauge length and final diameter. For mild steel, if loading is gradual and material is free from defects, a typical cups and cone fracture is observed.

From the observations, the stress strain curve shall be plotted and verified with that of the curve recorded by the plotting unit of U.T.M.

OBSERVATIONS

Diameter of rod	Trial 1 =	mm
	Trial 2 =	mm
	Trial 3 =	mm

Average diameter of rod (D)	=	mm
Gauge length of rod (L_0)	=	mm
Yield point load (P_y)	=	
Ultimate Load (P_u)	=	
Breaking Load (P_b)	=	
Total elongation of the rod (L_1)	=	mm
Final diameter at neck (D_f) (Cone part area)	=	mm

Calculations:

Original area (A) = mm^2
Final area (A_f) = mm^2
Yield stress = P_y/A N/mm^2
Ultimate stress (Pu/A)= N/mm^2
Breaking stress P_b/A= N/mm^2
% Elongation =
% Reduction in area =

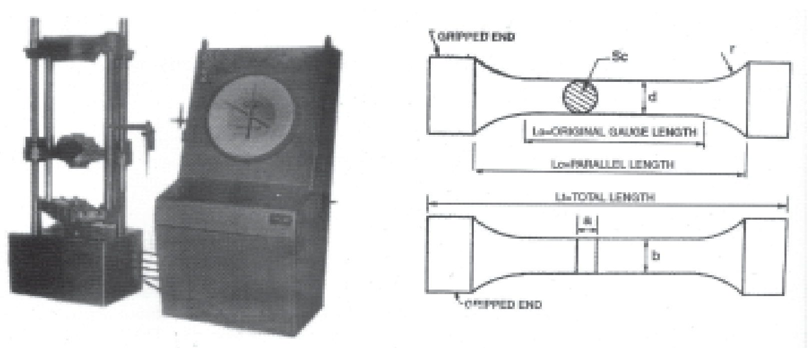
To determine Young's modulus, a graph is drawn between stress (on y – axis) and strain (on x – axis) or graph can be directly obtained from UTM mechanical graph plotter drum. From the graph, with in the limit of proportionality, the stress and strain can be found and Young's modulus is calculated.

E = Stress/Strain= N/mm^2

Results:

1. Yield Stress =
2. Ultimate stress =
3. Breaking stress =
4. % Elongation =
5. % Reduction in area
6. Young's modulus =

FIG. 5.1: UTM



5.2 Double shear test on mild steel rod

Aim: To find the ultimate shear strength of the given rod

Material: Steel rod specimen
Apparatus: UTM, Shear tool assembly

Procedure: The diameter of the given steel specimen shall be accurately determined by taking the average of three readings taken at different points along the length of the specimen.

To select the load range in the U.T.M the maximum shear stress for steel shall be calculated as given in I.S.800 (Max. shear stress permissible V_v max = 0.45 f_y) knowing the yield stress of given steel specimen. Taking a factor of safety of about 4, the failure load shall be calculated. Since the specimen to be tested is in double shear the failure load will be equal to 2 X V_v max X C.S.area of specimen X 4. This will help to select the suitable load range in the UTM before starting the experiment.

Then, the top part of the shear attachment shall be mounted on the middle adjustable cross-head and the bottom part of the shear attachment shall be mounted on the lower compression crosshead by the mechanism provided for that so that the holes provided for inserting the specimen in the shear attachment are in line.

Now, the specimen shall be inserted to pass through the holes centrally in the shear attachment. The inner diameter of the hole in the shear test attachment shall be slightly greater than that of the specimen. Thus the arrangement is made so that the specimen will be sheared off at two cross-sections due to the applied load and the test performed is known as double shear test.

Then the load is applied gradually making sure that the correct load range is maintained without altering. Application of load is continued until the specimen breaks by shearing at two cross-sections. This load at failure shall be recorded and the load is removed so that the shear attachment and broken pieces can be taken out. The nature of failure of sheared surface shall be examined and it will be smooth in the case of mild steel.

The specimen is inserted in the internal jaw hole. Afterwards, the external shearing jaws are to be inserted over the specimen ends, one on either side. To keep the shearing jaws in contact with each other in their proper places, the clamp shall be screwed tightly on both the sides. Then the shearing equipment shall be placed at the center of lower compression plate such that the shearing tongue is vertically upwards.

The adjustable crosshead is now lowered so that the top compression plate comes just above the top of the shearing tongue. Now the hydraulic device of the UTM is put on and the suspension shackle of the machine is lifted up. As such, the shear tongue is pressed down and consequently, the specimen is sheared between the shearing jaws on two planes. The load applied is indicated on the dial gauge. The loading is gradually increased until the specimen is sheared completely. Note the maximum load. Load is then removed to take out the shear attachment from which the broken pieces shall be taken out.

OBSERVATION:

Average diameter of the specimen (d)=

Load at shear failure (L_f) =

CALCULATIONS:

Ultimate shear stress for the given steel specimen

$$= \frac{\text{Load at shear failure}}{\text{2x C.S. area of the specimen}}$$

$$= \frac{L_f \times 4}{2 \times \pi d^2} =$$

RESULT : Ultimate shear stress of the given Steel specimen=

5.3 Rockwell and brinell hardness tests on steel / brass

1. Rockwell hardness Test

Aim: To measure the hardness of the given specimen

Material: Hard Steel, Mild steel, Brass specimen

Apparatus: Rockwell hardness testing machine, Emery paper, Indentors

Theory: Hardness may be defined as resistance to penetration or resistant to abrasion. The test involves in determining the depth of impression caused by the penetration of certain standard load on the specimen. Rock well hard ness testing machine is more extensively used because of its simple testing procedure, direct reading access of hardness number. This machine can be used to test materials like hard steel, mild steel, Aluminum, cast Iron, Brass etc. The load is applied on the specimen by means of compound lever system. The indentator or penetrator is either a steel ball or diamond cone with slight rounded point. A steel ball is used with a load of100 kg to test softer materials like brass and hardness number is found on B – scale. A diamond cone is used with a load 150 kg to test harder materials like hard steel and hardness number is found on C – scale.

The principle consists of application of small initial load to the penetrator to elimination any effect due to surface imperfections. The major load is then added and the depth of penetration is measured. The reading is inversely proportional to the depth of penetration so that the greater penetration, the lower the hardness number and vice – versa.

Description of equipment:

1. Rock well Hardness testing machine: This consists of a dial gauge with red and black scales. A long pointer in the machine. Red scale is used for readings obtained with Ball indenter and black scale is used for Diamond indenter. Scales B & C are used for major loads 100 and 150 Kg respectively for both these scales the minor load is 10 kg.

2. Indentors: Ball Indentor is of 1.5875 mm made of Tungsten carbide or Hardened steel. The diamond indentor is having 0.2 mm radius tip with an apex angle of 120.

Procedure: Depending on the material of the specimen to be tested, suitable loads (100kg or 150kg) are placed. The corresponding penetrator is fixed in the indentor hole. The surface of the specimen is rubbed with Emery paper and placed on the disc. Turn the hand wheel to move the disc upwards till clear contact is made with the indentor. Continue carefully rotating the hand wheel until the small needle (pointer) on the dial reaches the set position. Now the specimen is under application of minor load of 10 Kg.

Continue rotating the hand wheel to apply the major loads (90 kg for sale B and 140 kg for scale C) to the specimen with in about 10 seconds. When the penetration is completed, release the major load by pulling backward the loading handle keeping the initial load 10 kg still on the specimen.

Now read the hardness number C or B on the dial and record it. Release the minor load of 10 kg by rotating the hand wheel anti clock wise and lowering the screw. Repeat the procedure for four times for the same material.

OBSERVATION

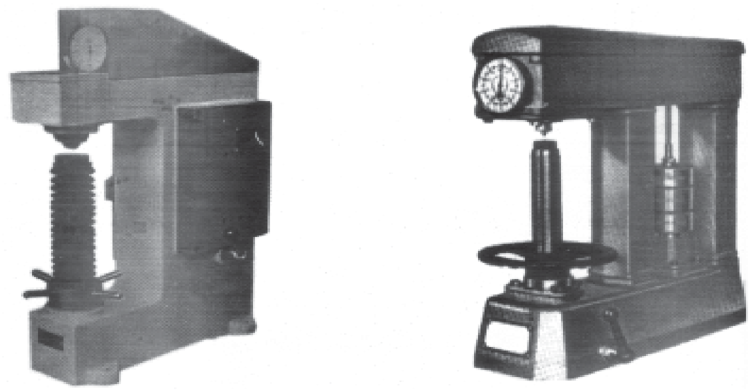
Table 5. 3.1

Sl.	Material	Trial No.	Indentor Load	Major Load	Scale Number	Hardness No.
1.	Hard Steel	1 2 3 4	Diamond	140 kg	C	RHC
2.	Mild Steel	1 2 3 4	Steel ball	90 kg	B	RHB
3.	Brass	1 2 3 4	Steel ball	90 kg	B	RHB

Result: -

1.Rockwell hardness Number for hard steel =
2.Rockwell hardness Number for Mild steel =
3.Rockwell hardness Number for Brass =

Fig. 5.3 : ROCKWELL HARDNESS TESTING MACHINE



2. Brinell Hardness test:

Aim: - To determine the Brinell hardness number of given material specimen.

Apparatus: Universal Testing Machine, 10mm diameter steel ball fixed in a standard die, microscope.

Procedure: The 10mm diameter ball is fixed on a standard die shall be mounted properly in position and the specimen to be tested shall be kept on the bottom compressive cross head. Then the UTM is operated in such a way that load is gradually applied until the needle shows 300kg. At this stage further loading is stopped and this load shall be allowed to act for at least 15 seconds for other materials.

After loading as above, for the specified time, the load is released and the specimen shall be removed from the position and taken out. The diameter of the indentation is measured accurately with a microscope.

Let Diameter of steel ball=D=
Diameter of indentation=d=
Depth of indentation=h=

$$\therefore h = \frac{1}{2}\left[D-\sqrt{(D^2-d^2)}\right]$$

But the Brinell hardness number is the load applied (P) divided by the spherical area of indentation in sq. mm.

Spherical area of indentation=P . D.h

\ Brinell hardness number (BHN) = P / P . D.h

Table 5.3.2

S. No.	Material of the Specimen	Dia. of Indentor	Load applied	BHN

Result: Brinell hardness number of the specimen=

5.4 Izod and charpy impact tests on steel/brass

Aim: - To determine the impact resistance of materials using Izod and charpy test.

Apparatus: - Impact testing machine with pendulum hammer, brake handle and a dial graduated for both Izod and Charpy impact values.

Theory: - Many machine parts are commonly subjected to dynamic loads. The performance of the parts depends on the properties of the component materials under such applied loads. A load which falls from height on the member is known as impact load. Many structural members have to take impact loading such as forging machines, machine bases, hooks of cranes, crane chains, etc. In doing an impact test, load may be applied in flexure. After impact, the energy absorbed by the material is known as impact value, which represents the toughness of the material. There are mainly two tests widely used to find the impact strength. They are

1) Izod test (or) Cantilever test
2) Charpy test (or) Simple beam test.

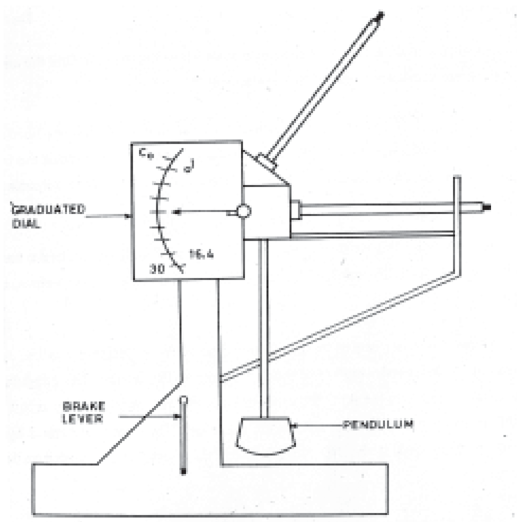
1. IZOD TEST: - The machine used to conduct the impact test has a capacity of 17 kg-m (or) 16.4.kg-m (or) 19 kg-m depending on the type of make. The specimen to be tested is 10mmx10mm in cross-section and 75 mm long having a standard 45^{o} notch 2mm deep at a distance of 47mm from one end of the specimen. The specimen shall be placed in between the two vices with notch towards striking edge.

Rise the pendulum with hammer until it is locked in IZOD position. A small pointer is connected to the pendulum, which shows 17kg-m reading when pendulum locked into Izod position.

A dummy pointer on the dial case is rotated to contact with main pointer attached to pendulum. Now the pendulum is released by operating the lever so that the pendulum strikes against the specimen and breaks it. Note the reading indicated by the dummy pointer.

Result: - 1) Initial reading as indicated by the dummy pointer on Izod scale (R1)=
2) Final reading as indicated by the dummy pointer on Izod scale (R2)=
3) Impact energy absorbed by the specimen at the time of breaking (R2 – R1) =

Fig. 5.4 : IZOD / CHAPRPY TESTING MACHINE



2. CHARPY TEST: The specimen to be tested is 10mmx10mm in cross-section and 60mm long having a standard 45o notch 2mm deep in the center. The specimen is mounted horizontally between the two anvils with a clear span of 40mm.The specimen shall be placed such that the notch is on the other side to that of striking edge.

The catch is adjusted to Charpy test i.e. for 30 kg-m capacity and the pendulum is raised from its seat when it automatically gets locked by the catch and releasing mechanism, to give a constant height of fall. The loose pointer is brought to coincide with the pendulum pointer.

After making this arrangement, the pendulum is released by operating the lever so that the pendulum strikes the specimen on the opposite face to that of the notch provided face and breaks the specimen. Now, the reading as indicated by the loose pointer on scale shall be noted.

Observations:

Initial reading (R1)=

Final reading (R2)=

\ Energy absorbed by the specimen=R2-R1= kg-m

Result:

\ Charpy Test Result=

6
TESTS ON CONCRETE

6.1 Preparation of cement mortar for given proportion

Aim:- To prepare cement mortar of different proportions.

Materials:- Cement, sand, water.

Apparatus: - Spade, concrete Mixer, Balance, Measuring jar

Theory: - Mortar is a paste prepared by mixing cement with fine aggregate like sand and required quantity of water. Depending upon the strength required and importance of work, the proportion of cement to sand by volume varies from 1:2 to 1:6 or more. The properties of mortar such as strength, durability, etc. mainly depend upon the quality and quantity of the cement used for making the mortar. For example, if in a mortar, the ratio of matrix (cement) to aggregate is 1:3, it means, 1 part of matrix (cement) is mixed with 3 parts of aggregate (sand). The strength of mortar depends upon the ratio of matrix to aggregate.

PROCEDURE:

To prepare cement mortar, good quality of cement and sand should be used. The sand that is taken from pit or River should be free from clay and organic impurities with sharp, angular and durable grains only used.

Cement and sand are mixed in required proportions in dry state on a watertight plat form or steel trough. Cement mortar may be mixed by hand or by a mechanical mixer. Mechanical mixing is adopted when cement mortar is required in large quantities continuously. The required quantity of sand is spread on a dry, level, watertight plat form. Then cement in required quantity is put over the sand heap. By using a spade, the ingredients are turned over a number of times, backward and forward, till the mixture attains a uniform colour. Now a catre (depression) is formed of the dry mix and water is added in the center of the catre. The mixture from the sides is turned over into the center of the catre and then the whole thing is turned and mixed thoroughly. After preparation the mortar should be used within 30 minutes after adding water.

In cement mortar, cement and sand are used in varying proportions, depending upon the nature of work. Table shows the types of mortars to be used for various engineering constructions.

Table 6.1 (a)

Sl. No.	Nature of Work	Type of Mortar
1.	Plastering work	1:3 to 1:6
2.	Pointing work	1:1 to 1:4
3.	Masonry in foundation and Plinth	1:5 to 1:6
4.	Masonry in Superstructure for single or two storeyed buildings	1:6
	for Multi-storeyed buildings	1:3 for ground floor 1:4 for I & II floors 1:6 for other floors
5.	Partition walls and Parapet Walls	1:5 to 1:6

Observations

Table 6.1(b)

Sl. No.	C.M. Proportion	Quantity of cement	Quantity of sand	Quantity of water

6.2 Workability test on concrete – slumps test

Aim: - To find the workability of given mix of concrete by slump cone test.

Material: - 1) Cement 2) sand 3) Coarse aggregate 4) water

Apparatus: - slump cone apparatus, steel tamping rod, trowel, Balance, measuring jar, scale, iron pan to mix concrete.

Theory: - Concrete prepared from different batches should be of uniform consistency and workability so that it can be easily handled and applied in the required form. The term workability is used to describe the ease or difficulty with which the concrete is handled, transported, placed in the forms and compacted. The degree of workability depends on water cement ratio. To measure the workability of concrete, slump test is commonly used in the field.

Description of equipment: Slump cone consists of a metallic mould in the form of a frustum of a cone having top diameter 100 mm, bottom diameter 200 mm and height 300 mm. The thickness of the mould should not be thinner than 1.6 mm. The mould is provided with two handles at side for lifting the cone vertically up. Steel tamping rod 16 mm dia and 600 mm long with bullet end is used for compacting concrete. An arrangement is provided for clamping the slump cone to non-absorbents surface and vertical guide scale for measuring the amount of slump.

Procedure: - The internal surface of the slump cone is thoroughly cleaned and clamp it to a non-absorbent surface. Slightly apply oil to the inside surface.

Prepare four mixes of concrete with water-cement ratio of 0.5, 0.6, 0.7, and 0.8 and mix proportion 1:2:4. For this take 3 kg of cement, 6 kg sand and 12 kg of 20mm size coarse aggregate.

The cone is filled with prepared concrete in four layers each approximately ¼ of the height of the mould. Each layer is tamped 25 times with tamping rod and the strokes are distributed in a uniform manner over the area. After placing and tamping the top layer of concrete, open the clamps and slowly lift the slump cone vertically up. This will allow the concrete to subside. This subsidence is known as slump of concrete and measured in mm (i.e. the difference between initial height of cone and final height of subsided concrete).

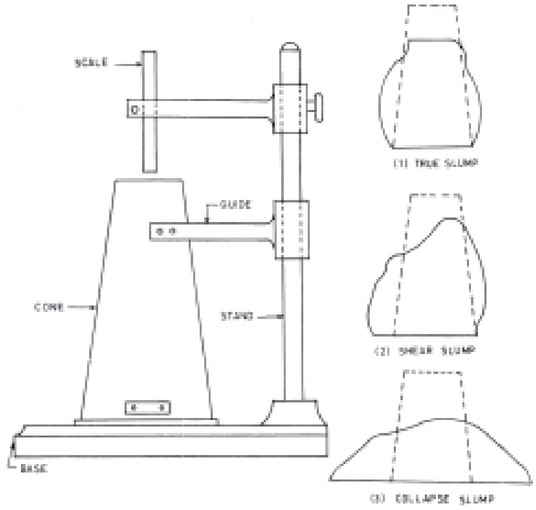


Fig. 6.2 The Slump Cone kinds of Slump

Graph: - A graph is drawn to show the variation of slump with the change in water – cement ratio. Take water-cement ratio along x-axis and slump in mm along y-axis.

The following table shows the recommended slumps of concrete for various types of works.

Table 6.2(a)

Sl. No.	Type of work	Slump in mm
1	Concrete for road construction	20 to 40
2	Concrete for beams, slabs, etc.	80 to 100
3	Concrete for canal linings	70 to 80
4	Mass concrete	25 to 50
5	Vibrated concrete	10 to 25

Observations:

Sl. No.	Water - cement Ratio	Slump in mm	Nature of slump
1 2 3 4			

6.3 Casting of cement concrete cubes and testing for compressive strength.

Aim: To prepare and test the concrete cubes for determining compressive strength of concrete.

Materials: Cement, sand, 20 mm size coarse aggregate, water oil.

Apparatus:

1) Cube moulds of size 150 mm
2) Tamping rod
3) Trowels
4) Balance with weights
5) Measuring Jar
6) Concrete mixing pan
7) Scale
8) Compression testing machine

Theory: The Compressive strength of concrete is the most important of all the properties. It is determined by casting and testing cubes. The compressive strength of concrete is defined as the load which causes the failure of a standard specimen divided by the area of cross-section. In the field a random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested i.e., the sampling should be spread over the entire period of concreting and cover all mixing units. The minimum frequency of sampling of concrete shall be:

Table 6.3(a)

Quantity of concrete at the work, m^3	Number of samples
1 – 5	1
6 - 15	2
16 – 30	3
31 - 50	4
51 and above	4 plus one additional sample for each additional 50 m^3

Description of equipment:

1) **Moulds:** The mould shall be made with steel or C.I. and strong enough to prevent distortion. It shall be constructed in such a manner so as to facilitate easy moulding and demoulding of specimen without the corners getting damaged. The dimensions of internal faces shall be accurate within the tolerable limits as per IS 516 – 1959. Each mould shall be provided with a metal base plate.

2) **Tamping rod:** The tamping rod shall be a steel bar of 16 mm diameter and 600 mm long with bullet pointed end.

3) **Compression Testing machine:** It consists of 3 parts namely pumping unit, straining unit and the load-measuring unit. The upper compression plate is of steel surface that can be adjusted to touch the specimen. The pressure comes through lower plate from the pressure cylinder at the bottom of the machine. The applied load can be measured with a pressure gauge mounted on the front panel.

Procedure: The moulds are assembled and a thin coat of oil is applied on the inner faces. The ingredients of concrete are taken and mixed by hand mixing or machine mixing. In hand mixing, mix cement and sand first in dry condition, add the coarse aggregate to the mixture and mix thoroughly. Add the required water and mix all the ingredients for 2 minutes to get good mix of concrete.

Fill the concrete in moulds in three equal layers. Each layer shall be compacted for 25 times with a tamping rod. Remove the excess concrete and level the surface with a trowel. The cubes are marked with identification numbers.

The cubes may be compacted using vibrators. For this place the wet concrete in the mould at a time and keep the moulds on vibrating table and start vibrating the table. Continue vibration for a period of 2 minutes and remove the moulds from vibrating table. Remove the cubes after 24 hours and immerse in water tank. Change the water in the tank once in every seven days.

The concrete cubes are taken out from water tank, the surface is wiped out with dry cloth. Measure the dimensions of the specimen. Place the cube in between plates of compression testing machine such that the load should be applied on the opposite sides of the cube as cast and not to the top and bottom so as to obtain parallel forces. Tighten the upper plate, close the release valve, open the inlet valve and apply the load uniformly at a rate of 14 N/mm^2 by regulating the inlet valve.

Note the maximum load reached when the cube is fully crushed. Remove the crushed specimen from the machine. Test at least three cubes from each batch for determining the average compressive strength.

Observations:

Grade of Mix =
Size of specimen =
Cross – sectional area of specimen =
No. Of specimens tested =
Date of casting =
Date of testing =
Curing period =

Result: Average compressive strength of concrete =

The following table shows the standard values of compressive strength for 150 mm concrete cubes as per IS 516 – 1959:

Table:6.3(b)

Grade of Conrete	Compressive strength in N/mm^2	
	After 7 days	After 23 days
M10	7	10
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40

Table: 6.3 (c)

Sl. No.	Idenitification No. of cube	Loat at crushing	Compressvie Strength	Average Value
1				
2				
3				

7

Study of manufacturing/preparation of construction materials

During field visits or Educational tour or in the OJT (On the Job Training) program, the students are advised to observe and prepare detailed reports on the following topics:

1) Manufacturing of different types of bricks in factory.

2) Manufacturing of different types of Tiles and clay products in factory.

3) Visit to cement factory.

4) Manufacturing of pre-cast concrete members in factory.

5) Concrete mixing methods – Hand mixing and Machine mixing.

6) Compaction methods of concrete – by tamping and by using vibrators.

REFERENCES

1. Manual of strength of materials & Soil Mechanics by Department of Technical Education and Training, Andhra Pradesh

2. Strength of Materials Laboratory Manual by premier Publishing House

3. Reinforced Concrete by H.J. Shah

4. Engineering Materials by Rangwala.

5. Manual of Strength of Materials by Department of Civil Engg. S.V. University, Tirupathi.