SNS COLLEGE OF TECHNOLOGY

AN AUTONOMOUS INSTITUTION

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

23GET102 – BASIC CIVIL AND MECHANICAL ENGINEERING

I YEAR / I SEMESTER

Unit 1 : Civil Engineering Materials and Surveying

Topic : Stones and Types

Stone as a Building Material

The main uses of stone as a building material are:

- As a principal material for foundation of civil engineering works, and for the construction of walls, arches, abutments and dams.
- In stone masonry in places where it is naturally available.
- As coarse aggregate in cement concrete (crushed form of rock).

Types of Building Stones and Uses

Based on Geology, stones or rocks are classified into three types:

1. *Igneous Rocks* - *Basalt, Trap, Andesite, Rhyolite, Diorite, Granite.*
2. *Sedimentary Rocks* - *Lime stones, Dolomite and Sandstones.*
3. *Metamorphic Rocks* - *Gneiss, Quartzite, Marble, Slate.*

Types of Building Stones and Uses

- Most of the prehistoric monuments are built with natural stones as they remain stable with time.
- Before the advent of concrete, stones were highly preferred for heavy engineering works like bridge piers, harbor walls, seaside walls, and for facing works.
- Stones for construction purposes are obtained by quarrying from solid massive rocks.
- The stones used for masonry construction should be hard, durable, tough, and should be free from weathered soft patches of material, cracks, and other defects that are responsible for the reduction of strength and durability.

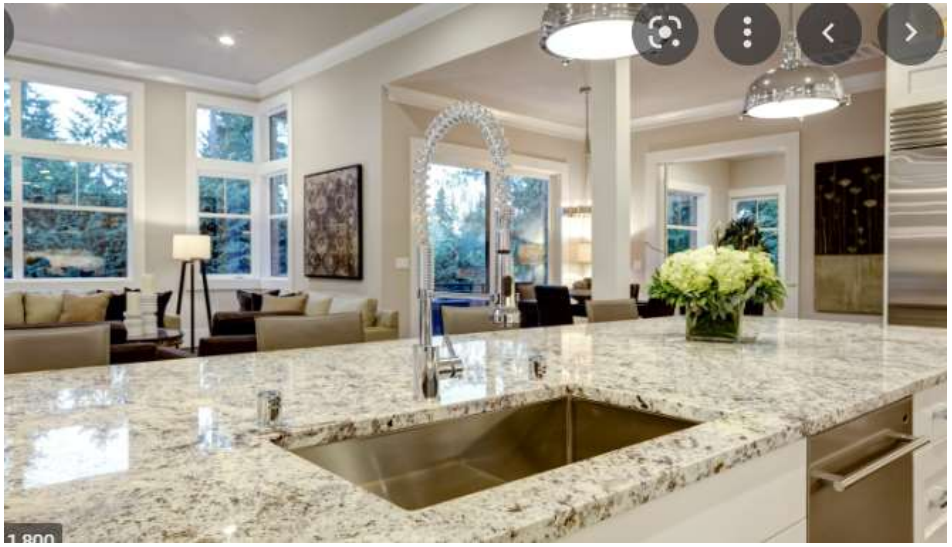
Types of Building Stones and Uses

- Granite
- Basalt and Trap
- Limestone
- Sandstone
- Gneiss
- Marble
- Slate
- Quartzite
- Laterite

Granite

- It is a deep-seated igneous rock, which is hard, durable and available in various colours.
- It has a high value of crushing strength and is capable of bearing high weathering.
- Granite is used for bridge components, retaining walls, stone columns, road metal, ballast for railways, foundation, stonework and for coarse aggregates in concrete.
- These stones can also be cut into slabs and polished to be used as floor slabs and stone facing slabs.
- It is considerably hard and durable, and its compression strength ranges from 100MPa to 250MPa.
- It takes polish well, and the color varies from light gray to pink.
- The polished granite can be used as table tops, cladding for columns and walls.
- Granite is found in Maharashtra, Rajasthan, Uttar Pradesh, Madhya Pradesh, Punjab, Assam, Tamil Nadu, Karnataka and Kerala.

Granite



Granite

Basalt and Trap

- They are originated from igneous rocks in the absence of pressure by the rapid cooling of the magma.
- They have the same uses as granite.
- Basalt stone, which is also known as traps, is commonly used in road construction, as aggregate in concrete production, rubble masonry works for bridge piers, river walls, and dams.
- The compression strength of this stone type ranges from 200MPa to 350Mpa, and its weight is between 18KN/m3 and 29KN/m3.
- Basalt has good resistant to weather, impervious to moisture, very hard, and very difficult to dress in fine shapes.
- The color of basalt changes from dark gray to black.

Basalt and Trap

Limestone

- It is a sedimentary rock formed by remnants of seaweeds and living organisms consolidated and cemented together.
- It contains a high percentage of calcium carbonate.
- Limestone is used for flooring, roofing, pavements and as a base material for cement.
- However, dense, compact, and fine textured types which are free from cavities and cracks can be easily dressed and take a very fine polish.
- The use of limestones as facing stones should be avoided in areas where the air is polluted with industrial gases and also in coastal regions where saltish winds can attack them.
- It is found in Maharashtra, Andhra Pradesh, Punjab, Himachal Pradesh and Tamil Nadu.

Limestone

Sandstone

- This stone is another form of sedimentary rock formed by the action of mechanical sediments.
- It has a sandy structure which is low in strength and easy to dress.
- They are used for ornamental works, paving and as road metal.
- Sandstones in combination with silica cement are used in the construction of heavy structures.
- It is also employed in masonry works, dams, bridge piers, and river walls.
- The compressive strength ranges between 20MPa and 170MPa, and specify gravity varies from 1.85 to 2.7.
- It should be known that weathering sandstone makes it unsuitable for building construction.
- It is available in Madhya Pradesh, Rajasthan, Uttar Pradesh, Himachal Pradesh and Tamil Nadu.

Sandstone

Gneiss

- It can be recognized by its elongated platy minerals usually mixed with mica and used in the same way as granite.
- They can be used for flooring, pavement and not for major purposes because of its weakness.
- This type of stone is used for minor construction since the presence of deleterious substances in its constituents makes it undesirable for building construction.
- However, hard varieties of gneiss stone may be employed in construction works.
- The compression strength varies from 50MPa to 200MPa. It has fine to coarse grains, and its color may be light grey, pink, purple, greenish gray and dark grey.
- It is found in Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat.

Gneiss

Marble

- It is a metamorphic rock which can be easily cut and carved into different shapes.
- It is used for ornamental purposes, stone facing slabs, flooring, facing works etc.
- It is used for facing and ornamental works in columns, flooring, and steps.
- The compressive strength of marble varies from 70MPa to 75MPa.
- Marble stones are quite strong, uniform in texture, least porous, and take an excellent polish.
- It can be easily cut and carved into different shapes.
- Marble is available in different colors like white and pink, found in Rajasthan, Gujarat and Andhra Pradesh.

Marble

Slate

- It is a metamorphic rock which can be split easily and available in black colour.
- It is used for damp-proofing flooring and roofing.
- Slate shows great variation in its building properties which depend on the thickness of the sheets and the color of the rock.
- It is used as roofing tiles, slabs, and pavements.
- It consists of quartz, mica, and clay minerals.
- The compression strength of slate changes from 100MPa to 200MPa, and its color can be dark gray, greenish gray, purple gray to black.
- The structure of slate is fine grained and its specific gravity is 2.6 to 2.7.

Slate

Quartzite

- It is a metamorphic rock which is hard, brittle, crystalline and durable.
- It is difficult to work with and used in the same way as granite but not recommended for ornamental works as it is brittle.
- It is used as building blocks, slabs, and as aggregate for concrete.
- The structure of quartzite is fine to coarse grain and mostly granular and branded, and mainly composed of feldspar and mica in small quantities.
- The crushing strength is between 50MPa to 300MPa.They are available in different colors like white, gray, yellowish.

Quartzite

Laterite

- It is decomposed from igneous rocks; occur in soft and hard varieties.
- It contains a high percentage of iron oxide and can be easily cut into blocks.
- The soft variety is used for walls after curing while the hard blocks are used for paving the pathways.
- Laterite is used as building stone, but its outer surface needs to be plastered.
- It contains a high percentage of iron oxide and can be easily cut into blocks.
- Laterite occurs in soft and hard varieties and the compressive strength of laterite is between 1.9MPa and 2.3 MPa, and its strength is increased with seasoning.
- Laterite color may be brownish, red, yellow, brown and grey.

Laterite

Uses of Building Stones

The stones used for various types of works are as follows:

- *Fine-grained granite and gneiss stones are used for Heavy engineering works such as building bridge piers, breakwaters, monuments, etc.*
- *Granite, quartzite and compact sandstones are used for masonry works in industrial areas exposed to smoke and fumes.*
- *Marble, granite and sandstone are used for facing work of buildings.*
- *Limestone and sandstone are used for general building works.*
- *Fine-grained granite, marble, and soft sandstone are used for Carvings and ornamental works.*
- *Compact limestone and sandstone are used for Fire-resistant masonry.*
- *Granite, quartzite stones are used in foundations of building in places with the high groundwater level.*
- *Marble, slate, sandstone and granite stones are used for floor pavings.*

Thank You!!

Properties of good building stone ;

- **Texture :** A good building stones must compose fine crystalline structure which should be free from cavities, cracks or patches of soft or loose material. Stones with such texture are so strong and durable.
- **Toughness Index :** If the value of toughness index comes below 13 in impact test, then the stone is not tough. If the value comes in between 13 & 19 then stone is said to be moderately tough and if it exceeds 19 then stone is said to be highly tough.
- **Hardness :** As worked out in a hardness test, the coefficient of hardness should be greater than 17 for a stone to be used in a road work. If it is between 14 & 17 then it is said to be medium hardness and if it is less than 14 ,it is said to be of poor quality.
- **Crushing strength :** For a good building stone, the crushing strength should be greater than 100 N/mm^2.
- **Durability :** A good building stone should be durable and for making stones durable, their natural bed should be carefully noted.
- **Appearance :** Those stones which are used for face work should be decent in appearance. They should be able to protect their color for a long time.
- **Percentage wear :** If the wear is more than 3 in attrition test, the stone is not acceptable. For a good building stone, the wear should be equal to or less than 3%.
- **Specific gravity :** Good building stones must have specific gravity greater than 2.7
- **Water Absorption :** We know that all the stones are more or less porous in nature but for a good building stones, percentage of water absorption by weight after 24 hours should not exceeds 0.60 .

Uses of good building stone ;

Stones are used in the following civil engineering constructions:

- Stone masonry is used for the construction of foundations, walls, columns and arches.
- Stones are used for flooring.
- Stone slabs are used as damp proof courses, lintels and even as roofing materials.
- Stones with good appearance are used for the face works of buildings. Polished marbles and granite are commonly used for face works.
- Stones are used for paving of roads, footpaths and open spaces round the buildings.
- Stones are also used in the constructions of piers and abutments of bridges, dams and retaining walls.
- Crushed stones with graved are used to provide base course for roads. When mixed with tar they form finishing coat.

Crushed stones are used in the following works also:

- As a basic inert material in concrete.
- For making artificial stones and building blocks.
- As railway ballast.

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Topic : Tests on Stones

Tests on Stones

- There are various tests on building stones to know its properties and suitability for various construction works.
- Tests on building stones provides physical and chemical properties as well as strength and hardness properties.

Tests on Stones

Following are different tests on building stones:

1. Acid test
2. Attrition test
3. Crushing test
4. Crystalline test
5. Freezing and thawing test
6. Hardness Test
7. Impact test
8. Water absorption test
9. Microscopic Test
10. Smith's Test

Acid Test

- This test is carried out to understand the presence of calcium carbonate in building stone.
- A sample of stone weighing about 50 to 100 gm is taken.
- It is placed in a solution of hydrochloric acid having strength of one percent and is kept there for seven days. Solution is agitated at intervals.
- A good building stone maintains its sharp edges and keeps its surface free from powder at the end of this period.
- If the edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate and such a stone will have poor weathering quality.
- This test is usually carried out on sandstones.

Acid Test

Attrition Test

- This test is done to find out the rate of wear of stones, which are used in road construction.
- The results of the test indicates the resisting power of stones against the grinding action under traffic.

The following procedure is adopted:

- Samples of stones is broken into pieces about 60mm size.
- Such pieces, weighing 5 kg are put in both the cylinders of Deval's attrition test machine. Diameter and length of cylinder are respectively 20 cm and 34 cm.

Attrition Test

Attrition Test

- Cylinders are closed. Their axes make an angle of 30 degree with the horizontal.
- Cylinders are rotated about the horizontal axis for 5 hours at the rate of 30 rpm.
- After this period, the contents are taken out from the cylinders and they are passed through a sieve of 1.5mm mesh.
- Quality of material which is retained on the sieve is weighed.
- Percentage wear worked out as follows:

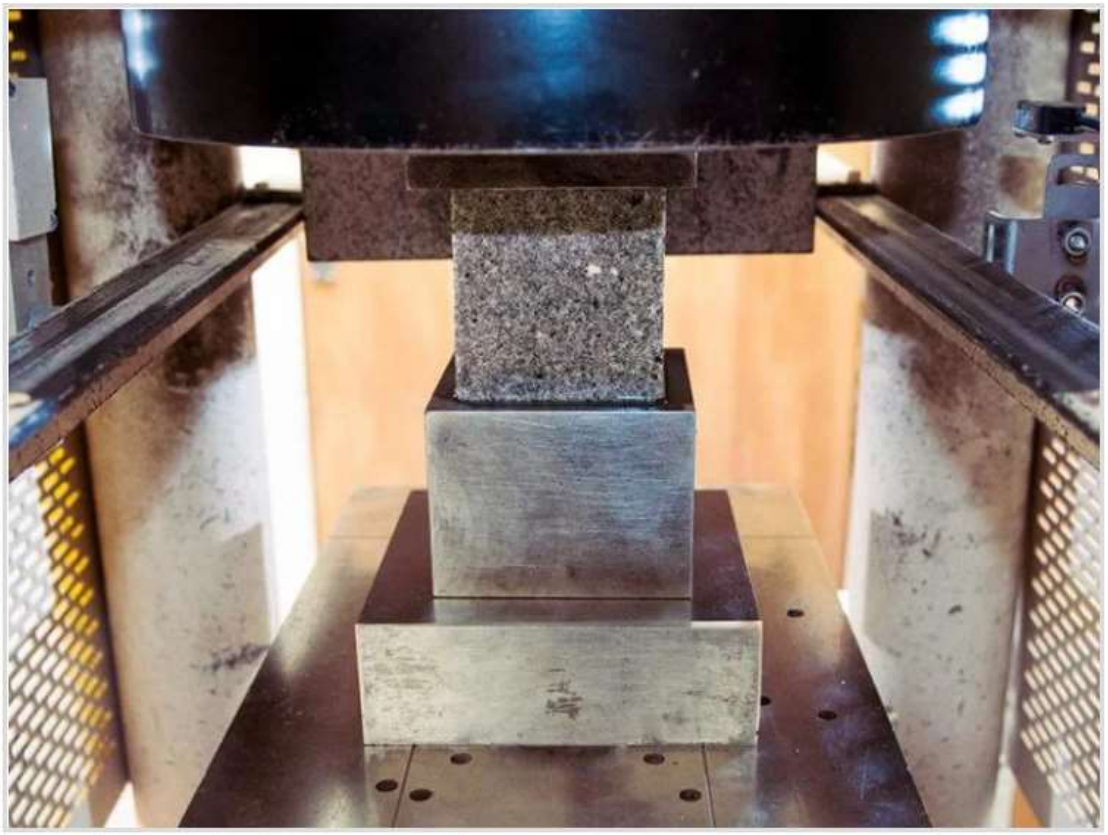
Percentage wear = (Loss in Weight/Initial Weight) x 100

- Maximum abrasion value is 30%

Crushing Strength Test

- ✓ For conducting this test, a specimen of size 40 × 40 × 40 mm is prepared from parent stone.
- ✓ Afterward, the sides are finely dressed and placed in water for three days.
- ✓ The saturated specimen is provided with a layer of Plaster of Paris on its top also bottom surfaces to get even surface so that load applied is distributed uniformly.
- ✓ Uniform load distribution could be obtained satisfactorily by providing a pair of 5 mm thick plywood instead of using Plaster of Paris layer also.
- ✓ The specimen so placed in the compression testing machine is loaded in the rate of 14 N/mm^2 per minute. The crushing load is noted.
- ✓ Then crushing strength is equal to this crushing load divided by the area where the load is applied.
- ✓ At least three specimens must be tested, and the average ought to be taken as crushing strength.

Crushing Strength Test



Crystalline Test

- To determine the durability or weathering quality of the stone.
- At least four cubes of stone with side as 40 mm are taken. They are dried for 72 hours and weighted.
- They are then immersed in a 14% solution of Na_2so_4 for 2 hours.
- They are dried at 100 degrees C and weighted. The difference in weight is noted.
- This the procedure of drying, weighing, immersion, and reweighting is repeated at least 5 times.
- Each time, a change in weight noted, and it is expressed as a percentage of the original weight.

Freezing and Thawing Test

- Stone specimen is kept immersed in water for 24 hours.
- It is then placed in a freezing machine at -12 deg C for 24 hours.
- Then it is thawed or warmed at atmospheric temperature.
- This should be done in shade to prevent any effect due to wind, sun rays, rain etc. this procedure is repeated several times and the behaviour of stone is carefully observed.

Hardness Test

For determining the hardness of a stone, the test is carried out as follows:

- ✓ A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
- ✓ It is weighed.
- ✓ The sample is placed in **Dorry's testing machine** and it is subjected to a pressure of 1250 gm.
- ✓ Annular steel disc machine is then rotated at a speed of 28 rpm.
- ✓ During the rotation of the disc, coarse sand of standard specification is sprinkled on the top of disc.
- ✓ After 1000 revolutions, specimen is taken out and weighed.
- ✓ The coefficient of hardness is found out from the following equation:

Coefficient of hardness = 20 - (Loss of weight in gm/3)

Hardness Test

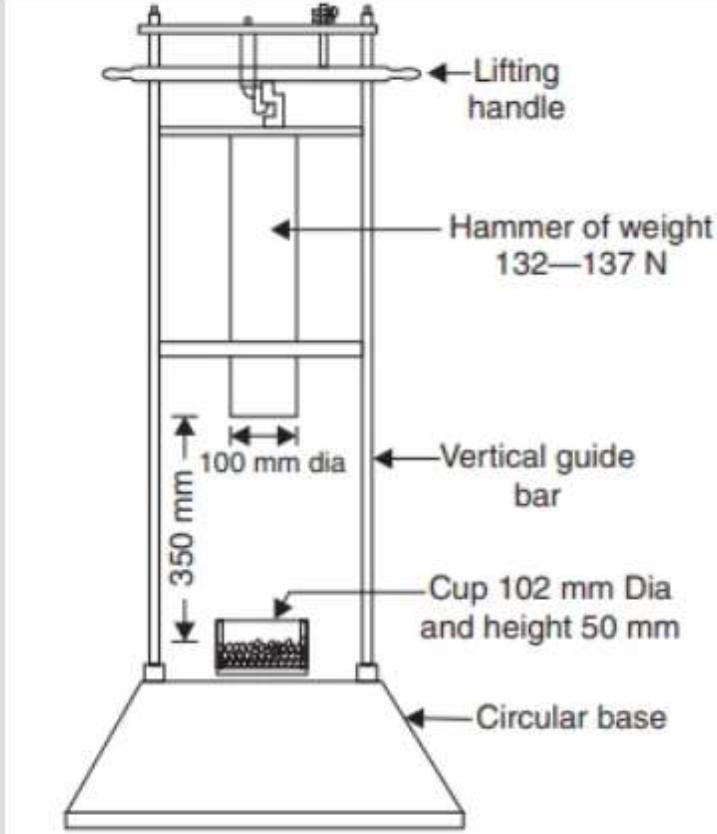
Impact Test

The resistance of stones to impact is found by conducting tests in impacting the testing machine.

- ✓ A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
- ✓ It is placed on the machine. And taken a 2kg stone sample at 24 hours put in the oven.
- ✓ Fill the cylinder cup in three-layer.
- ✓ Each layer 25 times compacted.
- ✓ Take the weight of the cylinder.
- ✓ Falling the hammer 15-time blow allowed to fall axially in a vertical direction over a specimen in an impact testing machine.
- ✓ The Hight of the first blow is 1cm, that of the second below 2cm, that of the third below 3cm.

Impact Test

Impact Test


Lifting handle
Hammer of weight 132—137 N
100 mm dia
350 mm
Vertical guide bar
Cup 102 mm Dia and height 50 mm
Circular base

Impact Test

- ✓ Blow at which specimen breaks is noted. If it is nth blow, ‘n’ represents the **toughness index of stone.**

Impact value = w2*100/W1

- Where, W1 =passing stone in a 12.5mm sieve before falling hammer
- w2 = after falling hammer wt. of stone

Microscopic Test

- The sample of the test is subjected to microscopic examination.
- The sections of stones are taken and placed under the microscope to study the various properties such as
    - Average grain size
    - Existence of pores, fissures, veins and shakes
    - Mineral constituents
    - Nature of cementing material
    - Presence of any harmful substance
    - Texture of stones etc.

Smith's Test

- This test is performed to find out the presence of soluble matter in a sample of stone.
- Few chips or pieces of stone are taken and they are placed in a glass tube.
- The tube is then filled with clear water.
- After about an hour, the tube is vigorously stirred or shaken.
- Presence of earthy matter will convert the clear water into dirty water.
- If water remains clear, stone will be durable and free from any soluble matter.

Water Absorption Test

- With this test **cube specimen weighing about 50 grams** are Ready, and the test is carried out at the steps given below:
- Note the weight of dry specimens as **W1.**
- Place the specimen in water for **24 hours**.
- Take out the specimen, wipe out the surface with a piece of cloth, and weigh the specimen. Let its weight be **W2.**
- Suspend the specimen freely in weight and water it. Let its weight be **W3.**
- Place the specimen in boiling water for **5 hours**.
- Then take it out, wipe the surface with a cloth, and weigh it. Let this weight be **W4**. Then,

Water Absorption Test

- Percentage absorption by weight = **(W2 – W1) / W1 x 100 …….(1)**
- Percentage absorption by volume = **(W2 – W1) / (W2 – W3) x 100 …….(2)**
- Percentage porosity by volume = **(W4 – W1) / (W2 – W3) x 100 …….(3)**
- Density = **W1 / (W2 – W1) x 100 …….(4)**
- Specific Gravity = **W1 / (W2 – W3) x 100 …….(5)**
- Saturation Coefficient = Water Absorption / Total Porosity **= (W2 – W1) / (W4 – W1)**

Thank You!!