1.1 Stone as building material

Stones form one of the most important building materials in civil engineering. Stones are derived from rocks, which form the earth's crust and have no definite shape or chemical combination but are mixtures of two or more minerals. The mineral is a substance which is formed by the natural inorganic process and possesses a definite chemical combination and molecular structure. They are strong, durable and descent in appearance.

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)

Many types of stones are available such as basalt, marble, limestone, sandstone, quartzite, travertine, slate, gneiss, laterite, and granite which can be used as construction materials. The stones used for building 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. Stones for construction purposes are obtained by quarrying from solid massive rocks.

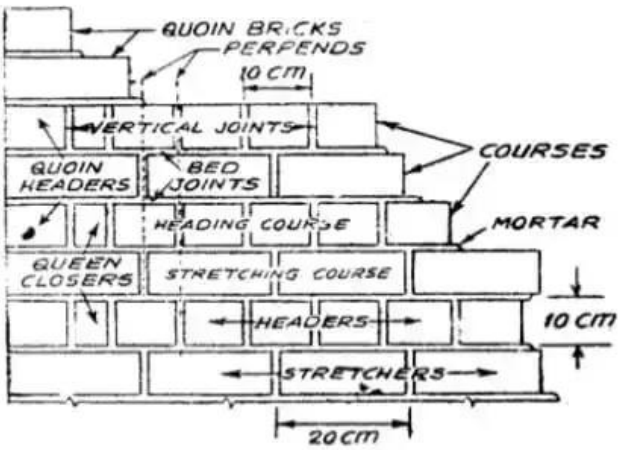
Terms used in masonry construction

Course in Masonry: A course in a masonry structure is the horizontal layer of stones.

Header in Masonry: The header is the arrangement of brick laid with its breadth or the width parallel to the face of the front direction of the brick or stone masonry wall.

Stretcher in Masonry: The stretcher is the arrangement of brick laid with its length parallel to the face of the wall. A course that contains a stretcher is called a stretcher bond.

Bed in Masonry: A bed is a surface of brick or stone that is perpendicular to the line of action of pressure. In each course of stone or brick, it represents the bottom surface.



Types of Stones Used for Building Constructions

Here, the different types of stones are as follows.

1. Granite

Granite is one of the most commonly utilized building stones. Granite is popular because of its hardness and durability, even though it is no longer the most commonly used building stone. It's a deep-seated igneous rock with a crystalline structure and fine to coarse grain. Because of its crushing strength, this stone is extremely precious. It can also tolerate extreme weathering.

2. Marble

Marble is a metamorphic rock formed by excessive pressure and heat through claystone. The compression strength of this pillar is naturally tough and compact, around 70 MPA. Its gravity is approximately 2.65.

3. Laterite

Laterite is a building stone, but it must be plastered on the outside. It has a high iron oxide content and may be easily cut into blocks. Laterite comes in soft and hard variants, and its compressive strength ranges from 1.9 to 2.3 MPA, with seasoning increasing its strength. Laterite comes in a variety of colors, including brownish, red, yellow, brown, and grey.

4. Quartzite

After high temperature and pressure, quartzite is the result of a sandstone. Its granular texture and crystalline structure are the main feature of this stone. Quartzite is broken and hard, so it's not easy to work.

Quartzite is approximately 115 MPA in crushing strength. Quartzite in different colors is available, e.g. grey, white and yellowish. This stone is dense with a high chemical resistance that is ideal for use in a kitchen as well.

5. Alabaster

It's a very transparent stone, Alabaster. It is a rather uncommon construction material, which is only used in construction. It is mainly utilized to create tiny aesthetic objects rather than a whole structure. It is nevertheless mixed with other elements which have contributed to its extension.

6. Basalt

Basalt is sometimes called white stones, green stones or blue basalt. It's an ignorant rock. This stone is strong and harsh and nice as well as nasty. This hardness makes it difficult for any purpose to use rock as readily. Basalt has a strong compressive strength between 150 and 190 MPA. The structure of the stone is medium to thin. It is also small with many color options. Basalt stones may be found in black to dark grey, an element which makes house design more popular.

7. Limestone

limestone is a sedimentary rock produced when particles are weathered. Mostly calcium carbonate is used in this pier. Compared to others in this post, this makes it a soft rock, making it easy to work for diverse buildings. The compressive power of the stone is around 55 MPA. It is typically combined along with magnesia with minor quantities of alumina and silica. Magnesia becomes magnesian when 10 percent or above. If the magnesia is over 45%, calcareous stone is referred to be dolomites.

8. Sandstone

Sandstone is a sedimentary rock composed of many minerals, such as feldspar, quartz, silica, and many more. The stone is provided in many colors including brown, grey, white, yellow, red, and dark grey. Its strength is about 65 MPA in compression.

9. Slate

Slate is a rock created through a metamorphic process in which the shale is subjected to low heat and pressure. It consists mostly of minerals from mica, clay and quartz. The slate is fragile and difficult with a fine-grained, foliated structure. This stone is mainly in black, but can also be in greenish-gray, grey or purplish grey. Slate may readily be divided into slabs, simply by following the inherent planes of the rock. Its strength is about 75-210 MPA for compression.

criteria for selection of good stones

Being cheap, hard, durable and naturally good looking, stones are often used in construction but keeping in view the variable properties of stones of different types, there must be some criteria for the selection of stones for construction. The criteria is based upon the following parameters

- Chemical composition of stone
- Strength and hardness
- Durability:
- Resistance to fire
- Bio-Deterioration
- Appearance
- Toughness
- Porosity and Absorption

1. Chemical composition of stones:

Using/selecting a stone for construction, its chemical properties and composition must be tested and verified because different elements and compounds in stones have different properties. For instance, Magnesium in Limestone causes it to be stronger and is called Dolomite. Feldspar, in large quantities in stone is a source of weakness because CO2 dissolves Potassium, Sodium, and even Calcium in the Feldspar leaving pure white clay behind. Presence of Mica, even less than 2-3% makes stone unsuitable for building purposes. Stones with silicates as cementing materials are resistant to weathering.

2. Strength and hardness:

The more compact grained and heavier a stone, the more stronger it is. A crystalline stone is superior to a non-crystalline texture. The specific gravity of good stone should be above 2.7. Stones used for road metal, paving blocks, floor slabs and railway ballast have to withstand mainly abrasion or wear and tear. Stone wall subjected to vibrations of machinery and moving loads should necessarily possess toughness. Strength and hardness itself depend on some factors:

3. Resistance to heat:

Resistance to heat means that the stone must have a very low amount of expansion due to large increase in temperature. Silicious materials are good at areas where resistance to fire is required.

4.Bio-deterioration:

Certain trees and creepers thrust their roots in the joints of stones and have both mechanical and chemical adverse effects. Special microbes can grow on the surface and in minute fissures, their by-products cause flaking and discoloration.

5. Appearance:

The aesthetic aspect that is color, appearance and show of stones must also be considered when being used in a project. Appearance depends on the color and the ease with which the stone can be dressed, rubbed or polished.

6. Toughness

Toughness of stones means it ability to resist impact forces. Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road constructions should be tough.

7. Porosity and Absorption

Porosity of building stones depend upon the mineral constituent and structural formation of the parent rock. If stones used in building construction are porous then rain water can easily enter into the pore spaces and cause damage to the stones. Therefore, building stone should not be porous. Water absorption of stone is directly proportional to the porosity of rock. If a stone is more porous then it will absorb more water and cause more damage to stone.

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.

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 on Building Stone

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 hydrophobic 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

Attrition Test on Building Stone

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

The following procedure is adopted:

1. Samples of stones is broken into pieces about 60mm size.
2. Such pieces, weighing 5 kg are put in both the cylinders of Devil's attrition test machine. Diameter and length of cylinder are respectively 20 cm and 34 cm.
3. Cylinders are closed. Their axes make an angle of 30 degree with the horizontal.
4. Cylinders are rotated about the horizontal axis for 5 hours at the rate of 30 rpm.
5. After this period, the contents are taken out from the cylinders and they are passed through a sieve of 1.5mm mesh.
6. Quality of material which is retained on the sieve is weighed.
7. Percentage wear worked out as follows:

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

Crushing Test on Building Stone

Samples of stone is cut into cubes of size 40 x 40 x 40 mm sizes of cubes are finely dressed and finished. Maximum number of specimen to be tested is three. Such specimen should be placed in water for about 72 hours prior to test and therefore tested in saturated condition. Load bearing surface is then covered with plaster of paris of about 5mm thick plywood. Load is applied axially on the cube in a crushing test machine. Rate of loading is 140 kg/sq.cm per minute. Crushing strength of the stone per unit area is the maximum load at which the sample crushes or fails divided by the area of the bearing face of the specimen.

Crystalline Test on Building Stone

At least four cubes of stone with side as 40mm are taken. They are dried for 72 hrs and weighed. They are then immersed in 14% solution of Na2SO4 for 2 hours. They are dried at 100-degree C and weighed. Difference in weight is noted. This procedure of drying, weighing, immersion and reweighing is repeated at least 5 times. Each time, change in weight is noted and it is expressed as a percentage of original weight. Crystallization of CaSO4 in pores of stone causes decay of stone due to weathering. But as CaSO4 has low solubility in water, it is not adopted in this test.

Freezing and thawing test

Stone specimen is kept immersed in water for 24 hours. It is then placed in a freezing machine at -12 degC 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 on Building Stone

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

1. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stone.
2. It is weighed.
3. The sample is placed in Dorry's testing machine and it is subjected to a pressure of 1250 gm.

4. Annular steel disc machine is then rotated at a speed of 28 rpm.
5. During the rotation of the disc, coarse sand of standard specification is sprinkled on the top of disc.
6. After 1000 revolutions, specimen is taken out and weighed.
7. The coefficient of hardness is found out from the following equation:

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

Impact Test

For determining the toughness of stone, it is subjected to impact test in a Page Impact Test Machine as followed:

1. A cylinder of diameter 25mm and height 25mm is taken out from the sample of stones.
2. It is then placed on cast iron anvil of machine.
3. A steel hammer of weight 2 kg is allowed to fall axially in a vertical direction over the specimen.
4. Height of first blow is 1 cm, that of second blow is 2 cm, that of third blow is 3 cm and so on.
5. Blow at which specimen breaks is noted. If it is nth blow, 'n' represents the toughness index 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

1. Average grain size
2. Existence of pores, fissures, veins and shakes
3. Mineral constituents
4. Nature of cementing material
5. Presence of any harmful substance
6. 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

The test is carried out as follows:

1. From the sample of stone, a cube weighing about 50gm is prepared. Its actual weight is recorded as W1 gm.
2. Cube is then immersed in distilled water for a period of 24 hrs.
3. Cube is taken out of water and surface water is wiped off with a damp cloth.
4. It is weighed again. Let the weight be W2 gm.
5. Cube is suspended freely in water and its weight is recorded. Let this be W3 gm.
6. Water is boiled and cube is kept in boiling water for 5 hours.

7. Cube is removed and surface water is wiped off with a damp cloth. Its weight is recorded. Let it be W4 gm.

From the above observations, values of the following properties of stones are obtained.

Percentage absorption by weight after 24 hours =(W2 - W1) x 100 / W1

Percentage absorption by volume after 24 hours = (W2 - W1) x 100 / (W2 - W3)

Volume of displaced water = W2 - W3

Percentage porosity by volume = (W4 - W1) x 100 / (W2 - W3)

Density =W1 / (W2 - W3) kg/m3

Specific Gravity = W1 / (W2 - W3)

Saturation Coefficient = (Water Absorption/Total Porosity) = (W2 - W1) / (W4 - W1)