

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



# **STONE**

## **An Ancient building Material**

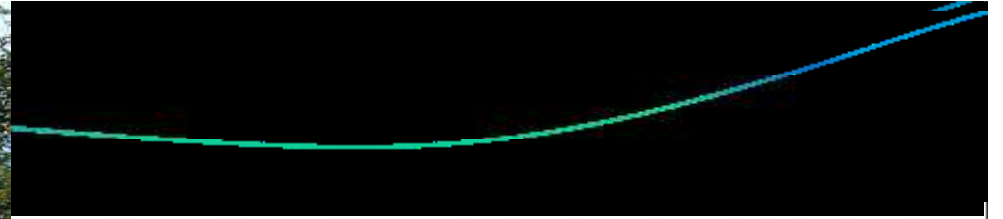
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# History of Stone as Building Material.

- Stone is the oldest construction material known to mankind.
- The most ancient remaining dry stone structures are scattered throughout the world, with Egyptian pyramids and Peruvian temples as world-class examples.
- Others include remains of Greeks and Roman structures.
- Dry stone terraces and canals built to aid agriculture around the world are equally ancient and widespread.
- Buddhist Temples and caves in India.
- Massive beautiful buildings made Akbar and Shahjehan in Indo-Pak sub continent.
- Taj Mahal Agra has the charming example of strength and feminine in beauty.





# Basic definitions and Types:

- The term rock is commonly defined as a hard mass of mineral matter having, as a rule, no definite external form. In engineering construction the word stone is applied indiscriminately to all classes of hard rocks.
- According to their geological origin, rocks may be classified as igneous, sedimentary, and metamorphic.
- Scientific classification of stones:
  - Siliceous Stones: Basic constitute in silica: Sandstone, Trap and Granite.
  - Argillaceous Stones: Clay based. Laterite and Slate
  - Calcareous Stones: Where base is Carbonates of Lime. Lime stone and Marble.
- Important building stones include: Granite, Gneiss, Trap, Limestone, Marble, Sandstones, Slate and Quartzite

# Hardness of Stone

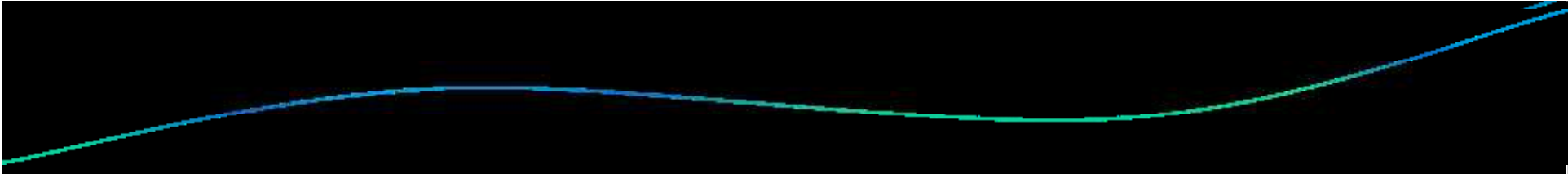
material.

- Hardness is measured by scratching of stone and compared with the following:
  - - Talc: Easily scratched by the thumb nail
  - - Gypsum and Rock salt: Can be scratched by Thumb nail
  - - Calcites: Cannot be scratched by thumb nail but can be easily cut by knife.
  - - Fluorite or Fluorspar: Can be cut with a knife but difficultly.
  - - Apatite: Can be cut only with difficulty with a knife.
  - - Feldspar and orthoclase: Can be cut only with great difficulty with a knife in thin edges.
  - - Quartz: Cannot be scratched by steel but scratches glass
  - - Topaz:
  - Corundum or Sapphire
  - Diamond. The harness factor

# Characteristics of Building Stones:

- - **Availability:** To be reasonably available near construction sites.
- - **Durability:** Wind, rain and temperature and pressure affect the strength of rocks. The best way is to observe the old buildings.
- - **Strength against crushing:** The texture and specific gravity affect the crushing strength of stones. Stones with even texture and specific gravity more than 2.7 is considered as strong enough.
- - **Appearance and colour:** Stones with uniform colour are durable. Good weathering stone should always be free flaws and clay holes.
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- **Texture, Hardness and Toughness:** Stones with homogenous and crystalline texture are coarse grained hard and compact. Stones quarried from greater depths are durable and suitable for building construction as it has been compacted. Hardness combined with toughness are specially important for stones used in road metal, floor slabs, door steps, paving blocks etc.
  - **Porosity and Absorption:** The volume of pores to the total volume of stone. Clayey varieties have 5-8% of their weight. Porous stones shouldn't be used in the facing of the buildings.



Name of Stone	Porosity= (Volume of water absorbed / Volume of stone)* 100
1. Marble	Practically Nil
2. Trap or Basalt	1%
3. Granite	0.5-2%
4. Good Sandstone	8% -10%
5. Lime Stone	14-16%

- **Facility of Working:** Economy seems to be an important consideration. The cost of dressing the stone is a major component.
- **Weight:** Heavy stones are suitable for marine works and retaining walls, whereas light stones are best adopted for arches.
- **Fire resistance:** The difference in temperature between exposed surface and inner surface of stone may cause its disintegration . Traps and basalts are good fire resisting but granite disintegrate quickly when exposed to temp difference due to free quartz as at 600 C quartz expands suddenly and disintegrate granite. Limestone disintegrate at 800 C. Sandstones are good in fire resisting.
- **Seasoning quality:** Freshly quarried stones contains some moisture and hence it can be cut easily. Hence it must be dressed roughly as early as possible. Its final dressing is done at site.

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- The sap must be removed which is called seasoning and the stones are placed in the open for 6-12 months. But at site this precaution is not taken.
- **Natural Bed:** The original position of the stone during its formation is called its bed. The natural bed of sedimentary rocks can be easily identified. Stones should be placed at right angle to its bed. The lamination of the stone must be at right angle to the load.
- **Appearance**
- The appearance of stone is often a matter of importance, especially in the face work of conspicuous buildings.
- In order that the appearance may be preserved, a good weathering stone should of course be selected, free from flaws, clay holes, etc. All varieties containing much iron should be rejected, or they will be liable to disfigurement from unsightly rust stains caused by the oxidation of the iron under the influence of the atmosphere.
- Stones of blotched or mottled color should be regarded with suspicion. There is probably a want of uniformity in their chemical composition, which may lead to unequal weathering

# Important Building Stones:

- **Granite, Gneiss and Syenite**

- The granites are massive rocks occurring most frequently as the central portions of mountain chains. They are a hard, granular stone, composed principally of quartz, feldspar and mica, in varying proportions. When the stone contains a large proportion of quartz it is very hard and difficult to work. When there is a considerable proportion of feldspar the stone works more easily.
- The color of the granite is principally determined by the color of the feldspar, but the stone may also be light or dark, according as it contains light or dark mica. The usual color of granite is either a light or dark gray, although all shades from light pink to red are found in different localities.
- Gneiss (pronounced like nice) has the same composition as granite, but the ingredients are arranged in more or less parallel layers. On this account the rock split in such a way as to give parallel flat surfaces, which renders the stone valuable for foundation walls, street paving and flagging. Gneiss is generally taken for granite, and is frequently called by quarrymen stratified or bastard granite.
- Syenite is a rock also resembling granite, but containing no quartz. It is a hard, durable stone, generally of fine grain and light gray color.

# Granite

- Non-porous, hard, strong, durable
- Color Range
- Surface Textures
- Sources
- Primary Uses







**Polished Surface**

**Rough Texture**



# Shape

## Flat to Round

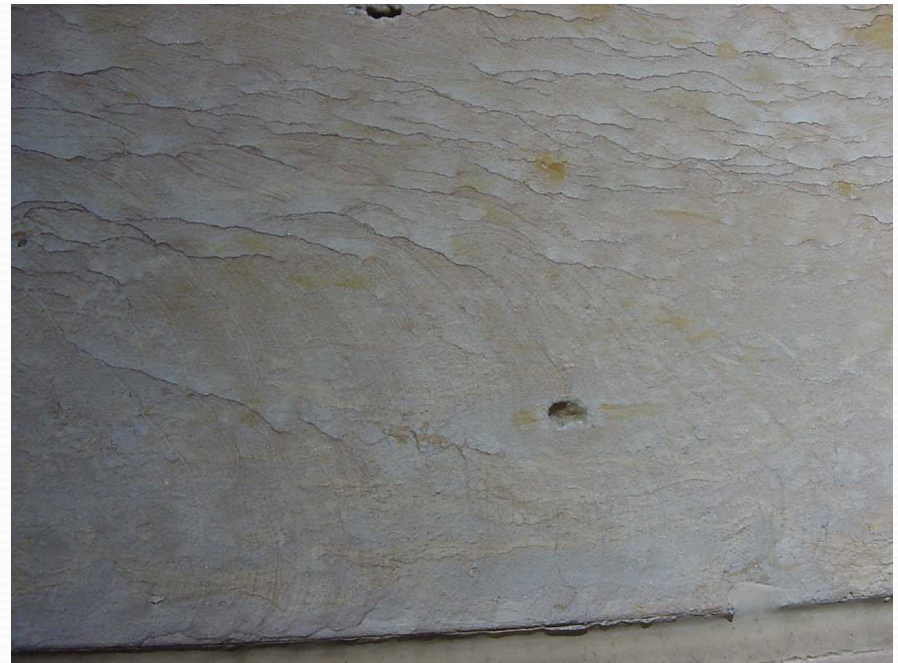


## TYPES OF ROCKS USED IN STONE MASONRY (Cont'd)

- - **Shale**: Derived from clays and silts; weak along planes and is in thin laminations - High in limestone and color varies from black to red, yellow, and blue - **Limestone**: Sedimentary rock composed of calcite and dolomite - Three types: oolitic, dolomitic and crystalline - Has high compressive strength - Used for building stones and for paneling - **Metamorphic**: Igneous or sedimentary rock transformed by heat and pressure into another rock - **Marble**: Recrystallized limestone, color varies from white through gray and black, red, violet, pink, yellow, and green - Presence of oxides of iron, silica, graphite, carbonaceous matter, and mica produce these color variations

# Limestone & Sandstone

- Porous, relatively weak
- Color Range
- Surface Textures
- Sources
- Primary Uses







**Limestone with Granite**

## TYPES OF ROCKS USED IN STONE MASONRY (Cont'd)

- **Quartzite**: It is a variety of and stone composed of mainly granular quartz cemented by silica, color varies from brown, buff, tan, ivory, red through gray
- **Schist**: Made of silica with smaller amounts of iron oxide and magnesium oxide - Color varies from blue, green, brown, gold, white, gray, and red
- **Slate**: Consists mainly of clays and shales - Major ingredients are silicon dioxide, iron oxide, potassium oxide, magnesium oxide, and sometimes titanium, calcium and sulfur - Slate found in parallel layers, which enables it to be cut into thin sheets



# Metamorphic Rock

Marble



Slate



**Marble - Exterior Application**



A close-up photograph of a slate floor. The floor is composed of large, rectangular tiles arranged in a diamond or herringbone pattern. The tiles are a dark, muted green color with a natural, slightly textured surface. The grout lines are dark and recessed, creating a grid of diamond shapes. The lighting is even, highlighting the subtle variations in the stone's color and texture.

**Slate Flooring**

# Types of Stone

- Fieldstone
- Rubble Stone →
- Dimension Stone ↓

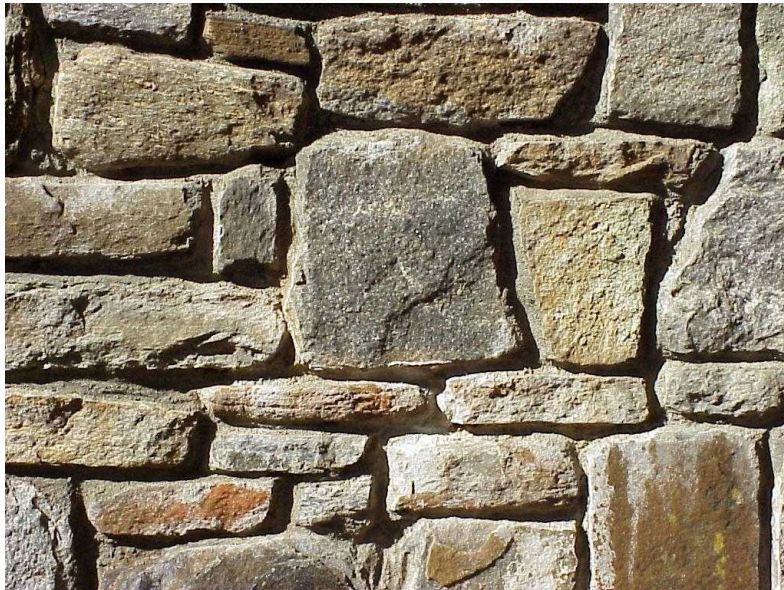




# Stone Masonry Patterns

## Laid in Mortar

- Rubble (Unsquare pieces)
- Ashlar (Square Pieces)
- Coursed or Random
- Orientation











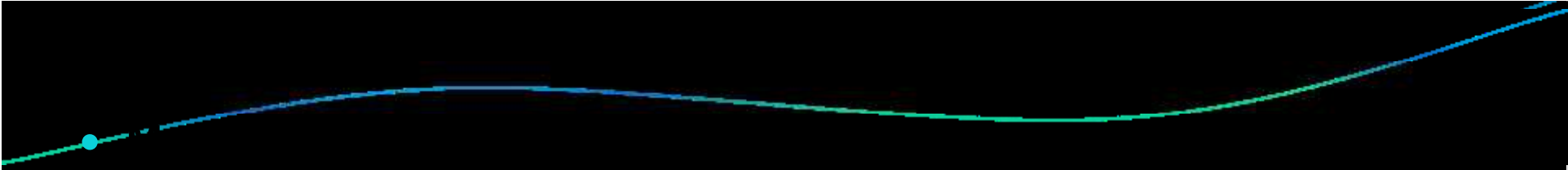
**Splitface, Brick, & Tile**

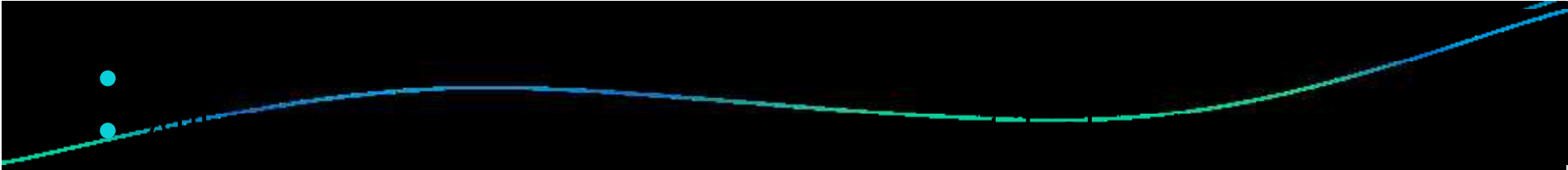
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For building purposes contain one or more of the following substances, in addition to lime :

- Carbonate of magnesia, iron, silica, clay, bituminous matter, mica, talc and hornblende.
- There are three varieties of limestone used for building purposes, viz.: Oolitic limestone, magnesian limestone and dolomite.
- Oolitic limestones are made up of small rounded grains (resembling the eggs of a fish) that have been cemented together with lime to form a solid rock.
- Magnesian limestone include those lime stones which contain 10 per cent, and over of carbonate of magnesia.
- Dolomite is a crystalline granular aggregation of the mineral dolomite, and is usually whitish or yellowish in color. It is generally heavier and harder than limestone.
- All varieties of limestone are liable to contain shells, corals and fossils of marine animals, more or less pulverized. A limestone can be identified by its effervescence when treated with a dilute acid.
- All kinds of limestone are destroyed by fire, although some varieties will stand a greater degree of heat without injury than others.



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- Marble is simply a crystallized limestone, capable of taking a good polish.
  - The scarcity and consequent expense of good marbles have in the past prevented them from being used in constructional work, except occasionally for columns. Most of the marbles obtained from the older quarries also stain so easily that they are considered undesirable for exterior work.
  - Since the rapid development of the Georgia and Tennessee marble quarries, however, stone from these quarries has been much used for exterior finish, and even for the entire facing of the walls. These marbles will probably be more extensively used for exterior work in the future, as they are exceedingly strong and durable and do not stain readily.
  - Nearly all varieties of marble work comparatively easy, and the fine-grained varieties are especially adapted for fine carving.
  - They generally resist frost and moisture well, and are admirably suited for interior decoration, sanitary purposes, etc., and in clear, dry climates make a splendid material for exterior construction.
  - The strength of marble varies from 5,000 to 20,000 pounds per square inch, and only when used for columns need its strength be considered.



covering the roofs of buildings, for blackboards, sanitary purposes, etc., and the architect should be familiar with its qualities and characteristics.

- The ordinary slate used for roofing and other purposes is a compact and more or less metamorphosed siliceous clay. Slate stones originated as deposits of fine silt on ancient sea bottoms, which in the course of time became covered with thousands of feet of other materials and finally turned into stone.
- "The valuable constituents in slate are the silicates of iron and alumina, while the injurious constituents are sulphur and the carbonates of lime and magnesia."
- One of the most valuable characteristics of slate is its decided tendency to split into thin sheets, whose surfaces are so smooth that they lie close together, thus forming a light and impervious roof covering. These planes of cleavage are caused by intense lateral pressure, and are generally at very considerable though varying angles with the ancient bedding.
- The most valuable qualities of slate are its strength, toughness and non-absorption.

# Composition of important building stones:

Stone	Important Constituents	Weight/cft	Av Crushing Strength ( tsf)
Sandstone	Silica mixed with Alumina and carbonates of Ca ,Mg Iron Oxides.	145-150	400-8--
Lime stone	Calcium Carbonates or Magnesium Carbonates mixed with Silica	145-150	Hard: 400 Soft: 100
Marble	Calcium Carbonates Mostly	160-165	300
Granite and Gneiss and Schist	Quartz and Feldspar with small quantities of Hornblendes and Mica	170	900-1000
Lateraite	Sandy Clay stone	140-150	60-100
Slate	Clay mixed with silica	160-165	800
Trap or Basalt	Silica with Feldspar , Hornblendes	180	1000



# TYPES OF STONE MASONRY WALLS AND THEIR CONSTRUCTION

- **Types of Stone Masonry Walls:** (i) **Solid masonry wall** made by laying stone masonry over a prepared bed of mortar, and proceeding in a similar manner to increase the height; (ii) **Composite wall** made of an outer wall of large stone slabs, attached to a backing of structural frame or brick/concrete masonry wall; and (iii) **Cavity wall** made by two different types of masonry wall separated by a cavity, which is either insulated or empty and connected together by metal ties
- **Laying of stone masonry blocks in a wall:**
- **(a) Rubble Masonry** - Composed of unsquared pieces of stones; mason has to choose carefully each stone so that it can fit into the available space –
- **(b) Ashlar masonry** - Made of squared pieces of stones; mason has to carefully lift the heavy stones by a hoist and lower it into place –
- **(c) Coursed stone masonry:** has continuous horizontal joints –
- **(d) Uncoursed or random masonry :** Does not have defined bedding planes for the wall

# Blasting of Rocks

- blasting, shattering, breaking, or splitting of rock or other material by the discharge of an explosive substance that undergoes decomposition or combustion with great rapidity, evolving much heat and producing a large volume of gas. The reaction products fill a much greater volume than that occupied by the original material and exert an enormous pressure,
- It is a necessary part of many engineering operations. An ancient method of breaking rock consisted of heating the rock by fire and then pouring water on it, the sudden contraction resulting in shattering or cleavage. Modern methods of blasting involve four operations:
  - Drilling the holes to receive the charge,
  - placing the charge.
  - Stemming the hole (i.e., filling the hole above the charge with earth or clay), and
  - Igniting or detonating the charge.

## Stone disintegration:

- - The disintegration or decay of stone is commonly referred to as weathering, and is caused by agents of three kinds; namely, physical or mechanical, chemical and organic.
- - The mechanical agents are heat and cold, air in the form of wind, and water in the form of rain and ice.
- - The chemical agents are the various acids present in the atmosphere.
- - The organic agents are vegetable growths that thrive in damp and shady places, and marine insects or boring mollusks, which perforate the stone between the high and low water marks.



# Fire and high Temperature

- All building stones are injured by high temperatures. Sandstones, if somewhat porous, uncrystallized, and free from feldspar, are the most refractory of the common building stones. Gneiss is quite fire resistive when it contains a large proportion of quartz in which the particles are of the nature of sand. Lime stones and granitic rocks usually crack when subjected to a high temperature.

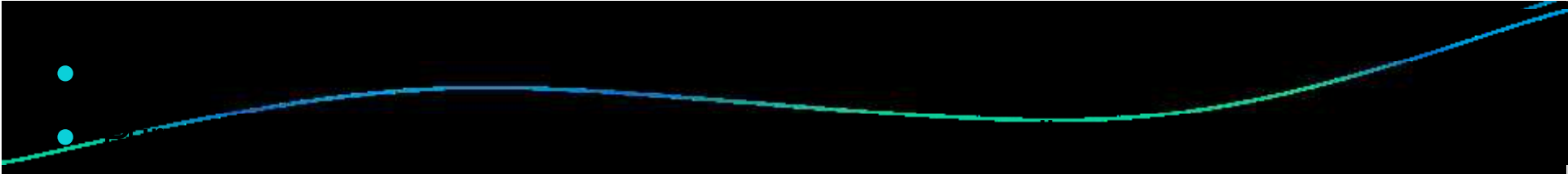
# Heat and Cold

- An increase in temperature causes expansion in a stone, and a decrease in temperature causes contraction; hence, as a result of ordinary changes in temperature, there is a continual slight movement among the particles of the stone, which may destroy their cohesion, and thus produce a slow and gradual disintegration.

# Air and Water

- Air acts mechanically in the form of wind, especially when it carries dust; it erodes the surface and removes small particles, much in the same way as a sandblast apparatus, thus, exposing new surfaces to be acted on. Rain alone has a slight mechanical effect when simply falling on the stone and washing loose particles away. Rain and wind together, however, act very energetically.





contains many acids which, in combination with rain, form powerful solvents of mineral matter. The stones that are most susceptible to this dissolving action are limestone, sandstone, and granite containing feldspar.

- **Carbonic acid,**
- This acid transforms the insoluble earthy carbonates of lime and magnesia into bicarbonates, which are soluble in water and can, therefore, be washed away.
- On granite, carbonic acid acts by eliminating the alkaline constituents in the form of carbonates; a friable or crumbly residue of hydrated silicate of alumina is left, which contains the unaltered particles of quartz and mica.
- In the case of greenstones the acid acts on the iron present, and also dissolves out the lime, leaving a loose, friable, and bulky stone of a red or brown color. Sandstones containing iron are disintegrated by the solution and washing away of the iron.
- **Nitric acid** is frequently present as a constituent of the atmosphere; its destructive action is exerted on the lime stones.

- **Sulfuric acid**, which results from the combustion of coal, is present in the atmosphere of cities to an extent as great as 250 parts in 1,000,000. It has a



- **Living Agents-**

- The disintegration and decay of stone by the inanimate agents are frequently hastened by many forms of life, such as bacteria, mosses, worms, etc., all of which are in a sense destructive agents. Their presence gives rise to small amounts of organic acids which exercise a corrosive influence.

# Selection of Stone as building Material

- When an important masonry structure is to be built, it is essential to select a stone that is strong and durable. Probably nothing in engineering construction is so neglected as the preliminary inspection of building stone.
- **Inspection of Stone at Quarry**
- Careful inspection at the quarry will frequently reveal much information regarding the durability and uniformity of the stone. Exposed quarry faces will sometimes indicate the weathering properties of the stone, as well as its liability to disintegration caused by moisture and running water containing injurious acids and alkalis.
- **Inspection of Stone in Buildings.-**  
If, after years of exposure in the atmosphere of an industrial city situated in the temperate zone, the building stone shows no disintegration and has retained its original luster and color, except for the soil of dust and smoke stains, it certainly can be considered of the best structural value for building purposes. If a stone from a certain quarry shows poor weathering qualities in a structure, an investigation should be made to determine whether the best grade from the quarry has been used, before the product of the quarry is condemned.





- **Laboratory Investigation.-**

When the stone to be used is from a new quarry, the characteristics of the product are little known, and this investigation is then necessary. The laboratory investigation of stone usually consists of chemical analysis, microscopic examination, and mechanical tests.

# Tests on Stones:

- **Specific Gravity test.**
- **Amount of water absorbed ( Absorption Test)**
- **Fire resistance ( Fire tests)**
- **Abrasion and Hardness tests**
- **Resistance to Acids**
- **Color**
- **Compressive Strength**
- **Cohesive Properties ( Barad's test)**
- **Resistance to Acids ( Acid tests)**
- **Structure Crystalline or not ( Smith's test)**
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# Preservation of Stones:

- ~~Plastering (Plaster of Paris)~~
- Plaster
- Paints oils and chemical solutions
  - Linseed oil boiled
  - Melted paraffin
- Ransome's process
  - Potassium or Sodium Chloride is fed into the pores of stones by repeated application
- Use of Solution of Barium Hydrate (Bayrta) in atmosphere charged with Carbonic and Sulphur acids
- Szerelmeys Stone Liquid
  - Silicates of Sodium and potassium applied with chlorides of Calcium and Barium
- Cleaning and washing etc.



# Quarrying

- extraction of useful natural stone from a man-made open pit called a quarry by cutting, digging, or blasting.
- Rock is either quarried as solid blocks or slabs, or crushed and broken. Minerals produced from quarries include coal, clay, gypsum, marble, gritstone, limestone, sand, and sandstone.
- The industry is distinguished by dimension-stone and crushed-stone quarrying. The dimension-stone process involves the quarrying of solid blocks or slabs of stone used for decorative and ornamentation purposes. In the crushed-stone process, materials such as granite, limestone, sandstone, and basaltic rock are crushed for use in concrete aggregate or road stone for road construction.
- The method used to quarry stone depends on the stone's composition, hardness, structure, cleavage, and other physical properties. The characteristics and placement of rock mass deposits is also an important consideration. For stone that is deposited in relatively accessible beds, hand tools such as drills, hammers, and wedges are employed. The demand for crushed rock such as limestone has actually led to the development of new kinds of quarrying techniques and quarrying is a less selective process than it used to be

# Assignments:

1. Write names of the important building stones and their uses in the construction industry.
2. Explain the Quarrying and blasting of Stones for construction purposes. ( Study from your book)