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Study of Laterite Stone as Building Material

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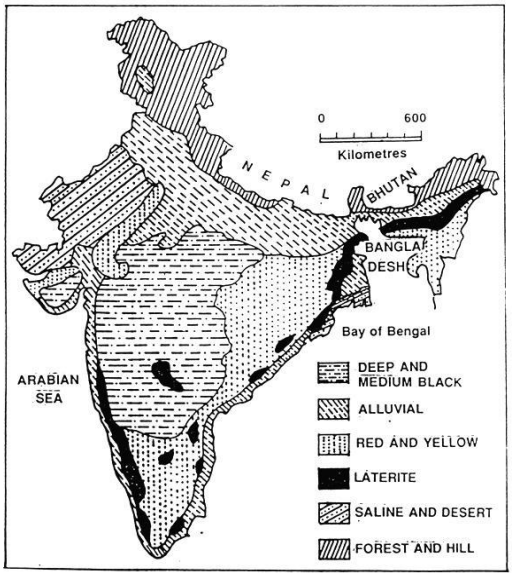
Abstract: The paper deals with understanding of laterite as a building material and study of their various properties. Observations of the structures built in laterite blocks would be the part of the study. The research aimed at providing appropriate use of laterite as a building material. The rising construction cost and drive towards locally available material have fuelled a demand for this product in recent years. The basic properties of laterite should be studied. This will thus help in understanding it better as a building material. The method used for research was survey and observation analysis. Literature reviews, interviews and case study based inferences and findings showed that Laterite is found in tropical regions and the structures built in laterite are mostly of load bearing. The study also showed that laterite can be considered as a very good construction material for building various structure like residential buildings, bridges etc.

Keywords:
Laterite stone, chemical properties of laterite, characteristics of laterite, types of laterite, laterite sizes, uses of laterites in construction.

1. Introduction

Laterite is a residual ferruginous rock, commonly found in tropical regions and has close genetic association with bauxite. The term 'laterite' was originally used for highly ferruginous deposits first observed in Malabar Region of coastal Kerala and Dakshin Kannad and other parts of Karnataka. It is a highly weathered material, rich in secondary oxides of iron, aluminium or both. It is either hard or capable of hardening on exposure to moisture and drying. Aluminous laterites and ferruginous laterite are quite common. Laterite is found in various parts of India, where it is extensively used as building material in regions of Kerela, Goa, Karnataka and Andra Pradesh. Lateritic soils are formed in the tropics through weathering processes that favour the
formation of iron, aluminium, manganese and titanium oxides. These processes break down silicate minerals into clay minerals such as kaolinite and elite. Iron and aluminium oxides are prominent in lateritic soils, and with the seasonal fluctuation of the water table, these oxides result in the reddish-brown colour that is seen in lateritic soils.

These soils have served for a long time as major and sub-base materials for the construction of most highways and walls of residential houses in tropical and sub-tropical countries of the world. Laterite is a building material which can be used in construction from flooring to roof construction. The rising construction cost and drive towards locally available material have fuelled a demand for this product in recent years. The basic properties of laterite should be studied. This will thus help in understanding it better as building material. Laterite is found in the region of mean annual temperature of 23 to 26-degree C and rainfall 1200 to 4000 mm and with the number of rainy months 8 to 10. Laterite can occur at every altitude from sea level to about 2500 m. A considerable area of the former cultivated land is covered by laterite.



MAP 1. Map showing locations where laterite stones are found.

2. Classification

Laterites are formed from the leaching of parent sedimentary rocks. They belong to Non-transported sedimentary rock category. They are formed in in-situ conditions. The mechanism of leaching involves acid dissolving the host mineral lattice, followed by hydrolysis and precipitation of insoluble oxides and sulphates of iron, aluminium and silica under the high temperature conditions of a humid subtropical monsoon climate. The term laterite first appeared in scientific literature a little over hundred and fifty years ago. The word 'laterite' was suggested by Buchanan (1807) to denote a building material used in mountain regions of Malabar (India). He named it laterite from the Latin word later, which means a brick; this rock can easily be cut into brick shaped blocks for building (Norton, 2000). Buchanan

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11-12 Jan. 2018

observed a type of weathered material used for building, which was an indurated clay with full of cavities and pores, containing a large quantity of iron in the form of red and yellow ochre. Its appearance is that of a ferruginous deposit of vesicular structure, apparently unstratified and occurring not far below the surface. When fresh it can readily be cut into regular blocks with a cutting tool. On exposure to the air it rapidly hardens and becomes highly resistant to weathering. Because of these properties it is frequently used as a building material comparable to bricks.

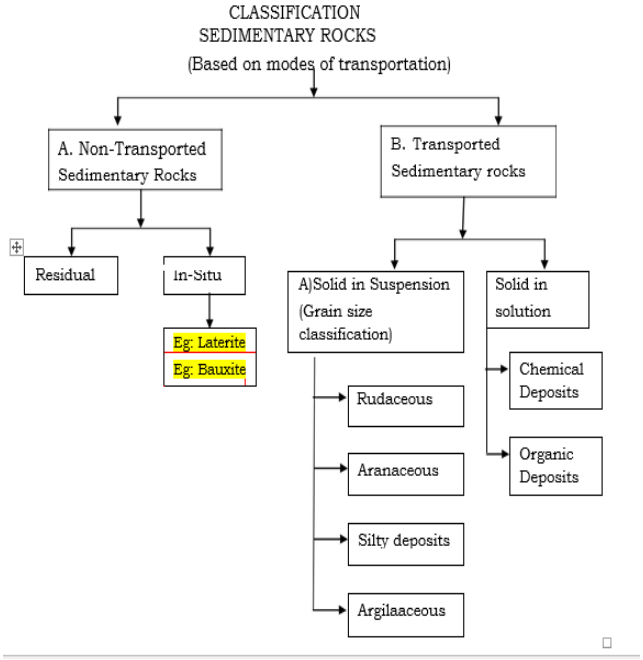

Chart 1 showing classification of laterite

3. Characteristics of laterite

3.1 Indurated occurrence

Newbold (1844) gives the following description (cited from Prescott and Pendletom,1952):'The laterite of Beder, generally speaking, is a purplish or brick-red, porous rock, passing into brown perforated by numerous sinuous and tortuous tubular cavities either empty, filled, or partially filled with a greyish-white clay passing into an ochreous, reddish and yellow-brown dust. The sides of the cavities are usually ferruginous and often of deep brown or chocolate colour. The hardest varieties of the rock are the darkest coloured, and most ferruginous. The softness of this rock is such that it may be cut with spade; hardening by exposure to the sun and air.

3.2 Structure

Laterites are greatly in structure, but can be reduced to the following three structural patterns: (a) the indurated elements form a continuous, coherent skeleton; (b) the indurated elements are free concretions or nodules in an earthy matrix; (c) the indurated elements cement pre-existing materials.

3.3 Colour

Laterites vary in colour, but are usually bright. The shades most frequently encountered are pink, ochre, red and brown, but some occurrence mottled and streaked with violet, and others exhibit green marbling. A single sample may exhibit a whole range of colours merging more or less perceptibly into one another in variety of patterns and forms. Laterites owe their colours to iron oxides in various states of hydration and sometimes also to manganese. Iron compound yields a grey-black colour and manganese compound a velvety black in a reducing medium, while in an oxidizing medium iron yields ochre, red or black, and manganese violet.

Fig.1 Showing different colours in laterite

3.4 Types of laterite

Laterite can be differentiated into two types: Aluminous Laterites and Ferruginous Laterites. The laterite in which the content of Alumina is more is known as Aluminous laterites and in which the content of iron is more is known as Ferruginous laterites. Ferruginous laterites are higher in density, are more dark than aluminous and can be considered as a good building material.

Table 1 showing characteristics of laterite stone

Characteristic	Aluminous laterites	Ferruginous laterites
Site	Old forms	Principally deep-seated
Induration	Slight to moderate	Moderate to heavy and even very heavy
Colour	Whitish-rose to red	Rust to dark brown
Density	Low	High

4. Chemical properties

Mature laterites are made up primarily of iron, aluminium, silica, titanium and water. Generally, laterites are poor in alkali and alkaline earth metals. The average composition of typical laterites is as follows:

H_2O-with large quantities of alumina, the combined water in laterite varies from 20-30%

Al_2O_3-In general, Al_2O_3 forms the most abundant constituent in laterite varying from 50 60 %. With an enrichment of iron or Quartz, the alumina content is lowered.

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Fe_2O_3-The content of Fe_2O_3 may vary considerably, ranging from 35 to 80%.
SiO_2-In typical laterite the SiO_2 will be very low.
TiO_2-Generally the TiO_2 content in laterites are high about 2%. Though, it may be completely lacking in some cases.

Table 2 showing physical properties of laterite

Colour	Structure	Depth (m)	Compressive Strength N/mm2	Water Absorptivity %	Specify Gravity
Brownish-Yellow	Vermicular	1.8 M	1.44	10.82	2.15
Whitish - Yellow	Vermicular	3.0M	1.05	13.20	1.74
Reddish- Brown	Vermicular	3.0M	2.57	11.02	2.31
Yellowish- Red	Vermicular	10.8M	1.66	13.40	1.82
Red	Mottled	6.0M	1.13	13.92	1.85
Pink	Mottled	5.2M	0.66	15.73	1.51

5. Case study

Visit to Laterite Stone Quarry in Goa

Nearly two third of Goa is covered with mantles of laterites ranging in thickness from couple of meters to 25 meters. The laterites in Goa occur as plateau (higher level) and as detrital (lower level) laterites throughout the length and breadth of Goa. The stone quarry was located in Bicholim area. These rock have special significance in Goa as they serve both as building material and as good water bearing formation.

5.1 Steps involved in quarrying of laterite

Laterite blocks are soft for easy quarrying and shaping, but they become hard when exposed to atmospheric oxygen. The ease of cutting and shaping laterite and hardening with age due to
atmospheric exposure makes its use different and versatile in building applications

- Removal of overburden either using simple tools in manual operation or through the use of bulldozers in semi- mechanized quarries. The overburden is then stacked by the side of the quarries.
- The Laterite slab is then sized in situ using long nails and strings.

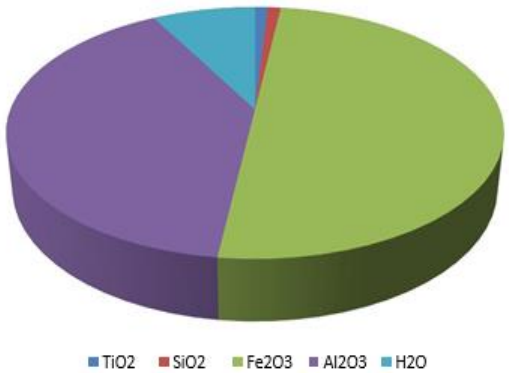

Chart 1 showing chemical composition of laterite

- In manual operation, the stone is then cut along these markings using pickaxes and crow bars. In a semi-mechanized mine, the mechanized plough is used to cut along the markings.
- The waste rock is collected using spades and carried to the side of the quarry in cane or metal baskets.
- The stone is then loaded on to trucks. The stones are further dressed as per the mason's requirements at the construction site.

5.2 Tools used

Laterite is sized and then cut into blocks and used for construction of walls and houses. These blocks are generally in the size of 35 x 28 x 15 cms. There are two types of operations observed: those are totally manual and those that have limited mechanization. The former use pickaxes, pickaxes are modified with a flat blade, spades and metal baskets. The overburden is removed manually too. In a limited mechanical quarry, same tools are used but they are supplemented by motorized hand ploughs to which a wheel cutter is attached.

5.3Laterite sizes

Laterite blocks are available in different sizes of:
390 x 190 x 190mm
490 x 190 x 190mm
590 x 190 x 190mm

Fig.2 showing different sizes of laterite stone

6. Use of Laterite as building material

6.1 Laterite interlocking blocks

Laterite stone have traditionally used after directly extraction from the naturally occurring laterite sources, after which they are cut into bricklike shapes for use as walling units. Recently, there has been advancement in using laterite in the form of interlocking bricks used to construct walls without the use of cement mortar. Laterite stone is ground and filtered using a sieve, which is then mixed with 5% cement mixture and a chemical setting agent. This mixture is then machine compressed to form high density interlocking bricks. They are manufactured in two widths of 6 inches and 8 inches; and are also available in varying lengths. Each interlocking brick has grooves and locks on its sides which can be fitted with each

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other to form a block wall that does not need cement mortar for bonding. They have lower embodied energy due to use of natural locally available materials- stone and wood. The only energy spent is in transportation of materials. The high recyclability factor – especially in case of interlocking blocks which don't use connecting mortar is a bonus.

6.2 Structures in Goa built in laterite

- Load bearing structures are constructed using laterite blocks.
- Many churches in Goa are built in laterite stone and Plastered with lime mortar.
- The Vice Roy arch is built in laterite except for the façade on the river side which is which is facetted with greenish laterite. The historic monument built by Portuguese in Goa.
- The Patto bridge is fine piece of architecture with roman style arches completely built in laterite stone
- Laterite is used for making various landscape elements.
- The brick is soft and lumpy but they create rustic beauty.

Fig.3 Vice Roy Arch, constructed in laterite stone, Goa.

Fig.5 Landscape elements made of laterite.

7.Analysis

- The use of laterite is cost effective as compared to concrete blocks.
- Reduces cost of plastering and painting.
- Reduces heat within the house.
- Soft when quarried hardens on exposure.
- Requires skilled workmanship.
- Porosity of laterite stones is more than bricks. Thus load bearing structure of laterite masonry cannot be more than double storey.
- The darker the laterite, the harder, heavier and more resistant to moisture it.

8.Conclusion

Laterite can support the demand of building material in sustainable way. These materials can be used to contribute to solving the problem of affordable housing by encouraging research on local materials and by implementing efficient training programs on the use of earth-based construction. It is economic, as the final cost of the construction can be reduced with local material utilization.

Laterite stone can be considered ecological, for reduction of nuisances and pollution related to cement and steel production.

It also reduces energetic costs due to better thermal insulation performances.

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