Basic Technology: Lime and its Production

This article is the first in a series projected by MIMAR dealing with basic technologies for the preparation and use of indigenous materials in construction and related fields of design. Alvaro Ortega is currently preparing a book which compiles the results of his many years of experience in the field and has kindly agreed to share with MIMAR readers fundamental facts about lime and its production. Presented in a simple straightforward way, MIMAR hopes that these articles will directly aid in diffusing know-how to potential users of these technologies.

Why we need lime.

The dogmatic position of *economics of scale* theory that means: big-technology and ever bigger cement plants, is not having any impact in the improvement of remote areas in some countries with *subsistance economies*. Moreover:

- Cement production is a capital intensive industry that requiries tens of millions of dollars.
- The cement industry is one of the biggest energy wasters in industrial activities.
- It creates over-centralised production of building materials.
- Concentrates the air and water pollution problems.

On the other hand, lime has an effect in the following ways:

- To create small producers, in remote country areas, who will live in those areas.
- The capital investment is modest.
- Limestone suitable for lime production is well distributed throughout most countries of the world.
- Lime possesses unique properties that produce long-lasting and less expensive buildings.
- In urban areas, one half of the Portland cement now used is for mortar and plaster. Lime could replace this wasteful practice.

Everybody needs a reduction in building costs so priority should be given to reductions in the costs of basic building materials. The small-scale manufacture of lime for use in isolated settlements has the potential of making a significant contribution to meet the needs for shelter of the lowest-income families.

Lime possesses unique properties which result in better quality construction. The advantages are:

- better workability
- low shrinking on drying
- good strength
- elimination of major cracking
- resistance to moisture
- excellent edherence to masonry
- continuous strength improvement

The use of lime in conjunction with Portland cement in mortar further extends the usefulness of both materials. The National Building Organisation in India suggests for general purpose mortars, the following mixtures: 1 part of cement, 1 of lime, 6 of sand and 1 of cement, 2 of lime and 9 of sand.

History

The manufacture and use of lime for mortar and plaster are among the most ancient building activities known to mankind.

In the beginning perhaps, around some ancient fireplace made of blocks of limestone, some *quick-lime* was accidentally produced by the heat of the fire and was then transformed into "putty" by the effect of subsequent rain. Once the useful properties of the lime putty were understood, it was a comparatively easy step to make it intentionally and apply this new plastic building material in construction. Lime is now used throughout the world for mortar, plastering and white-washing walls and roofs.

Lime, it was found, could be used in combination with other materials, like Portland cement and gypsum plaster, extending the usefulness of each of these materials and giving better results in many cases than any of them were used separately. Lime confers on mortar and plaster mixes the valuable properties associated with good workability, low shrinking on drying which makes for durability, resistance to moisture, elimination from major cracking, good adherence to masonry units, improvement in strength continuously with time.

As mentioned before, lime is made by burning limestone to form *quick-lime* and then slaking it with water to give *hydrated lime*. In many countries lime is marketed either as *quick-lime* or *hydrated*. When limestone is burnt, carbon dioxide is driven off, leaving behind soft, porous white lumps called *quick-lime*. When a properly-burnt lime is in contact with water, it breaks down a very fine powder. Coarse material in a lime is an indication that it has not completely slaked and may lead to future expansion or what is called *unsoundness*. Such failures are of two types:

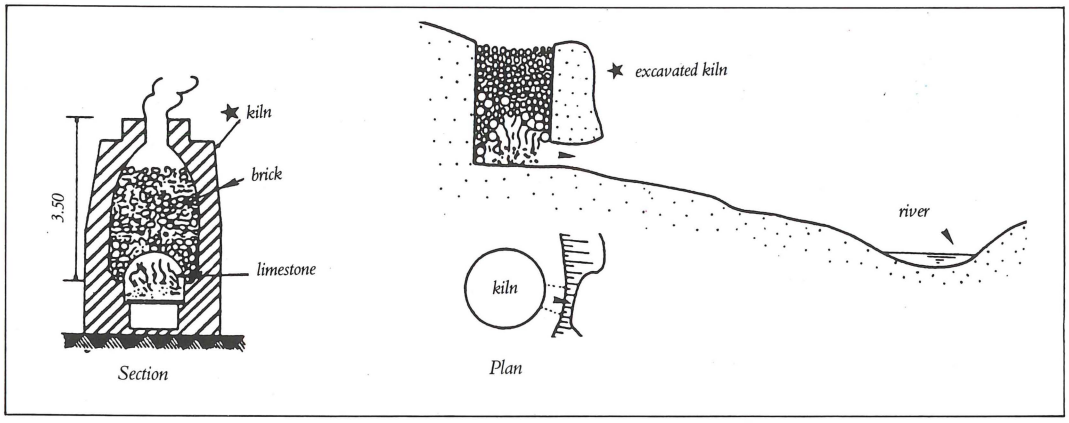
- Firstly, the formation of small crater-like pits in the plaster.
- Secondly, the expansion of mortar between courses of brickwork resulting in horizontal cracking.

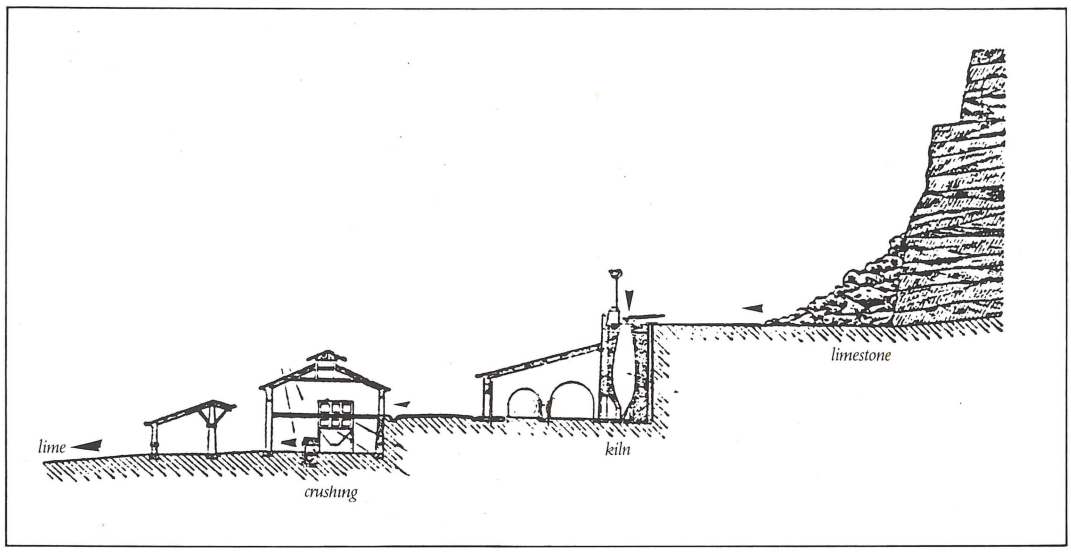
The first type of failure, which is due to the expansion of coarse particles of lime, can be avoided by ensuring that the lime contains no coarse particles larger than about 0.5 millimetres. The second, more serious type of failure can only be eliminated by hydrating the lime under special conditions. Certain tests on a lime can indicate whether a lime is likely to lead to this type of failure or not.

Several decades ago practically the only uses for lime were for building or agricultural purposes. At first, only the easily accesible limestone deposits were exploited and were worked by local farmers purely to satisfy their own needs. The lime was burnt in cheaply constructed small kilns excavated in the hillsides.

Local wood was used as fuel

Text and illustrations by **Alvaro Ortega.**





Ideal location for lime production.

and production amounted to only a few hundred of kilogrammes per day. While the lime was suitable for agricultural and building purposes, it was not of sufficient purity to meet the quality demands of the chemical, metallurgical and other industries. While on technical grounds the modernisation of the lime industry is highly desirable, the economic resources are not available in most *under-paid countries*. Immediate results can be obtained by improving existing practices.

Production Today

In villages where lime is produced on a small scale from the local limestone and fuel using indigenous resources of men and materials for construction, the cottage-type industry should be supported by local and central government authorities. Therefore, rural areas should continue with mixed-feed kilns constructed, principally in masonry. The cottage industries need technical aid in the design of more efficient kilns, better construction techniques, and advice on kiln operation using locally available limestone and fuel. Such improved methods of lime burning can produce better quality lime at a competitive cost.

Financial assistance for constructing more efficient kilns could be an important action for improving the quality of life in rural areas.

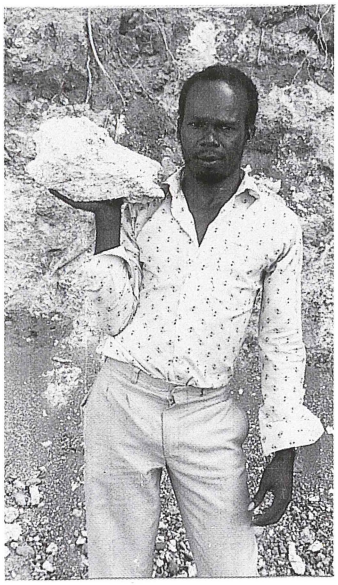
Examples

Limestone can be a high-calcium limestone (calcite) or a pure dolomite (dolomite mineral) or of a compostion in between the two. Geologists classify the rocks of intermediate composition as follows:

- *Limestone* — containing over 95% calcite; less than 5% dolomite.
- *Magnesian limestone* — 90—95% calcite; 5—10% dolomite.
- *Dolomitic limestone* — 50—95% calcite; 10—15% dolomite.
- *Calcite dolomite* — 10—50%; 50—90% dolomite.
- *Dolomite* — less than 10% calcite and more than 90% dolomite.

Dominica — Cottage Industry Level for Production of Lime

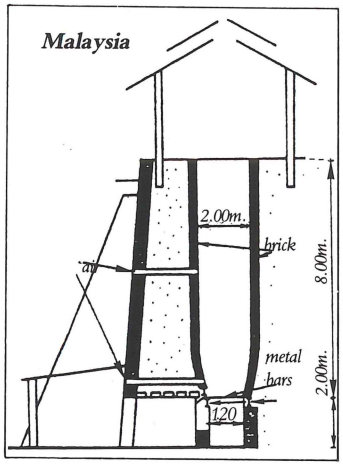
The tenacity of one family, using local resources, has been producing lime in the Commonwealth of Dominica, over a period of one quarter of a century. This *one-man operation*,



that with the help of his wife, collect the sea-shells and the wood for burning them, is a lime manufacturing process, although still primitive, could be of importance for the improvement of the rural housing.

For government authorities it may be useful to promote

View of the sea-shells used for lime production. All countries with sea beaches could manufacture lime products.



A typical vertical shaft kiln, Malaysia.

lime production at the cottage industry level. This type of small scale production of building materials is a most appropriate solution for rural housing. In Asia and in the Far East the *vertical shaft kilns* are used.

The quality and the production cost of lime is largely influenced by the type of fuel used. When there is a wide choice the economics of operation should determine the choice. The location of the limestone quarry in relation to the kiln is also a very important economic consideration. For every ton of lime required about 1.8 tons of limestone has to be burnt. It is better practice to burn the limestone as close to the quarry as possible.

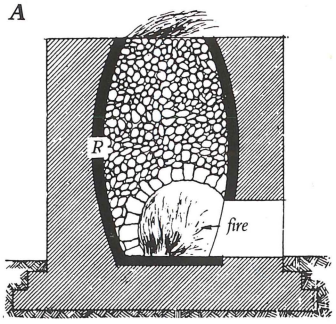
A mineral survey has been done in most of the countries of the world. These investigations need to be known by the general public with the aim of developing the low-cost building materials production. The compilation of existing data, air photographs, geological and geomorpholic maps could be one first step for the increase of lime production. The needs of building material in the field of low-cost housing are: gypsum, sulphur and clay.

Lime Burning

Lime is produced by burning limestone in kilns. Three types of burning kilns are illustrated. The simplest burning facility is not more than a hole in the ground.

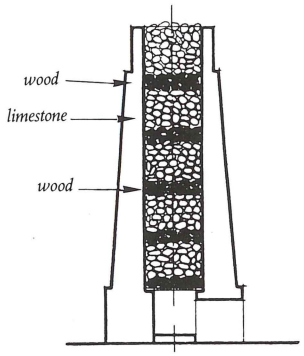
The lime production will have to increase in rural areas

A



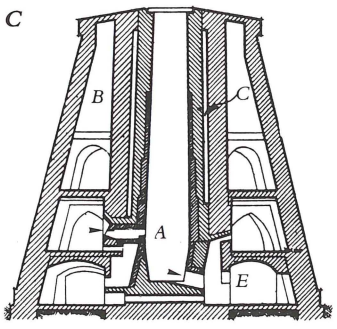
The rectangular updraught, Type "A" is a small country kiln, which have a normal output of less than one ton per day.

B



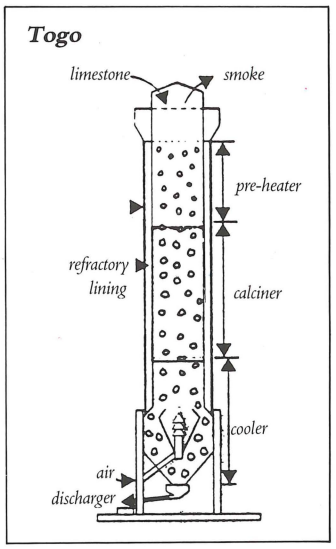
The vertical kiln, Type "B" has a cylindrical shape and a diameter of 3.50 metres with 16 metres in height. This kiln works continuously. It is loaded one limestone layer and one of fuel-wood or charcoal as shown in the drawing. The vertical kiln is economical and suited to all under-paid countries. The kiln, though continuous, has the following sections: the hopper, the pre-heater, the calciner, the cooler and the discharger.

C

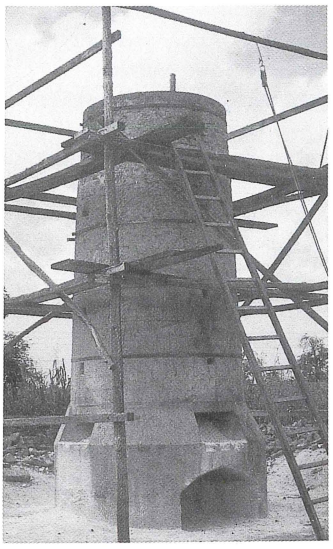


The "Rudersdorf" kiln, Type "C" has a diameter of 2.5 metres and 14 metres in height.

- *The limestone is introduced through the top.*
- *The lime is taken out through section "E".*
- *At 4 metres from the kiln base fire is introduced in 4 locations "A".*
- *The space "C" is used for heat insulation material.*
- *The space "B" helps to reduce heat-radiation losses.*



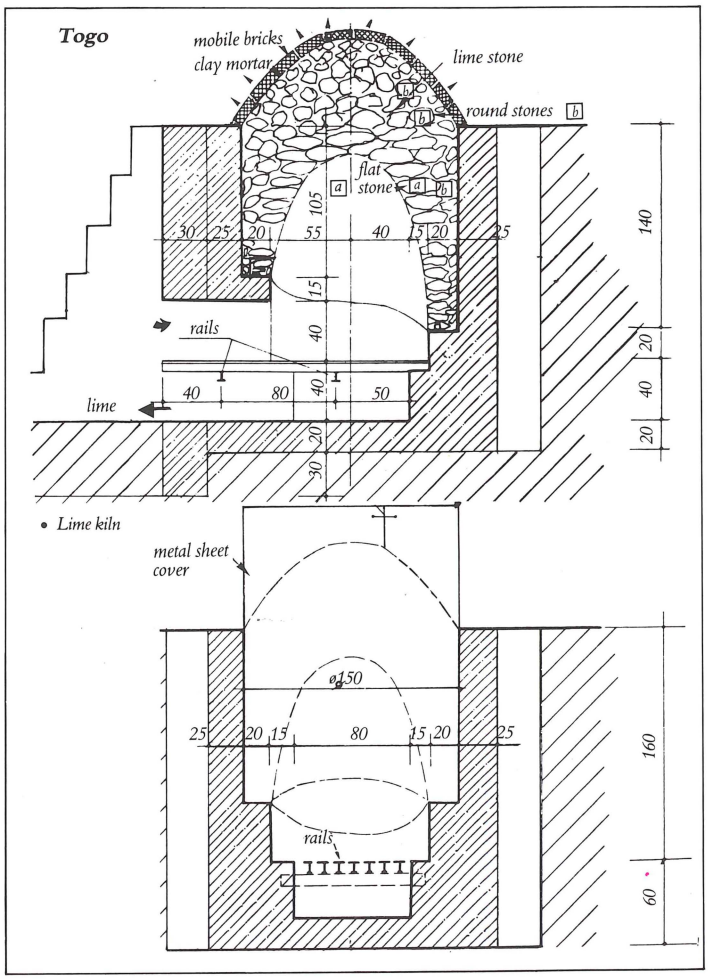
Operation principle for a solid fuel kiln.



A masonry mixed-feed kiln, Lome, Togo.

and some improvements in existing designs and practices are required. What this cottage-type industries need, in most countries, is technical aid in the form of more efficient kiln design, better construction techniques and advice on kiln operation using locally available limestone and fuel.

Improved methods of lime burning can produce better quality lime. The best burnt lime is white in colour and is in



An example of a simple lime kiln from Togo. Elevations show the placement of rails for loading and unloading.

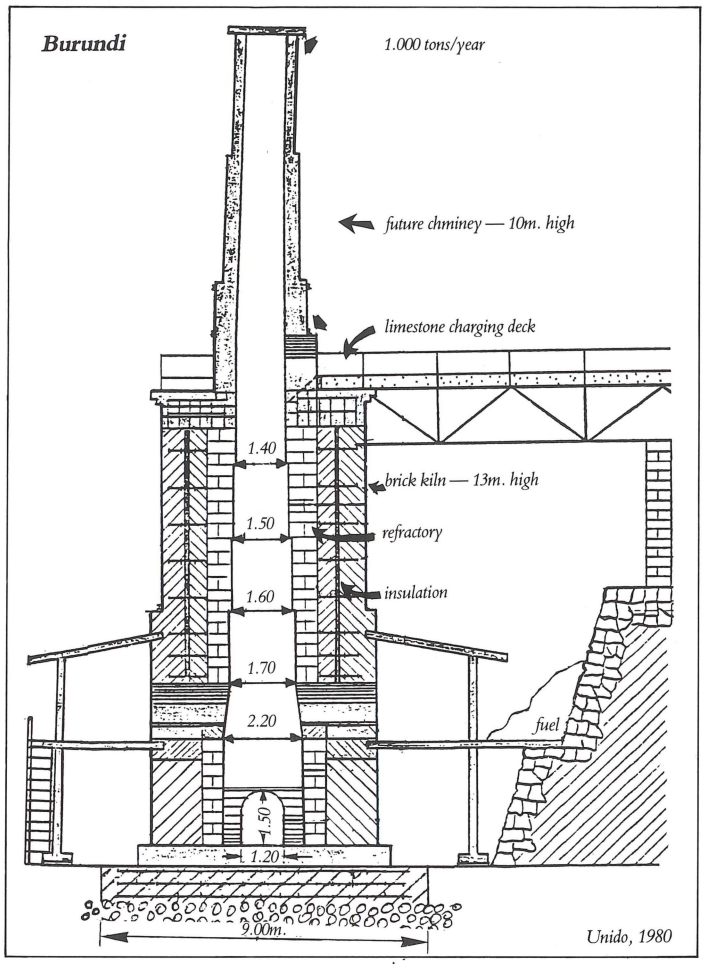
form of soft and porous lumps. If the lime is overburnt it becomes dense with low permeability and slakes slowly, depending on the extent of overburning. Such lime is not safe for use and the delayed slaking action can cause cracking of the walls and plaster. On the other hand, with underburnt lime, due to low temperature or to insufficient burning time at high temperature, the limestone is not calcined. Between the overburnt and underburnt limes, the last is preferable as it does not involve any structural risk in its use.

It is difficult to obtain 100 percent pure lime owing to the present of impurities in the limestone like magnesia, alumina, milica and iron oxide. As magnesia in lime is difficult to hydrate, it should not exceed 5 per cent.

Improvements in existing kiln designs and lime use practice.
A team of experts of the *National Building Organisation*, in New Delhi, India prepared the following suggestions for the improvement of lime burning practice in rural areas.

- Increase the height of the kiln so that the hot gases leaving the kiln are at a temperature not higher than 300 C. The diameter of the kiln may be 1.5 metres and the maximum effective height could be above 13 metres;
- Provide a refractory lining to the kiln;
- Insulate the kiln to reduce radiation losses, the insulation could be 5 to 8 centimetres thick layer of dry fired clay, loosely filled or paddy husk placed behind the refractory lining. An air gap could also serve this purpose;
- Raise the kiln sufficiently above ground level and equip it with the facilities for periodic discharges;
- Provide bracing around the kiln with metal bands at a distance of approximate 100 centimetres.

The mixed-feed vertical kiln for lime burning can produce good quality lime for house construction. A masonry kiln can be constructed utilising locally available labour and cheaper natural resources and has several economical attractions for use in rural areas.



Improvement to an existing kiln.

The fuel efficient of a kiln and the quality of the lime could be improved by determining the temperature at various places of the kiln through pyrometers inserted in observation holes at various levels in the burning zone. Masonry kilns work mostly on natural draught but additional draught that can be induced or forced will increase the lime output substantially.

Simple instrumentation like temperature indicators, draught gauges and gas analysers should therefore be introduced in the design of all new kilns.

In addition to the use of lime for building there are numerous other uses in the chemical, fertilizer, sugar, paper, iron and steel industries.

What type of affordable fuel should be used for burning?
There are several fuel possibilities for burning limestone, but most of them are not economically feasible for use in *under-paid* countries, oil, gas, coal, charcoal, wood, agricultural waste and other organic materials. More than one-third of the world's population depends on wood for cooking and heating. In Africa and Asia timber provides 80 per cent of the energy requirements.

Unfortunately, as a consequence of this energy need, the forest is being used up more quickly than it grows. The renewable boimass energy source that includes animal and agricultural wastes, forestry wastes and crops which have been grown specifically as an energy source, seems to be one appropriate alternative solution for providing energy in rural areas.

What happens when the wood runs out? There is an acute problem due to the rapid disappearance of forests throughout the world. The most severe repercussions are in the under-paid countries where all too often life is literally sustained by the presence of fuelwood. Wood cutting is far outpacing its replacement.

What can be done to replace the disappeared wood? There are several countries where the *shrub bush* is used for fuelwood instead of large trees, but no governments are attempting to *rebrush* as opposed to *reafforest*. The selection of fast-growing trees is an important consideration. They may be a low-density wood, with little value for construction but suitable as firewood.

Basic Questions

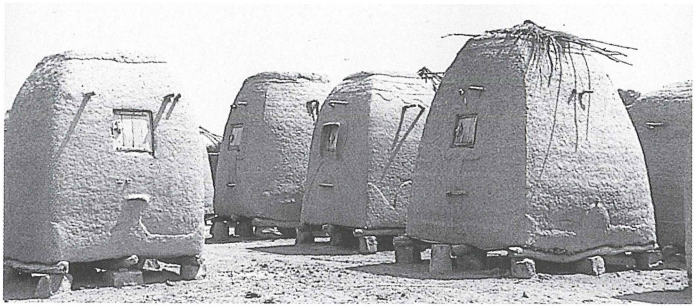
What do I need to produce lime?
Since lime is made by burning limestone to form quick-lime and slaking this with water to give hydrated lime, it is clear that you need: a limestone quarry, a place to burn, fuel and water.

What type of raw material can I use?
Depending on the raw material used you can produce: stone lime from limestone. Shell lime is obtained from sea-shell, coral lime from coral-reefs and gypsum lime from gypsum.

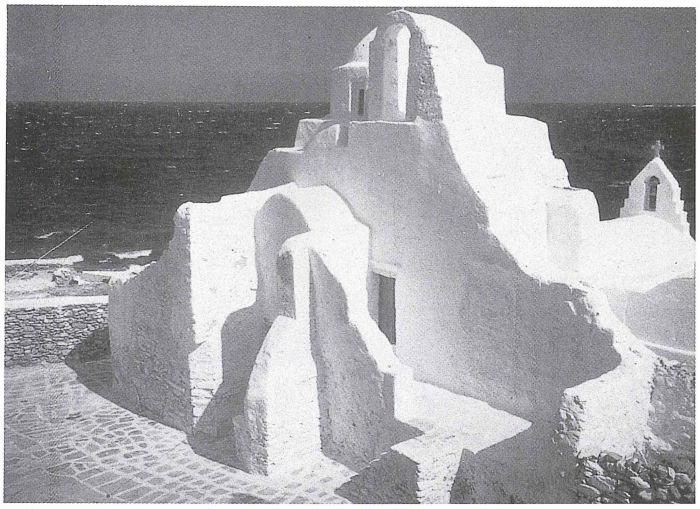
Where can I obtain information of limestone sources?
Start by visiting the local geological survey office. Abundant information is generally available in most countries on the locations of limestone deposits. Make use of this fact.

What else do I need for producing lime?
In countries where wood cutting is outpacing its replacement, it is essential to grow trees and bushes specifically as energy source. The rapid disappearance of forests needs to be stopped.

Examples of the uses of lime in construction.

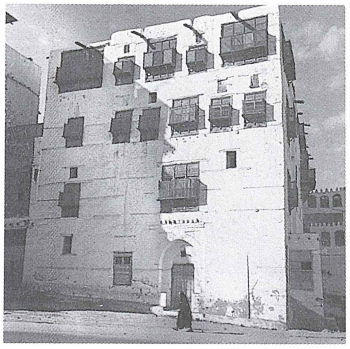


Mali

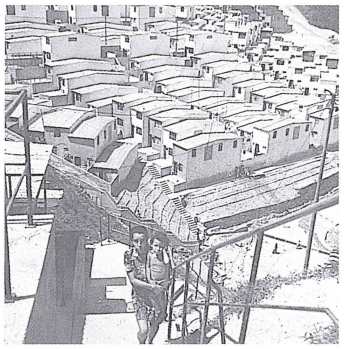


Greece

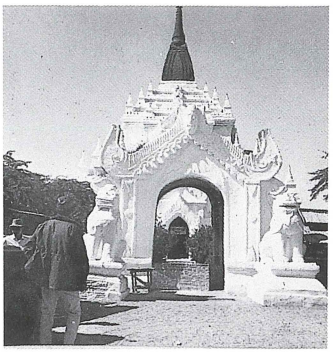
Colombia



Saudi Arabia



Venezuela



Burma

Which type of fuel is required for burning?
For the small-scale production of lime wood is the fuel most utilised. There are other alternatives: coal, charcoal, forestry wastes, as well as animal and agriculture wastes.

Where can I get information of renewable sources?
Visit the local forestry department, they may be able so suggest ways for planting and types of fast-growing trees suitable as firewood. Then you will be able to produce your own energy.

Which are the uses of lime in construction?
Lime is now used throughout the world for mortar, plastering, external rendering and white-washing. Hydrated lime is used for stabilisation of streets and roads.

Can I improve other building materials mixing them with lime?
The use of lime in conjunction with Portland cement in mortar further extends the usefulness of lime and gives the best results: better workability
low-shrinking resistance to moisture.

Which are the other uses of lime?
In addition to the production of lime for building, limestone is put to numerous other uses. Its importance to the chemical, fertilizer, sugar, paper, iron and steel and cement industries is now a well recognised fact. Lime is also used in the neutralisation of acid wastes, in the purification of water and in refining of sugar.

Bibliography

Building limes *No. 46 — Building Research Station Digest, U.K. British Standard for Building Lime No. B.S. 890, U.K.*

The uses of lime in building — *The Building Research Bureau of New Zealand.*

Lime industry in Australia, *by J.S. Hosfing — Division of Building Research in Australia.*

Lime in the building trade, *RDO-136 — National Building Research Institute — Pretoria South Africa.*

Lime, mortars and plasters — *National Building Organisation, Delhi 6, India.*

Masonry mortars *No. 26 — Central Building Research Institute, Roorkee, India.*

Rice hull utilisation — *U.S. Agricultural Research Service-Albany, California, U.S.A.*

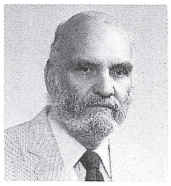
Proposition d'installation d'une chulerie a Tienfala — *Centre de Technologie Adaptee-Bamako, Mali.*

Production artisanale-La chaux au Togo — *Centre de la Construction et du Logement a Cacavelli-Lome, Togo.*

La chaux dans les pays en development-Une alternative au ciment — *Realisation Experimentales en Cooperation-Plan Construction, Paris.*

Cales, *F. Arredondo — Instituto Eduardo Torroja de la Construction y del cemento-Madrid.*

Facultad de Arquitectura, Universidad de Cordoba, Argentina Morteros, cales y yesos, Ernesto Schuster.



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