"Coralite" For Cheaper Building

In The Islands

In a series of experiments extending over the past nine years, the author has developed a method of processing coral to provide a cheap and efficient building material. In the Cook Islands, "Coralite" has been accepted as the standard building material for public buildings, and it is also widely used for homes, offices, stores, and a variety of other buildings. Costs are considerably below those for cement construction.

By WINTON H. RYAN*

London Missionary Society Church, Avarua, Raratonga. Built one hundred and twenty years ago, this church is an excellent example of the mission-introduced system of using burnt coral and sand to bind coral boulders. Note heavy buttresses. Walls are three feet thick.

Backlog Of Post-War Construction

After the second World War the Cook Islands, in common with other Pacific territories, were faced with a backlog of construction. This together with the provision of new services led to an unprecedented demand for new buildings.

A construction technique was sought possessing the following features:

(i) Ready availability of material;
(ii) low cost of construction;
(iii) simple building methods needing a minimum of trained staff;
(iv) permanence and neatness.

The system developed, and outlined in this article, meets all these requirements. In fact, it has been so successful that while alternative imported materials are now readily available, Coralite has been accepted as the standard building material for public buildings.

* Mr. Ryan is Superintendent of Works to the Government of the Cook Islands. It is in this capacity that he carried out the research outlined in this article.
A staff residence being built. The man on the barrow keeps two men occupied tamping the mix to preclude any voids in the mass. The technique is simple, and the whole construction is carried out by Rarotongan labour—no European staff at all are employed on this job.

in the Group. It has been found suitable for houses, schools, offices, stores, workshops and other structures.

In addition, it has been found to possess two other advantages which were not foreseen earlier. The first is that many islanders have copied the method in building their own houses, shops and sheds. As the main cost involved is that for labour, families find that by providing this themselves they can have much improved housing at very low cost.

The second advantage is that whereas money spent on cement and other materials is lost to the Group, money expended on Coralite construction benefits the local economy and gives employment to many islanders in the preparation of the lime. Many of these men would otherwise be unemployed.

**Lower Building Costs**

Since 1951 Coralite has been used for some 153,380 square feet of construction. This represents 42% of the total Government building programme carried out during this period. The latter includes 26 residences for European staff, school rooms, Government offices, cottage hospitals, dental clinics, etc. All these buildings are in perfect condition and there is no sign of deterioration. Production cost of lime (based on present rate of 11/6 per day for unskilled labour) is £4/8/- per ton. By comparison, Portland cement costs £21 per ton to land in the territory (prices by ton volume).

Coralite buildings cost from 21/6 per square foot for simple stores and workshops to 35/- for residences for European staff. These costs are considerably below those for cement construction.

**Selecting And Burning The Coral**

All forms of live coral when burnt will produce lime suitable for mixing with aggregate for construction purposes. However, undoubtedly the most suitable are the solid but soft nigger-heads found in such abundance in all lagoons. Methods employed in harvesting these include pulling with wires attached to tractors. More frequently, gangs of men equipped with heavy hammers break them into pieces which can be carried ashore.

There are also many forms of dead coral suitable for burning. These are recognizable by their fine, closely-grained, white compositions. In this form the coral is no longer soft, but is extremely brittle and splits easily under blows from a hammer or axe. Such deposits are found on the surface and are undoubtedly from coral heads broken during hurricanes and washed inland by heavy seas.

Extensive deposits of high-grade lime coral are to be obtained by quarrying the makatea walls found on all islands of volcanic origin. Unless, however, the quarrying is incidental to some other work (road or reef access cuttings), this source of supply would be uneconomical.

Coarse-grained rock, containing shells and other detritus, should be discarded, as too much fuel will be required to reduce it to usable lime and much dross will remain.

The fuel used is a mixture of fast-burning timber (usually coconut) with other local slow-burning timbers. The coconut timber maintains combustion of...
Above: A set of three Coralite staff residences being built. This class of construction, including all internal fittings, costs about 35/- per foot complete. Living room and lounge face the road, with bedrooms and service rooms on the far side. Right: Joinery factory at the Cook Islands Public Works headquarters, Rarotonga. This is one of a number of workshops, stores and offices which comprise the depot of some 42,000 square feet. The whole depot was constructed in Coralite at a cost of 21/- per foot.

The latter, which in turn prevent the coconut from burning away too quickly.

The fire is screened by tarpaulins rigged on the windward side. This prevents the fire from being forced to one side of the pile, and ensures even burning.

The fuel logs are laid in right-angled rows, with fallen fronds, husks, etc., layered between to act as kindling. Six lighting ports (they are fired simultaneously) are left around the pile. These also act as vents. Spare piles of coral are spaced around the pile, and during burning these are thrown on to patches where the fire breaks through.

During the first day's burning, men are in attendance with poles to prod the hot rock and thus help the breaking-up process.

As Coralite construction is constantly continuing in Rarotonga, it follows that the production of the lime itself has become quite an organised procedure. We have three pits, each with a capacity of 240 x 44-gallon drums working in rotation—number one is burning, number two is being prepared, while number three is being drawn off.

The pits burn for an average of eight days. After the second day they are sprayed with fresh water during normal working hours.

The Formula

There is some difference in the method used and materials available in different islands, but the basic formula is 6 parts 1/4 metal to 4 parts 1/4 "all in" metal to 2 parts lime pug, measured by volume.

In Rarotonga there is a quarry with a large crushing plant producing different grades of basalt chips. In other islands where we have a large construction programme proceeding (boat harbours, schools, hospital buildings, administration blocks, staff residences, etc.) we establish a crushing plant and process coral as a substitute for metal chips.

Where only isolated small buildings are required, and machinery is not warranted, a different procedure is used. This is particularly useful on atolls. Many experiments were carried out, and it was found that by mixing lime pug with metal aggregates in concrete mixers as for normal concrete (instead of making a mortar) a much stronger wall could be obtained with a reduction of thickness. From these experiments, mix No. 9 was evolved. It is this mix (which is described above) to which we have given the name "Coralite" to distinguish it from Portland cement concrete, and from other coral construction.

Mixing Procedure

As mentioned elsewhere, the best grade of prepared lime is of the consistency of thick pug, and in this stage it contains the quantity of water most desirable for a high-grade mix. It follows therefore that whatever aggregate is used, the mix will be hard to work, and a powered mixer is necessary.

It is true that some local builders on private work often mix by hand in various containers (an old canoe seems to be the most favoured) and add water to make the mix more workable. For public buildings, however, we prefer a higher standard and use 1/3 to 1/2 cubic yard capacity machines.

It should be noted that although lime while left in the pit will retain the correct moisture content for years, it soon dries out when removed. We therefore only extract sufficient at a time for immediate requirements.

The density of the mix depends on the aggregate used but is roughly in the proportion of 1-5, and is measured in 12" square boxes.

Placing The Mix

This operation is similar to ordinary concrete pouring. The forms used are flattened 44-gallon fuel drums with 3" x 2" timber framing. Timber—even sawn coconut planks—may be used of course, but if there are a number of buildings, the drum type of formwork will be found to be the most economical.

Wheelbarrows convey from mixer to shuttering. Vibrators are not used, but two men with heavy tampers are needed to cope with the output of one wheelbarrow. This is hard work owing to the density of the mix, and requires careful supervision if voids in the mass are to be avoided.

An alternative design for low-cost schools in Coralite. This type of block (including ceilings and internal fittings) is erected at a cost of 25/- per foot.
Coralite construction is becoming popular with islanders wishing to build permanent low-cost homes. Here a family on Mangaia is building a home. The Coralite was not machine-mixed, but otherwise the methods outlined in this article were followed in its preparation.

The formwork is best held in position by bolts, which can be used over and over again. These bolts should be gently loosened by turning on the day following pouring; otherwise, if left until the removal of the formwork, it will be found that there has been sufficient adherence to the bolts to cause a partial collapse of the face at the point of withdrawal. This is not serious, but as it can be easily avoided it is as well to do so.

If there is any likelihood of rain after pouring, the formwork is covered with old iron or by any other means available. In fine weather, particularly if exposed to wind, formwork may be lifted after three days.

As Coralite is air-cured (as opposed to Portland cement, which is water-cured) the setting process is expedited after the shuttering is removed. The refixing of the formwork will take, on an average-sized building, about two days, so that the second pouring may commence on the sixth day after the completion of the filling of the first form.

In practice we allow three days for the setting of the first fill before lifting, four days for the second, and for the remaining lifts, five days before the shuttering is finally removed. These timings are for a 10' stud building under favourable conditions of fine weather and exposure to wind.

It is of course assumed that a dry mix, relying on the water content of the pug alone, has been made; any variation of these conditions will naturally result in extension of the above timings.

If a large programme has to be carried out I consider it would be economical to have standard steel shuttering made, and in this case a 2' pour would be best, as the Coralite would be slower drying out than with timber boxing.

Depth Of Shuttering

With regard to the depth of shuttering, at one stage boxing 3' deep was used. However, this was reduced to 2' subsequently as—

(i) a 3' depth of Coralite took twice as long to dry out sufficiently for the next placing as did a 2' depth, and
(ii) much more bracing and battening of shutters was required for the deeper pour. The shuttering is a comparatively expensive item in construction even when coconut wood is used, as with the necessarily narrower strips of the latter, more nails and battening are required.

Contraction Details

As Coralite has a lower compression test value than Portland cement concrete, its reliability as a building medium lies in the provision of solid foundations, thickness of walls, and the capping of walls to ensure an overall distribution of weight of the roofing members. Reinforcing steel serves little useful purpose in this material, and is not used. Partitions are also of Coralite to provide lateral buttressing.

The following standards are adhered to:

(i) Foundations. In earth, or sand, a trench 24" wide by 18" deep is dug and "rough" Coralite poured to ground surface. This "rough" mixture consists of the residue of old pits and dross from the top of the pits. Large pieces of coral are mixed in with the foundations. This fill, as with all other pourings, is tamped hard.

(ii) Foundation Band. The formwork is centred on the filled foundation trench and the bottom 9", under all walls including partitions, is filled with dense Portland cement concrete. Two 1" mild steel reinforcing rods are inserted in this band at the base with a 2" covering at the bottom.

Staff residence in Rarotonga being plastered with a mixture of lime and sand. This reduces maintenance to "painting" with lime and seawater.
The purpose of this band is twofold. Firstly, Coralite is porous, and the dense concrete reduces capillary action in it. Secondly, it serves as a continuous firm base for the walls, guarding against possible local subsidences in the foundation trench which, if not provided against, could result in the cracking of walls. The form is then filled with Coralite without further alteration to the shuttering. When the Coralite filling is complete, selected flat, thin pieces of coral rock are centred edgeways in the filling to provide keys for the next sections. There should be roughly a 12" gap between these keys.

(iii) Top Band. The construction of this item follows that of the bottom foundation band. It also has a twofold purpose. Firstly, it provides an even distribution of weight of the roof members—thus guarding against wall cracking, and secondly, it serves as an anchor for the bolts securing the roof trusses. The holding-down bolts (of 4" threaded mild steel with a "U" end) are 42" in length. These bolts are anchored in the Coralite walls and pass through the concrete band securing the top plate and the truss beams by hooking over the top.

(iv) Other Concrete Work. A small quantity of concrete is inserted at the sides of doors and windows, in order to obtain a secure anchorage for the jamb fastenings. These are poured at the same time as the Coralite, and no stops are used in the formwork to separate the mixes. Although the concrete sets at a faster rate than the Coralite, no cracking between the two aggregates has occurred.

The need to provide concrete lintel bands affects to a considerable degree the design of the buildings themselves in that tropical habitable buildings need more openings than those elsewhere. We therefore design with a view to having the tops of all window and door openings in line and at such a height as to enable the top band of concrete (iii) to also serve as the lintel band. Floors are also of concrete.

(v) Thickness of walls and partitions. For well-partitioned buildings having a stud height of not more than 10' and a width not exceeding 24" (schools, residences, store buildings, cottage hospitals and ancillary buildings) the thickness of both walls and partitions is 12". A joinery factory building, without partition, of 12' by 36' with a 12' stud has walls 18" thick. An office building of similar dimensions but with partitioning for a third of its length has walls 15" thick.

(vi) Plastering. This is a stiff mix of 2 parts screened beach sand to 1 part screened coral lime mixed with salt water and applied with ordinary plastering tools. The mix is prepared in 44-gallon drums the day before applying. The excess water which accumulates on...
top of the mix overnight is drained off. Finishing with a wood float covers up
minor irregularities which would be highlighted were a smooth surface obtained
from the use of steel tools. The method used to obtain an even surface (in the
absence of tradesmen) is to carefully level and nail 4" thick wooden strips at
the corners. A taut string moved up and down the walls, as a check, between
these battens will achieve a reasonable standard. The exterior corners of the
buildings are chipped free of lime, and cement plaster substituted to prevent
damage. These corners are rounded.

For finishing exterior surfaces, a mixture of lime and seawater is used and,
indeed, this is all that is required from time to time to maintain the white sur-
faces. Various flat paints, including
plastics, are used for interior plastered
surfaces, but it has been found that
the cheap water paints are quite satis-
factory, and have better colour retention
than the several brands of plastic
products so far used here.

SPC Plant Introduction Service
Expanding Rapidly
The SPC Plant Introduction Service is
playing an increasingly important part in
the improvement of economic crops in
the South Pacific region. In the six
months ending June 30, nearly 300
species and varieties of economic plants
have been distributed, as against 115 for
the preceding six months.

Recipient territories were American
Samoa, British Solomon Islands, New
Hebrides, Cook Islands, Fiji, French
Polynesia, Guam, Netherlands New
Guinea, New Caledonia, Niue, Papua
and New Guinea, United States Trust
Territory of the Pacific Islands, Wallis
and Futuna Islands, and Western Samoa.

Plant material—mainly in the form of
rooted cuttings, seedlings and seeds—was
distributed of breadfruit, citrus, Maca-
damia nut, black pepper, soybean, grain
sorghum, several timber species includ-
ing pines, eucalypts, and teak, legumes
and grasses, coconuts, rice, vegetables
and pulses adapted to tropical conditions,
shade trees, vanilla, and the tung oil tree.

Niue Department Of Agriculture
Assists Planters
On Niue, the Department of Agricul-
ture has disked, harrowed and top-
dressed a number of half-acre blocks to
assist people of the Island to obtain bet-
ter crops. Well over fifty planters have
received assistance so far, and as well the
Department has a long waiting list. The
cost of approximately £7/10/- a plot is
paid back by the planters from their crop
returns.

In several instances the results have
been startling. The first grower to re-
cieve assistance netted £140 from a
quarter-acre of kumaras grown for ex-
port—a remarkable achievement in
Niue's rugged conditions.

... because there is a glass and a half
of pure, fresh, full-cream milk in every
half pound of Cadbury's Dairy Milk Chocolate