B

SOUTH PACIFIC COMMISSION
Technical Paper No. 28

c 3

SOUTH PACIFIC COMMISSION

CORAL AS A BUILDING MATERIAL

Loan no. 19347(B)

Social Development Notes No. 10

July, 1952.

SOUTH PACIFIC COMMISSION

Social Development Notes No.10

Coral as a building material

The following notes on the use of coral as a building material were compiled by Nancy Phelan, of the Social Development section staff, in connexion with the Commission's project of building research (S.8).

Acknowledgment is due to the Colonial Liaison Officer of the United Kingdom Department of Scientific and Industrial Research at the Building Research Station, Garston, Watford, Herts., for his assistance and advice, without which the paper could not have been prepared. Also to the Director of the Australian Commonwealth Experimental Building Station at North Ryde, N.S.W., for checking the text and providing valuable suggestions for additions and improvements; and the Imperial Institute, of London, for documentary material.

While the notes were originally compiled for internal reference only, and to reply to correspondents, it is felt that they may be of value to Government officers and others engaged in building projects in the South Pacific region.

Coral is the one building medium found in abundance in every territory in the Commission area, with the exception of Norfolk and Pitcairn Islands. That it is so seldom used in house construction is presumably due to the methods employed elsewhere not being generally known and to the fact, made clear in the paper, that not every form of coral is suitable for building purposes.

It is hoped that this paper, with its selective bibliography, may help to overcome the first difficulty, and at the same time serve to stimulate further research in individual territories with a view to discovering the best types of coral for use in building.

The appearance of the natural stone is far pleasanter than a plastered surface, and from time to time buildings have purposely been left unrendered. In these cases it appears that after a few years the outer surface becomes fairly waterproof, but that the damp penetrates for some time on the windward side and causes trouble.

It has been suggested that cavity construction might stop the rain soaking in, and that if the walls really do become less permeable with time a coat of lime-wash might be enough to protect them in their first few years.

In Barbados, and in Bermuda, where sawn coral has been widely used, the usual thickness for outside walls is:

Normal one storey	12 inches
Ground floor of two-storey building	1 ft. 6 inches
Partition walls	6 inches

Sometimes in large buildings the walls are 2 ft. thick, though a report made in 1949 suggests that 12 inch walls should be thick enough to stop damp reaching the inside surface.

The stone is bed, set, jointed and pointed in a mixture of cement, lime and sand. (The usual method of making this mortar is to first mix the lime and sand 1 : 2, then 1 part of cement is added to 8 parts of the mix).

In Bermuda, slates cut from coral rock are used for roofing and have been since the 17th Century. The slates (about 18" x 12" x 1") are cut from selected blocks with a hand saw, and when laid are washed over with a cement slurry, which is said to strengthen the roof and make it more weather-proof. The slates are laid with each course bedded in a cement-lime mortar on the course below it. (Fig. 1). The finished roofs are white-washed, usually once a year.

Fig 1

Although these coral slate roofs have been used successfully in Bermuda for centuries, they have not been satisfactory in Barbados. It is said that the Barbados rock is too

porous, but as both types appear to be very similar in texture it may be that the methods of construction are not the same. Another factor is that Barbados has a more intense rainfall in its wettest month than Bermuda.

A rough idea of the crushing strength of coral rocks in general might be had from the results of an experiment carried out on a sample of Barbados limestone, by the Building Research Station of the Department of Scientific and Industrial Research, (England). The tests revealed a crushing strength equivalent to that of a medium grade concrete made from normal materials. Limestone possessing such a strength could be adequate for ordinary domestic constructions.

The Barbados limestone was also tested for porosity and results showed that after repeated tests the specimen lost only 2.4% of its weight. This is considered a very good result, as poor quality limestones lose 50% or more of their weight under similar circumstances. It must be remembered, however, that these results apply only to Barbados limestone and cannot be regarded as correct for corals in general.

QUARRYING OF CORAL LIMESTONES

Until recently, coral blocks used in Barbados were quarried by hand. Coal cutting machines are now being tried there for extracting limestone, but they have not proved altogether successful and other methods are being considered.

When quarrying by hand, a vertical rock face is first made, then a chase is cut along three sides to the full depth of the stone, using a chisel-pointed bar about 6 ft. long. The bottom face is obtained by driving in wedges which easily split the stone. For better and more expensive buildings the blocks are dressed before use. This is done either by sawing - (blocks can be cut by hand saw) - or by surface dressing. (Fig. 2).

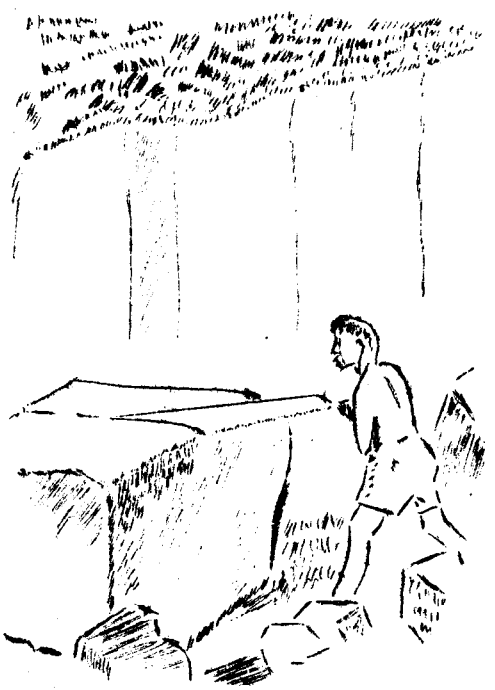


Fig. 2.

In Bermuda quarrying is done in very much the same way except that a chisel fixed to the end of a long pole (10 x 12 ft.) is used to make the vertical chases. The stone is quarried in large blocks, usually as long as the height of the quarry. After quarrying

they are sawn up into building blocks with a hand saw.

Where mechanical quarrying can be used, the Building Research Station suggests that it may be possible to quarry coral in the same way that soft limestone is quarried at Bonneuil en Valois, in France. Drilling machines are used to make the vertical and horizontal cuts in the quarry, and the extracted blocks are then sawn with multiple wire saws, capable of producing the equivalent of 90 cu. ft. per man per 8 hour day.

CORAL USED AS CONCRETE AGGREGATE

When coral is not suitable for direct building, it can be used in other ways. For example, at Ngambo, Zanzibar, coral rock rubble set in a lime-mud mortar is cast in panel walls between concrete posts, and at Mombasa, Kenya, coral rock blockwork, (a porous concrete block), is used for European houses.

However, the Draft British Standard Code of Practice, 121.202 states that for buildings, solid rubble walls 16" to 24" thick are only suitable for sheltered conditions of exposure. For moderate conditions of exposure such walls should be rendered externally, and for severe conditions they should be a cavity construction or battened and lined internally.

If fuel is available, lime can be produced by burning the coral reef rock - wood is suitable fuel. (Fig. 3). This lime is used for building blocks, either of coral and Portland cement, or of coral and slaked lime. The Imperial Institute, London, experimenting with coral from British Honduras, found that blocks of coral and slaked lime were stronger than those made with Portland cement.

Tests have been made, and are still being made in other areas. Following a request of the Department of Works and Housing, Queensland, the Commonwealth Experimental Building Station at Ryde, N.S.W., has carried out a number of tests on coral aggregate and coral sand from Nauru. Although the tests on the aggregate have not yet been concluded, the tables prove that it has a crushing strength which is considered a reasonable

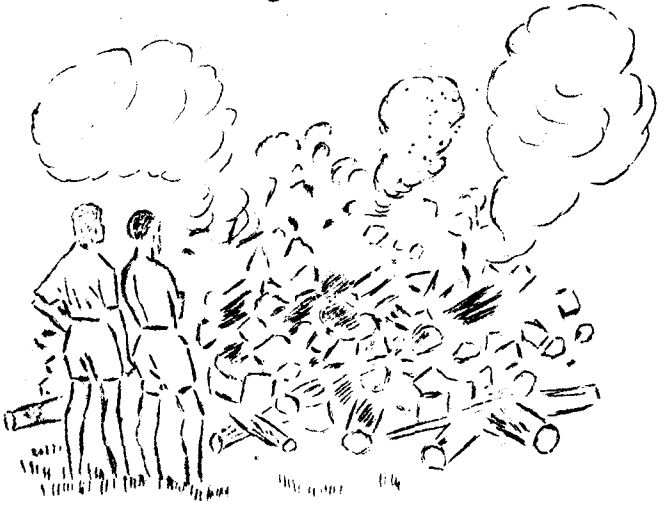


Fig. 3

average for coral. Tests on the coral sand show that certain sands can be used in good quality work and can therefore be considered satisfactory. (The Building Station emphasises that these results were obtained from particular samples of coral aggregate and should not be applied to other materials unless they are identical with the samples used).

On Guam Island builders have used concrete made from Japanese cement and an aggregate of coral sand and cascajo - (crushed metamorphosed coral). Cascajo has also been used for roads and for such things as reinforced canal banks. The concrete aggregate containing coral sand is said to make a dense and very workable material, although it is not very fire-resistant. If stone dust is added to these coral sand concrete mixes their strength is greatly increased.

Coral mixed with harbour mud (pipeshank) from Belize, British Honduras, was investigated at the Imperial Institute and it was found that although the crude pipeshank has no hardening properties, when mixed with slaked lime (prepared from the pipeshank) it can be treated so that it makes building blocks of satisfactory strength.

In a search for local building materials in Fiji, it was discovered that Fijian coral, red clay and limonitic quartz sand (Rewa Sand) are, after appropriate treatment, "a potential source of building materials, possessing considerable strength". An extract from an Imperial Institute bulletin gives the following results:

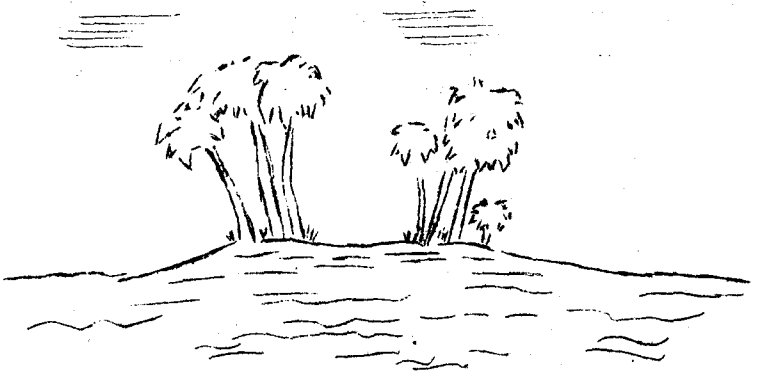
> Calcined red clay mixed with pure hydrated lime and standard sand gives a high tensile strength.
>
> Mortars made from coral lime, calcined red clay and quartz sand (Rewa Sand) show considerable strength with ageing. (Compressive strength of over 2,000 lbs/sq. inch at 6 months).
>
> Sand lime bricks made from 90% quartz sand (Rewa Sand) and 10% hydrated lime prepared from coral, gave an average compressive strength of nearly 3,000 lbs/sq. inch.

All these results are extremely encouraging but they do not necessarily mean that a coral unsuitable for direct building can be used automatically for aggregate. The consequences of using inferior coral could be unfortunate. There are a number of tests which should first be made, and further reference to these is made in the introduction.

CONCLUSION

Practical experience and scientific tests all show clearly that certain corals can be used successfully in some form or other as building materials; if not for direct building, then as a lightweight aggregate of moderate density.

On the other hand, it must be emphasised that all corals vary considerably in properties. The coral of any area under consideration would need careful investigation before it could be declared suitable for building, but experience in other parts of the world has shown that such investigations would be well worth making.



REFERENCE LIST

Imperial Institute Bulletin 1940. 38(2) 217-24
(Coral as a building material in British Honduras).
Gives an account of investigations made on pipeshank (coral mixed with harbour mud) from Belize, British Honduras. Report describes how lime is prepared from the pipeshank and gives suggestions how to make bricks from the mixture.

Imperial Institute Bulletin 1939. 37(3) 434-40
(Artificial pozzolana and sand-lime bricks from Fijian raw materials).
Describes experiments made on Fijian coral, red clay and Rewa sand in effort to find suitable pozzolana to be used with lime. The writer describes the preparation of lime-pozzolana mixtures as simple and considers the process would not be expensive.

Engineering News Record 1926. 97(3) 106.
(Difficulties of construction work on the island of Guam).
An illustrated article by a former U.S. Naval officer which mentions the use of coral sand and crushed metamorphosed coral used as concrete aggregate. Photographs show building and canal banks in which these materials were used.

Engineering News Record 1945. 135. No.6, pp.174-180
(Coral - a good aggregate in concrete).
A seven-page article by an officer of the Seebees in which he describes how coral was used by the U.S. forces in the Pacific war. Despite lack of laboratory tests, and emergency conditions, coral was found to be a most valuable material in building gun emplacements, incinerators, reservoirs, etc., and although it had to be mixed with sea-water, the buildings, etc., were found still standing after several years.

Engineering News Record July 13th, 1944. vol.29
("Characteristics of coral deposits" by Harold T. Stearns).
U.S. geological survey describing different types of coral and describing its use in constructing Pacific advance bases during the war.

American Concrete Institute Journal 1944. 16. proc. no.39, no.1, pp.53-55.
Describes the making of pre-stressed concrete tanks, made of coral and porous limestone. A pozzolanic admixture was added to reduce water content and increase density and the tanks were then used by U.S. Navy.

Colonial Geology & Mineral Resources vol.1. no.2. pp.152-163
(Building materials from St. Vincent (clay, volcanic rocks, sand and coral) by F.R. Stacey and W.O.R. Wynn).
Published by H.M.S.O.
An account of tests made on materials from St. Vincent, British West Indies. The St. Vincent coral was calcined and then slaked and dried and produced a good white hydrated lime, which was then used with the other materials - decomposed volcanic rock, grey volcanic ash, volcanic tuff and fine sand - in attempts to find a good pozzolana.

American Concrete Institute Journal September 1943. v.15. pp.61-65
(Use of coral aggregate, by Ben E. Nutter).

American Concrete Institute Journal April 1946. v.17. pp.547-551
(Concrete at advance bases, by I.S. Rasmussen).

Interim Report. Department of Engineering: Queensland University
(Coral sand as a material for concrete making, by G.H. Francey).

Le Journal du Batiment 21st May 1948
Contains illustrated advertisement dealing with quarrying soft limestone at Bonneuil en Valois, France.

Civil Engineering 1931. 1. (13), 1184-8
(Engineering problems in the tropics. C.B. Andrews).

Woodhouse, W.M.
Note on quarrying and use of Barbados coral.
Prepared for Colonial Office, 30th September, 1949.

Tests on Concrete containing Florida Ojus Rock Public Roads. 1944. 23 No.12, pp.315-318.

On the Ocean's Bosom Unespied. Fello Atkinson and Will Onions. Architectural Review, 107 No.642 (June, 1950) pp.405-416
(Describes the use of coral work in Bermuda).

Inventory of the Barbados Rocks and their possible utilization
A. Senn. Bulletin No. 1 (New Series) Barbados Department of Science and Agriculture, January, 1944.

****