LIMESTONE

Bermuda’s sedimentary stone was formed over the ages from wind-drifted coral sand, which settled onto a base of volcanic rock. Though it all looks rather similar, there are different varieties of Bermuda stone. The oldest formed, known as limestone, is the hardest. It has been hardened over time by minerals from the seepage of water and its main component is calcium carbonate. More recently formed stone, often called “sandstone” in Bermuda, is softer and more crumbly.

Bermuda’s stone was used from the early days of settlement for building, first for forts and public buildings and later for houses. Walls were made of soft stone sawn into building blocks with long

"It is a great advantage when you can dig your house out of your own backyard."

Carveth Wells (1935)
iron handsaws. [1] Then, it was common for blocks to be obtained from the site where a building was to be erected. Part of a sloping hillside was cut away and a house put in the space created, which formed the cellar. Many old properties have quarry “starts” which show that additional quarrying was also done on site. There were also common quarries, and blocks sometimes had to be carted to building sites or floated along the shore in small boats.

To begin the quarrying process, stonecutters would try and determine how the stone was bedded. They would select a suitable starting point and chisel and rake out a three inch trough around the first stone to be cut. This first stone, called the head stone or key block, was like the first piece of a pie. Getting it out was the hardest part of the job. The rest of the blocks were much easier to remove. The bottom of the blocks were riven with hardwood wedges or undermined in a wedge shape with chisels, and pried loose. They were allowed to fall to the ground where they landed on a bed of scrap stones, called “jacks” or “slipes”. [2,3] These absorbed the impact of the fall. The blocks, which were as large as 12 to 15 feet high, were then sawn or riven along the grain into building stones of different sizes. Sound stone with a very even grain was reserved for roofing slates. This was selected by eye or by tapping with the knuckles to hear what kind of ring it had. Inferior stone and off-cuts were used as slipes or for drystone walls. The sand that was a by-product of sawing stone was also used. There was never any waste.

Bermuda’s first stonecutters were often slaves or indentured labourers. After emancipation, the trade was often in the hands of working immigrants, both West Indian and Portuguese. In the 19th
century, skilled masons with the knowledge to lay newly cut Bermuda stone were mostly members of the black community.

TRADITIONAL LIME MORTARS
Mortars are used to bond together blocks of stone and to help form a level bed from which to build. Mortars were based on lime, which may be the single most important element in our traditional building. Lime was easily available in Bermuda though it was costly because of the fuel and the labour it required. It was made by burning hard stone in a limekiln. Some countries were not so lucky. They had to find alternate sources, such as shells from oyster middens or dumps. Some places even needed to import limestone and Bermuda was often happy to send this as ballast in its ships’ holds.

Lime is created by slowly burning limestone at high temperatures until its chemical composition has changed. Two kinds of limekiln seem to have been used in Bermuda. The earliest kilns, and by far the commonest, were simple, cylindrical furnaces, generally cut into hillsides.[4] They were about 10 feet high, tapering towards the top. Some later kilns, constructed in the 19th century by British engineers, were freestanding stone buildings lined with fireproof yellow brick. Sometimes they resembled funnel-shaped brick chimneys. In each type, the limestone needed to be fired continuously at a high temperature for three to five days in order to turn it into quicklime.

In the simpler earlier type of kiln, lumps of hard stone and wood for burning were arranged in alternating layers, starting with wood. The stone generally came from pockets
or “heads” of hard stone found throughout Bermuda amongst softer building stone. Lime burning, like stone cutting, was a local activity and often done on site. When the fuel had burned itself out, the cooled stones, now quicklime and often reduced to a gravelly powder, were raked out from the small opening in the bottom of the kiln. This kind of lime was “dirty”, meaning that wood ash was unavoidably mixed in with quicklime, which necessarily affected its properties in mortar recipes.

In the second later kind of kiln, wood ash did not come into contact with the lime to the same degree. A wood fire would be laid on the floor of the kiln, below a metal grille. Chunks of stone would be placed in the top part of the kiln on the grille, and layered not with wood but with coal. The wood fire ignited the coal, which burned up through the layers of limestone. A complex kiln might also have niches around its edge for secondary fires. Fires were tended day and night. At the end of the firing, when the chemical composition of the stone was changed, the wood ash and cinders were raked out, the grid dismantled, and the quicklime fell to the floor of the kiln. One kiln of this kind is on the water’s edge, and there is a dock for transporting fuel to the kiln and bagged lime to building sites. [5]

A number of limekilns have survived in Bermuda to this day, though only one, at Ferry Reach, was in recent use. Today we
get our lime packaged in a tidy brown bag or else we use a liquid mortar plasticiser, a lime substitute without the real properties of lime. Lime’s proper use is so little understood today that it is often shunned because of its caustic qualities. Some builders will not even allow it on a site.

It is true that quicklime is unstable and absorbs water from the atmosphere, so it needs to be slaked. Slaking is the act of dissolving quicklime in fresh water to stabilise it, which changes its chemical composition yet again. Quicklime chunks were sometimes hosed down with water. They hissed and steamed and then disintegrated into a white powder, which was sieved and bagged, ready for sale. Sometimes water was put into a vat and lime added slowly until it was half the depth of the water. It was stirred in with a shovel and considerable heat was produced by chemical reaction. If the water boiled, more water was added. It was important that the slaked lime did not come into contact with the air for prolonged periods of time. If this happened, carbon dioxide in the air began to change it back into limestone again, which explains how the slow setting of mortar occurs. When slaked, lime could be safely left to mature. People kept it on hand in rum barrels, ready for use. The lime particles sank to the bottom, forming a paste or “putty”.

The presence of wood ash from firing seems to have affected the properties of lime. Quicklime with high wood ash content was often “washed”. Fresh water was stirred into the barrel and, after separation had occurred again, the water containing soluble salts and ash was decanted from the top. This process needed to be repeated several times to ensure clean, usable lime, free of salts and cinders.

The basic principle of lime mortar technology is that lime hardens to create a bond when the water used in mixing dries out. This was knowledge that came with the earliest builders. There were masons on the Island within a year or two of settlement and they must have experimented with locally available materials to try and replicate the mortars that they knew from England. Apparently they were cautious of Bermuda stone at first and added extra calcium to the mortar in the form of shells. One of their recipes consisted of
“winkelshels and a hard white stone burned in a kiln and slaked with fresh water”. This was then mixed with turtle oil to keep it from drying out completely. It may have been used to plaster the in-fill in wood framed houses. Different kinds of mortars were gradually devised to suit different purposes: to build walls, to plaster exterior and interior walls, to line and waterproof tanks.

The use of lime in mortar is not a hard and fast matter that can be reduced to precise recipes. There are many variables that can change a mixture. If the lime itself is very pure, it will not set quickly and will harden from the outside inwards, taking many weeks to reach its maximum strength. Set mortar needs to be of a hardness compatible with the materials being bonded and, as Bermuda stone is rather soft, it was important to add the correct proportion of sand to the mortar. Too much sand and the mortar would be weak, too little and the mortar would shrink and crack. The kind of sand used also affected a mortar recipe. The preferred sand came from “clay” sand holes, which yielded a fat, loamy sand, needing less lime. “Sharp” sand, on the other hand, required more lime to form a usable mortar. These subtleties were understood by early builders who always carefully gauged their materials to get the right results.

Hydraulic mortars are particularly important in Bermuda. These are mortars that have the chemical capability to cure and harden under water, and we use them for lining water tanks and cisterns. One early mortar which had hydraulic and waterproofing properties had a pinkish hue and probably consisted of lime mixed with sand, perhaps tallow, probably whale or turtle oil, and red clay or ground brick dust. It was called “tarras”.

In the early 19th century, building technology in the Western World had begun to reflect the series of changes that we know as the Industrial Revolution. Advances in engineering enabled the development of modern docks and bridges, which were important to trade. There was a renewed interest in the technology of Roman mortars, which went hand in hand with the revival of styles called Neoclassicism. Portland cement was developed in England and imported to Bermuda, first to the British Naval Dockyard which was then under construction.
LIMESTONE IS QUARRIED.  A LIMEKILN BURNS THE LIMESTONE.

THIS MAKES QUICKLIME.

THIS THEN SLAKED IN WATER.

THE LIME IS MIXED WITH WATER, SAND TO MAKE MORTAR.

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THE LIME CYCLE

\[ \text{CaCO}_3 \xrightarrow{\text{Quicklime CaO}} \text{Ca(OH)}_2 \xrightarrow{\text{Ca(OH)}_2 \text{ Slaked lime}} \text{Hard mortar Ca(HCO}_3\text{)}_2 \xrightarrow{\text{cO}_2 \text{from air}} \text{H}_2\text{O water.} \]
Portland cement has chemicals added to boost its natural materials. It was gradually incorporated into our repertoire of building methods. Mortars using cement also required skill and involvement on the part of a mason because their proportions, too, were individually gauged according to the properties of materials. It was like cooking without a book. The kind of sand and the kind of lime used also affected cement recipes. We call them “gauged mortars”.

Gauged mortars can best be understood through general guidelines which differ for walls, external render, internal plaster, roof washes and tank linings. One part cement, one part lime and six parts sand or one part cement, two parts lime and nine parts sand are acceptable mixes to begin a gauged mortar, depending on the strength required. Strength is partly influenced by the sharpness of the sand. “Fat” sand with clay impurities helps setting and reduces the amount of lime required. Sand needs to be clean, crisp and free from sea salt and organic materials like dead leaves. Mortar is mixed twice, once dry and then again when water is added. It cannot be left exposed to the air for long once it has been wetted, as this begins the setting process, though it can be wetted down again. The minimum amount of water, sufficient only to make it usable, should be added to the dry mix to produce a workable but not runny mortar.

Though lime was still added to cement mortar to soften the mix, the setting qualities of lime mortar and the inter-relationships between lime and limestone slowly began to be ignored. Today, it is cement and not lime that is regarded as the basis of mortar. Lime is occasionally added to assist with flexibility but most people have never heard of the lime cycle. Though lime is still sometimes used in cement mortar to maintain plasticity, its original properties and function are not valued.

As we realise more and more the importance of lime in the technology of traditional Bermudian building, we understand that it is part of an organic and interrelated system that modern materials can actually interfere with, unless used sensibly and judiciously. Unfortunately there has been no analysis done of Bermuda’s individual mortar formulas as there are, as yet, no foolproof international standards for mortar analysis.