Background Information

Introduction

Located along the Beaufort River in the town of Port Royal, SC is the remains of Fort Frederick, a British colonial fort built in 1734. While Fort Frederick might look like it is made of **concrete**, it is actually made of a historic building material called tabby. **Tabby** is made of lime, sand, oyster shells, and water, and was used to construct all kinds of buildings in coastal South Carolina, Georgia, and northern Florida during the 18th and 19th centuries (Sickels-Taves 1997:22; Sheehan and Sickels-Taves 2002:16; Brooker 2020:1). While tabby is no longer used for construction today, the remains of historic tabby structures, like Fort Frederick, are important cultural resources. Understanding how these structures were made and how to repair them is critical for preserving these historic sites for future generations.

Figure 1: Fort Frederick, Port Royal, SC (Photo by Jamie Koelker, 2019)

Tabby Architecture

As a cheap, durable, long-lasting building material, tabby was used in a variety of ways, such as being poured into wooden molds and allowed to set forming solid tabby walls, cast as individual tabby bricks, poured onto the ground to form tabby floors, or daubed onto wattle frames to create wattle and tabby daub dwellings (Brooker 2020:3). Tabby was used to construct everything, from forts and churches to civic buildings and townhomes to plantation houses and quarters.

The ubiquity of tabby-building in coastal South Carolina, particularly in the **Sea Islands**, is due in large part to the natural environment. This region generally lacks good stone for building, as well as easily accessible clay deposits for brickmaking (Brooker 2020:77). Early colonists had to find an alternative way to construct strong, masonry buildings out of the abundant natural resources at hand — oyster shells, water, and sand.

Despite how common tabby architecture was during the 18th and 19th centuries, it is unclear who invented tabby. Some historians believe tabby is partially derived from a similar historic building material found in Morocco and southern Spain (Brooker 2020:16), while others believe knowledge of tabby-making was brought to South Carolina by the British after they besieged the Spanish colony of St. Augustine in 1702 (Sickels-Taves and Sheehan 1999:51). Other historians claim that antecedents to tabby architecture can be found along the Guinea Coast and that knowledge of tabby-making was brought to South Carolina by enslaved Africans from this region (Jones 1985:199).

Wherever tabby came from, it is clear from the historical and archaeological record that tabby was in use in South Carolina by the early 18th century. Rather than a single cultural origin, it is likely that tabby architecture emerged from a combination of different building traditions brought by various groups of people (British, Spanish, French, and African) to colonial South Carolina.

If tabby architecture continued after the Civil War, it did not last long. The introduction of Portland cement and concrete in the latter half of the 19th century rendered tabby obsolete as a building material. Coastal South Carolina communities began opting for the convenience of prepackaged cement over labor-intensive tabby (Brooker 2020:118). With the environmental, economic, and social conditions that encouraged tabby's use no longer in existence, knowledge of tabby architecture disappeared.

Tabby Recipes

Tabby architecture required a lot of knowledge and skill and was well-adapted to the unique context of coastal South Carolina. Tabby-making recipes were not standardized but varied tremendously based on regional influence, available resources, and personal preferences (Brooker 2020:90).

For example, Thomas Spalding, a planter from Georgia, recommended a recipe of equal parts lime, sand, oyster shell, and water (Brooker 2020:90, 265). Meanwhile, in North Carolina near the Cape Fear, a ratio of 1 part lime to 1/2 parts sand to 1 1/2 parts shell was used (Macomb 1811:129). Tabby-making recipes from Beaufort County consistently contained more shell, as demonstrated by a recipe calling for 1 part lime, 2 parts sand, and 4 to 6 parts shell (Brooker 2020:90). Historians and conservators studying a tabby building from Cumberland Island, Georgia report a recipe of 1 part lime to 3 parts sand to 1/3 parts shell (Sickles-Taves and Sheehan 1999:110-117).

African Americans used their knowledge of tabby-making to make tabby dwellings that were unique to them (Crook 2008; Cochran 2021). Tabby from Port Royal, South Carolina made and used by enslaved African Americans followed a recipe of 1 part lime to 1 1/3 parts sand to 1/7 parts shell. This recipe results in a material that is finer and smoother in texture than the tabby recipe by Thomas Spalding, or the recipe used for Fort Frederick. **Oral tradition**, rather than written sources or formal training, had the greatest influence on tabby-making recipes across coastal South Carolina, Georgia, and northern Florida.

Figure 2: Tabby Wall at B. B. Sams Plantation Complex, Dataw Island, SC (Photo by author, 2023).

The Chemistry of Tabby

Lime, sand, oyster shells, and water are the four primary ingredients of tabby. **Lime** works as the **binder**, meaning it holds the other ingredients together into a coherent mass, akin to marshmallows in a Rice Krispies Treat. The lime used in historic tabby buildings was made by burning oyster shells, setting into motion a chemical process called the lime cycle. The **lime cycle** refers to when chemically stable calcium carbonate is transformed by heat into a series of unstable compounds (an example of **thermal decomposition**) before reverting into calcium carbonate. The lime cycle is one of humanity's earliest known chemical processes and has been used by people for thousands of years to make mortars, plasters, and other building materials (Carran et al. 2012).

Oyster shell is mainly composed of calcium carbonate ($CaCO_3$), also known as calcite. When oyster shells are subject to intense heat (around 850˚ Celsius), carbon dioxide (CO_2) is released as a gas, leaving behind a white powder called **quicklime** or calcium oxide (CaO) (Sickels-Taves and Sheehan 1999:21–22). Heating calcium carbonate to produce calcium oxide is an **endothermic reaction** because heat is absorbed by the reactant from the environment to produce the chemical change.

Quicklime is not chemically stable and will react to carbon dioxide in the air, reverting to calcium carbonate and becoming unfit for making tabby. To expand and stabilize quicklime, water is added to produce **hydrated lime** or calcium hydroxide ($Ca(OH)_2$). Historically, the act of adding water to quicklime is called **slaking** and hydrated lime is also referred to as slaked lime. The addition of water to quicklime is an **exothermic reaction**, resulting in the release of heat as hot steam.

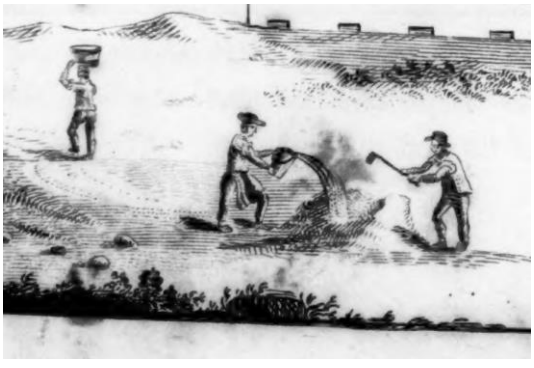

Figure 4: Historical illustration of slaking quicklime to make tabby ("Observations on the Art of Making the Composition called Tapia," Alexander Macomb, 1811)

After the quicklime has been slaked with water, sand, along with whole or crushed oyster shell, are added to the hydrated lime as aggregate. **Aggregate** offsets the shrinking and cracking of the hydrated lime as it dries, providing strength, workability, and durability to the material (Sickels-Taves and Sheehan 1999:23). Once the materials were mixed in the desired proportions, the worker had a few hours to pour the tabby mix into wooden formworks before it began to stiffen and lose its plasticity. From continued exposure to air, the calcium hydroxide reacts with atmospheric carbon dioxide, slowly releasing water and reverting to calcium carbonate. This final step of the lime cycle is referred to as **carbonation**.

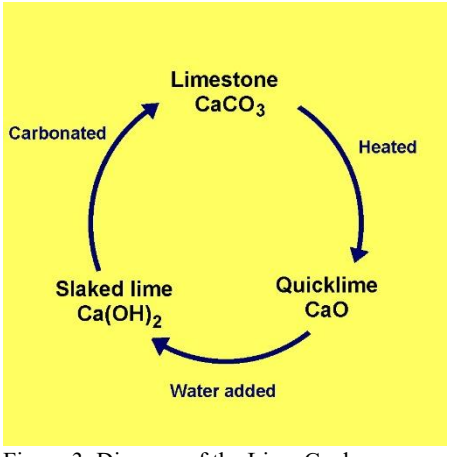

Figure 3: Diagram of the Lime Cycle
(Illustration by Peter Bell, 2013, CC BY-SA 3.0*)*

Advocates of tabby architecture during its period of use championed the material's strength and durability compared to wood and its affordability compared to brick and stone for construction. Today, concrete fills a similar role as a cheap yet versatile building material. Concrete is now the most widely used manufactured material on the planet with 30 billion tons of concrete produced worldwide each year (Nature 2021). Just like tabby, making concrete begins by burning calcium carbonate, which releases carbon dioxide into the atmosphere. The burning of limestone on an industrial scale has had a tremendous impact on the environment with the cement/concrete industry accounting for at least 8% of global carbon emissions (Nature 2021).

Scientists are looking for more sustainable ways to produce concrete, such as by recycling waste materials and reducing the amount of energy needed for lime burning. Oyster shells, which require less energy to burn than limestone, are currently being studied as an alternative source for lime and aggregate in some countries (Yoon et al. 2004; Ha et al. 2019). Studying the past can inspire future research, leading to solutions to issues facing the world today.

Vocabulary

- **Aggregate** – Broken or crushed material (often rock or shell) added to lime or cement to offsets the shrinking and cracking.
- **Binder** – A material that acts as bonding agent when mixed with water and aggregate. Examples include Portland cement and lime.
- **Calcium Carbonate ($CaCO_3$)** – A white, insoluble solid occurring naturally as limestone, mollusk shell, marble, and chalk.
- **Carbonation** – The process in which hydrated lime ($Ca(OH)_2$) reacts with atmospheric CO_2 to form calcium carbonate ($CaCO_3$).
- **Concrete** – A modern building material made from Portland cement, broken stone or gravel, sand, and water.
- **Endothermic Reaction** – A chemical reaction where energy as heat is absorbed from the environment.
- **Exothermic Reaction** – A chemical reaction where energy as heat (or light) is released.
- **Hydrated Lime ($Ca(OH)_2$)** – A white, odorless powder produced by mixing calcium oxide (CaO) and water.
- **Lime Cycle** – The process in which calcium carbonate is converted to quicklime by heating and then slaked with water to form hydrated lime which then naturally reverts to calcium carbonate by carbonation.
- **Oral Tradition** – a method of preserving, transmitting, and evolving knowledge and ideas through speech or song.
- **Quicklime** – A white, caustic, alkaline substance produced by heating limestone or other forms of calcium carbonate ($CaCO_3$).
- **Sea Islands** – A chain of low-lying coastal barrier islands and erosion-remnant islands extending south from the mouth of the Santee River in South Carolina to the mouth of the St. Johns River in northeastern Florida.
- **Slaking** – The process of adding water to quicklime (CaO) to form hydrated lime ($Ca(OH)_2$)
- **Tabby** – A historical building material made from lime, sand, oyster shell, and water that is geographically associated with the Sea Islands of South Carolina, Georgia, and Florida.
- **Thermal Decomposition** – The chemical decomposition of a substance through heat.