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Solidifying “Soil” in Africa

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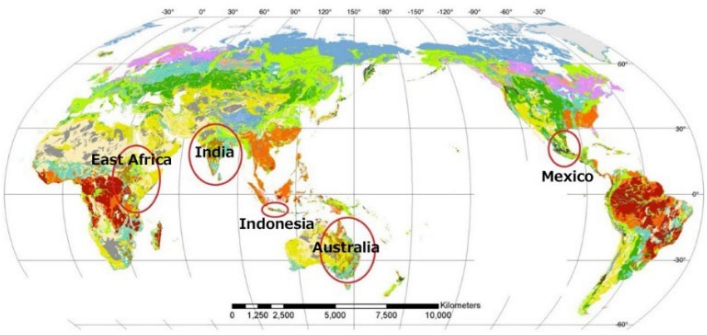
“Black Cotton Soil” is famous as “rampant soil” in Africa.
Because it is clayish, it holds water and nutrients well, making it fine for agricultural land. However, under buildings and roads, it expands with rainwater during the rainy season, breaking foundations and roadbeds. During the dry season, it cracks, sometimes creating cracks into which people can fall. For this reason, black cotton soil is considered “problem soil” in the construction and engineering world, and is removed, discarded, and replaced by other soil and crushed stone.

It would be a waste to dispose of this precious soil that the earth has produced over hundreds of millions of years just for human in-convenience. If it could be utilized, the labor and cost of bringing it out and in, as well as the carbon dioxide gas emissions associated with its transportation, could be reduced. Replacing a portion of cement with black cotton soil would also be in line with “de-cementing” and help solve the “aggregate shortage”. Black Cotton Soil can be a resource that can contribute to the sustainability of construction.

Can we somehow utilize black cotton soil as a building material and roadbed?
Since the year before last, we have been working with Jomo Kenyatta University of Agriculture and Technology (JKUAT) in Kenya.

What is “Black Cotton Soil,” a problem soil existing in the Pacific Rim?



【A “problem child” born of the same mother】

- The Earth was created about 4.6 billion years ago as a block of lava. Then the earth's surface cooled and hardened, forming the crust, and over billions of years, weathering and organisms formed the “soil” on the surface about 600 million years ago.
- The continents that covered the surface of the earth split into north and south about 200 million years ago. The southern continent, Gondwana, continued to break up and migrate, forming the present-day continents of eastern Africa, India, Southeast Asia, Australia, Central and South America, etc., surrounding the Pacific Ocean. The basalt of the Gondwanan continent was the mother of the “black cotton soil.”
- Therefore, black cotton soil is ubiquitous not only in East African countries such as Kenya and Ethiopia, but also in the Pacific Rim, including India, Indonesia, Australia, and Mexico, and is treated as “problem soil”.

【The problems with black cotton soil are swelling and shrinkage and disposal】

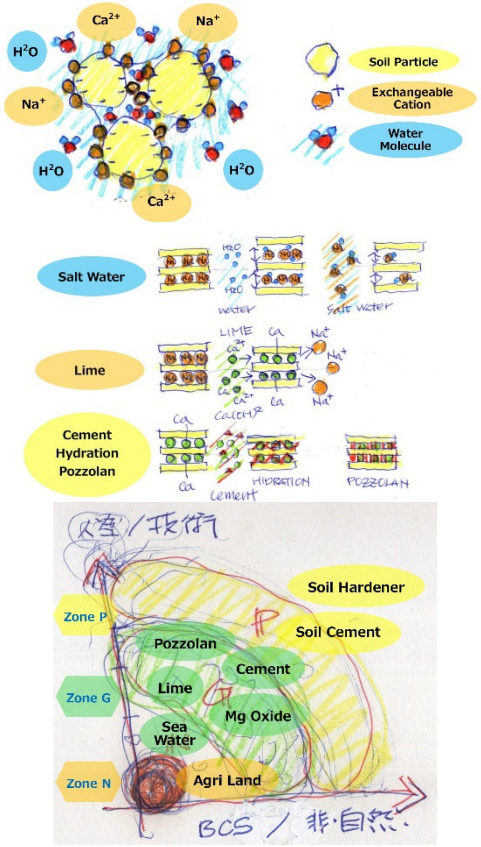
- Black cotton soil swells during the rainy season and shrinks during the dry season due to its crystalline structure unique to clayey soil, causing damage to building and road foundations, so if black cotton soil is present in a construction site, it must be replaced with other soil, crushed stone, etc.
- This project aims to reduce removal and disposal costs and carbon dioxide gas emissions by using black cotton soil as a stable foundation by consolidating it in place, and to use it as a “locally produced for locally consumed” inexpensive building material by using it for blocks, etc.

“Black Cotton Soil Project” with JKUAT

【”Black Cotton Soil Block” Demo-Experiment in JKUAT】

- From May 2024 to February 2025, a demonstration experiment (Phase 1) has been done to develop “Black Cotton Soil Blocks” with slaked lime and salt as non-cementitious materials as an inexpensive building material which is a “carbon-dioxide” and “locally production & consumption” type.
- In FY2025, we will examine the possibility by mixing volcanic ash obtained from volcanic areas in Kenya and rice husk ash, which is rich in silica, with slaked lime, learning from the ancient Romans, who created Roman concrete using slaked lime, volcanic ash and seawater, and left behind strong structures such as the Pantheon.

Solidifying BCS utilizing BCS’s power



【Negatively charged structure of soil particles】

- Soil particles are generally negatively charged and are surrounded by cations of sodium, calcium, potassium, magnesium etc. that are essential to the organisms of plants and animals.
- These cations are absorbed by plant roots to form plant organisms, which in turn are ingested by animals to sustain their organisms.The negative charged structure of soil particles is the fundamental reason why plants and animals can survive on earth!

【Utilizing the “Power” of Black Cotton Soil】

- Black cotton soil has a layered crystalline structure unique to clayish soils, and the negatively charged surface of the many interlayer have spaces to hold exchangeable cations such as calcium.
- This multi-layered, negatively charged structure of black cotton soil is the “power” of black cotton soil. In this project, we aim to take the approach of solidifying BCS from its inside by utilizing the inherent power of BCS, rather than simply solidifying BCS from the outside by cementing it by pouring cement.

【“Three Zones” of Technology and Nature】

- Take “Artificiality/Technology” on the vertical axis and “Non-Nature” or “Distance from Nature” on the horizontal axis, to describe the relationship between Humans and Nature, establishing on the diagram “Three Zones” in the relationship between Humans and Black Cotton Soil (BCS).
- Near the Point-Zero, there is BCS in its natural state, untouched by humans, which can be used as farmland. This area is called the “Zone N”. However, if there is BCS in the construction area of buildings or roads, it becomes necessary to introduce some kind of Artificiality/Technology to control the swelling and shrinkage of BCS, and this is where the departure from the “Zone N” begins.
- The path of departure from the “Zone N” is usually a diagonal line on the diagram. This is because the more technology humans put in, the more Non-Nature also advances. For example, if we use cement to harden BCS, it is no longer soil and cannot be returned to nature. To extend the diagonal line, there are “Soil Cement” or “Soil Hardener” that make solidification with cement more efficient. At this point, it is no longer an area that is freely accessible to the general public, but one that is enclosed by patents and intellectual property rights held by companies. This is called “Zone P” meaning “Patent” or “Property”.
- Our project aims to operate BCS in “Zone G” (G for Green) between N and P. The path of our progression aims rather a vertical movement, not diagonal. This is because it enhances Artificiality/Technology without departing from Nature as much as possible. We should learn from the “Roman concrete” of the ancient Romans, who built the Pantheon and other marvelous structures 2,000 years ago with slaked lime, volcanic ash, and seawater. Before the cement of modern industrialization, before reinforcing steel, it was not industrial waste, so it can be returned to the earth at the end. It is a great work of advanced Artificiality/Technology development without promoting “Non-Nature” process.
- In our project in 2025, we will test the solidification of BCS by a substance that promotes the effect of slaked lime like volcanic ash in Roman concrete (“pozzolanic substance”), which is also available in Kenya, and build small-scale structures with molded “BCS blocks”.

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