Creating a 'Recipe' for soil in the engineering of stable roads in Ethiopia

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Frehaileab Admasu came to do research for a doctorate in the Graduate School of Science and Engineering at Ehime University in Nov. 2020 in the Rock Mechanics laboratory. Coming from Ethiopia as part of a Japan International Cooperation Agency (JICA) project, his objective was to contribute to the building of roads in his country. In some areas there are no roads at all, making it very difficult for farmers to transport their produce to market. He wanted to develop a 'recipe' for a soil mix that could be produced easily with locally available materials and improve road conditions.

Soil in Ethiopia and worldwide is one of the most important and widely used building materials. It has been effectively used for a variety of purposes, such as housing, and agriculture. However, it sometimes poses a major problem in civil engineering projects such as the construction of roads, highways, and pipelines due to the instability of the foundation causing the collapse of the structure. This is because problematic/expansive soils undergo significant volume changes due to moisture content variation. The foundation of a roadbed must be strong and stable enough to support the traffic load for that particular road section. Figure 1 shows the road section collapsing due to foundation/subgrade failure.

Figure 1: Collapsed cobblestone road section founded on unstable subgrade soil

His research focused on improving the strength of weak/problematic soil by mixing it with cellulose-based additives derived from agricultural waste. There were two major objectives: the evaluation of the improvement of the engineering properties of weak soils through the use of various geotechnical testing methods, and the promotion of sustainability through the use of agricultural waste. The first problem he faced was that the problematic soils, such as expansive black cotton soil, don't exist in Japan. It was first necessary to create a pseudo-expansive soil with the engineering property similar to the expansive black cotton soil found in Ethiopia.

The pseudo-expansive soil, composed of various combinations of clay soils, was stabilized with varying percentages of cellulose fiber additives. Cellulose-based fiber additives are sustainable, environmentally friendly, and can be incorporated into expansive soils to create a stable soil mass. At his laboratory, several experiments were carried out to select suitable cellulose-based fibers from agricultural waste products. Thus, Bamboo fiber, rice husk, and wheat straw fibers were found to be suitable cellulose-based fibers to stabilize the soil. The cellulose-based fiber additives (bamboo fiber, rice husk, and wheat straw fiber) are shown in Figure 2.

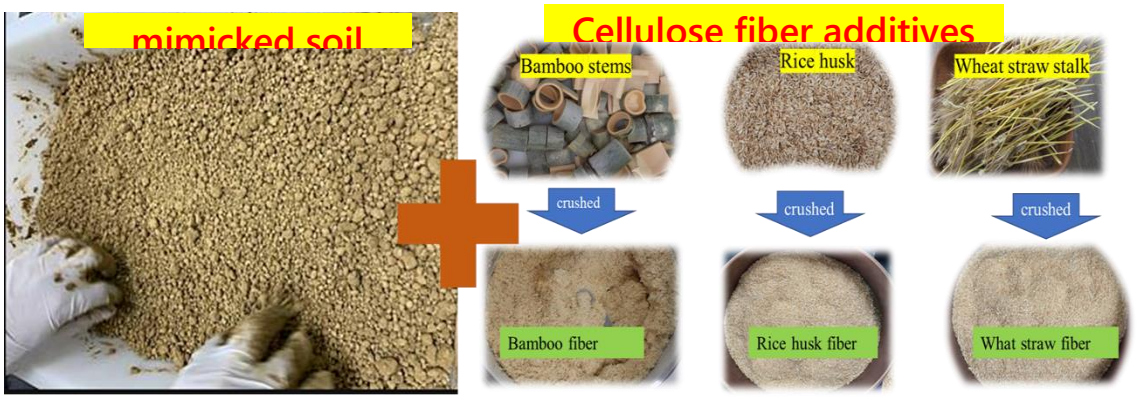

Figure 2: Stabilization process of the pseudo-expansive soil with cellulose-based fibers

There was one other issue. His research also needed to address how the results could be implemented in the construction of low-volume roads to benefit the local community. The participation of the local community would be essential, and the method should be relatively easy to implement. Cellulose fibers prepared from agricultural wastes can be spread on the surface of a road and mixed with the soil. However, using bags to pack the mixed plant additives with soil is the most effective method for improving its strength. This technique of using bags for packing is known as *donou* (土のう) technology has been developed in Japan. Small-scale road community-based construction using these bags filled with soil stabilized with fibers is shown in Figure 3.

Figure 3: Community participation in constructing small-scale roads with improved *donou* technology.

The use of sustainable and environmentally friendly soil stabilizers has tremendous potential in improving the engineering properties of the soil, reducing soil-related damage, and reducing the time and cost of construction. A significant improvement in terms of strength containing the water movement in the soil has been observed in the stabilized expansive soil with cellulose-based fiber additives. *Donou* technology can also be utilized in other countries with similar approaches. Moreover, this research not only introduced sustainable solutions but also promoted social participation with the help of technological tools. A road constructed in this way can last several years. The research will continue in Japan to extend the lifespan of these roads. Mr. Admasu is returning home to continue his research there.