論文の要旨

Reuse of stone powder in slag or cement-treated clay

（スラグまたはセメント処理土における石粉の再利用）

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To achieve Goal 12 of the United Nations Sustainable development goals (SDGs), the construction industry emphasizes reducing, reusing, and recycling waste materials. Also, to meet the Paris Agreement on Climate Change and the Goal 13 of the SDGs, the industry needs to find innovative ways to reduce its carbon emissions. The manufacturing process of cement contributes about 8% to global carbon emissions; hence alternative materials should be found to reduce the reliance on cement. Waste materials (stone powders) produced from crushing rocks such as limestone and granite are often discarded in an environmentally unfriendly manner. Stone powder accounts for up to 25% of the quantity of crushed rock aggregates produced, but due to their small particle size (<1- 850μm), they are disposed of; hence innovative ways to reuse waste should be investigated. Steel slag, a by-product of steel manufacturing, is increasingly utilized in constructing infrastructure worldwide. However, steel slag is produced in vast amounts and about 40% is used in China, while 1% of the over forty million tons produced in Japan is disposed of. This leaves the industry with financial and environmental costs associated with steel slags' abundant production, which necessitates further enhancement of its reuse.

Stone powder is increasingly being reused to improve the geotechnical properties of soils. However, the mechanisms governing the strength development of treated soils using stone powder are unclear. Also, there are limited studies on the reuse of stone powder mixed with steel slag to improve the properties of clays.

This research aimed to promote the reuse of stone powder and steel slag in improving the geotechnical properties of clay dredged from the sea. We mixed limestone or granite powder with cement or slag and clay to form cement-treated clay-granite powder, cement-treated clay-limestone, and slag-treated clay-granite composites. We investigated the mixing characteristics and physical, chemical, thermal, and microstructure properties governing the cement-treated clay composites' unconfined compressive strength (UCS) development. Further, the durability of the cement-treated clay-granite powder and slag-treated clay-granite powder composites under seawater exposure was determined.

The physical properties that influenced the UCS included granite powder particle size and specific surface area, and microstructural images proved the phenomena. Thermal properties were calcium hydroxide and bound water content of the composites. In contrast, the chemical properties included granite powder's pozzolanic reactivity and amorphous silica concentration. The slag/cement-treated clay-granite powder composites were more durable than their control samples, which did not contain stone powder under seawater exposure. This implies that granite powder can be used to construct sustainable infrastructure at sea.

Reusing stone powder at contents of 30%, 50%, and 70% results in a 6.9%, 14.7%, and 28.6% reduction in cement used per cubic meter of cement-treated clay, respectively. This leads the construction industry to realize target 5 of goal 12 of the SDGs, which emphasizes the substantial reduction of waste generation through prevention, reduction, recycling, and reuse. Goal 13 and Paris agreement on climate change are impacted by reducing the reliance on cement hence reducing carbon emissions.