Recycling Waste Coal Ash Promises More Sustainable Concrete Materials

The construction industry commonly uses lightweight aggregate — characterized by a bulk density lower than normal aggregates because of its porous structure — for applications such as lightweight concrete, insulating concrete, fire-resistant concrete, etc. Traditional lightweight aggregate is manufactured by mining natural materials such as slate or shale. The process includes crushing the mined material, screening it, and feeding it to a rotary kiln. As the material is heated, it turns into a partial liquid phase, where certain chemical compounds release gases that create porous structures in the lightweight aggregate.

Slate and shale quarries that have a suitable chemical composition for lightweight aggregate production have been found through years of geological explorations. Lightweight aggregate manufacturers in the U.S. are dependent on these specific quarries, which are often located far from areas with high lightweight aggregate demand for construction. The geographical distance between the lightweight aggregate manufacturers and their customers increases transportation costs, often doubling the material's price.

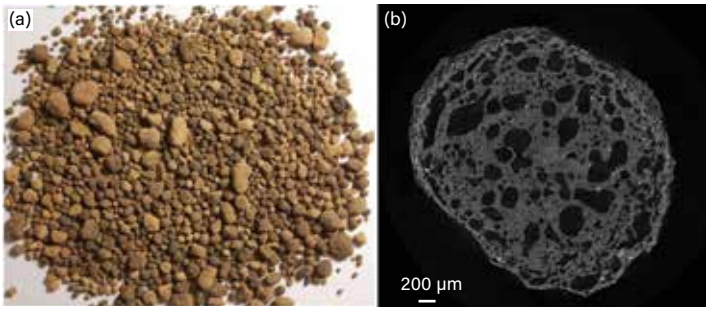
SusMaX — a start-up company funded by the U.S. National Science Foundation (NSF) — has overcome this geographic limitation by utilizing waste coal ash from landfills to manufacture lightweight aggregate. Their technology allows them to produce engineered lightweight aggregate locally from landfills across the country, irrespective of the material's chemical composition. Legacy coal ash landfills hold billions of tons of waste coal ash, a byproduct of burning coal that previously had no viable recycling solution. While recycling waste coal ash presents challenges due to the variability in its chemical composition across different landfills, SusMaX has developed an approach to address this challenge: a patented predictive thermodynamics-guided framework.

The company's innovative thermodynamics framework designs lightweight aggregate based on the waste coal ash chemical composition and the three required conditions for the formation of a porous lightweight aggregate. These three conditions include: the formation of a sufficient liquid phase, a suitable viscosity for the partially molten ash, and a sufficient gas release to create the porous structure.

As part of the first production step, SusMaX uses thermodynamics modeling (based on chemical oxides of the waste coal ash) to develop phase diagrams of the waste coal ash and predict the liquid phase quantity and its chemical composition during the sintering process. Next, it uses that data to make predictions about the lightweight aggregate viscosity using analytical models. Finally, it uses analytical analysis to confirm that the gas release is appropriate for creating pores in the lightweight aggregate.

This approach minimizes or removes the need for trial and error to optimize the design of an engineered lightweight aggregate. Once the design is finalized, SusMaX uses its proprietary manufacturing method to produce a high-performing lightweight aggregate that is highly suitable for construction applications. SusMaX's lightweight aggregate is 20% lighter than market alternatives but retains 15–20% more crushing strength, which could potentially reduce the required amount of cement in the concrete mix. And, the lightweight aggregate has a 50% higher water absorption capacity, which could also extend the lifetime of concrete structures through internal curing. Because the lightweight aggregate is sourced from waste coal ash landfills that are located close to customers, transportation costs could be reduced by more than 50%.

By recycling the waste coal ash from landfills, SusMaX will reduce the risk of landfill failures and alleviate the environmental impacts of coal ash landfills. Robert Buelt, Quality Control Manager at Schuster Concrete, explains, "A local lightweight aggregate manufacturer, such as SusMaX with their innovative product, has the potential to enhance our access to lightweight aggregate and help with reducing material costs for our projects. SusMaX's lightweight aggregate, which has a higher absorption capacity, could potentially contribute to achieving stronger and more durable concrete through advantageous internal curing. The sustainability aspects of their product make it an even more desirable choice for our projects." CEP



◀ (a) SusMaX is manufacturing lightweight aggregate for concrete from waste coal ash. (b) This X-ray computed tomography scan demonstrates the porous microstructure of the lightweight aggregate.

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