Comprehensive Use of Coalmine Overburden Waste in Construction Materials

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Abstract

Coalmine wastes are huge contributors to the burden on the biosphere that is fast exceeding the carrying capacity. Millions of tonnes of overburden are generated every year (Shrivastava et al., 2023). It has been clearly established that coalmine waste is devoid of nutrients necessary for plant growth, making it unsuitable for vegetation. The waste material has no major component that can be economically extracted, whereas it damages the ecosystem while occupying a vast area of land. Fortunately, the waste has some synergies with different components of construction materials. Therefore, converting the waste into construction materials will lead to its elimination from the site and embed the harmful elements in the construction materials for many years. Natural aggregate, sand, and ordinary clay are already scarce, and the coalmine waste can supplement a small fraction of it. The economic values are multi-dimensional.

A huge stream of research has resulted in the use of a small fraction of the waste and the amelioration of the waste-infested soil (Mohanty et al., 2023). However, the dimension of the problem is only getting compounded with the increasing generation of waste. This paper presents the process of comprehensive utilization of all the components of the coalmine overburden (OBD) wastes in construction works that can potentially eliminate it in entirety from the site and in the process, create economic value by supplementing precariously depleting natural aggregates. The process involves the segregation of the bulk of the waste into five different components for different applications: i) large rocks are comminuted and used as coarse aggregate, ii) fine rocks are used as fine aggregate, iii) very fine rocks are used as sand in concrete, bricks, and mortar, iv) silt is mixed with ordinary clay and used to make fired clay bricks and finally the v) carbonaceous matter is used for energy harvesting. Samples of concrete, bricks, and mortar were prepared by varying the percentage of the waste rocks of appropriate sizes respectively adding a varying percentage of ordinary Portland cement. The key physical and mechanical properties of the samples were observed to be within the range recommended in the Indian Standard IS2185 and IS2212 ensuring structural stability. Accelerated weathering tests for 200 hours in steps of 40 hours lead to no visible deterioration of physical and mechanical properties, thus assuring of a long life of the end products. Test of toxicity and heavy metals leaching was performed and the results eliminate concerns for leaching of toxic chemicals. The costs of production of bricks, concrete, and mortar using coal mine wastes compare favorably with fired clay bricks, traditional concrete, and mortar respectively.

The compressive strength (CS) of the brick produced out of coal mine waste (CMW) with 85% CMW (15% cement) is comparable to that of ordinary fired clay bricks (FCB). Water absorption rates appear to be slightly on the lower side indicating lower porosity than FCB. The cost of one brick with 15% cement is estimated to be less than Indian ₹ 2.00 (1 US $ = Indian ₹82.50 as on 25.02.2023) considering no cost of the mine waste but only the cost of cement, labour, and power. Thus the cost compares favourably to that of fly ash brick (₹ 5) and FCB (₹10).

As regards concrete made from stones in OBD, the densities of the M20 and M30 grades are observed to be 1607 Kg/m^3 and 1651 Kg/m^3 respectively, which are within the density range of conventional concrete of 1500 to 2000 Kg/m3. Thus concrete made of mine stones has similar specific gravity as conventional aggregates. The other mechanical properties are similar to that of traditional concrete.

The addition of up to 20% silt with clay for FCB, does not cause a substantial adverse impact on compressive strength, whereas the density reduces, and porosity increases. The water absorption of the bricks increases with a higher percentage of silt.

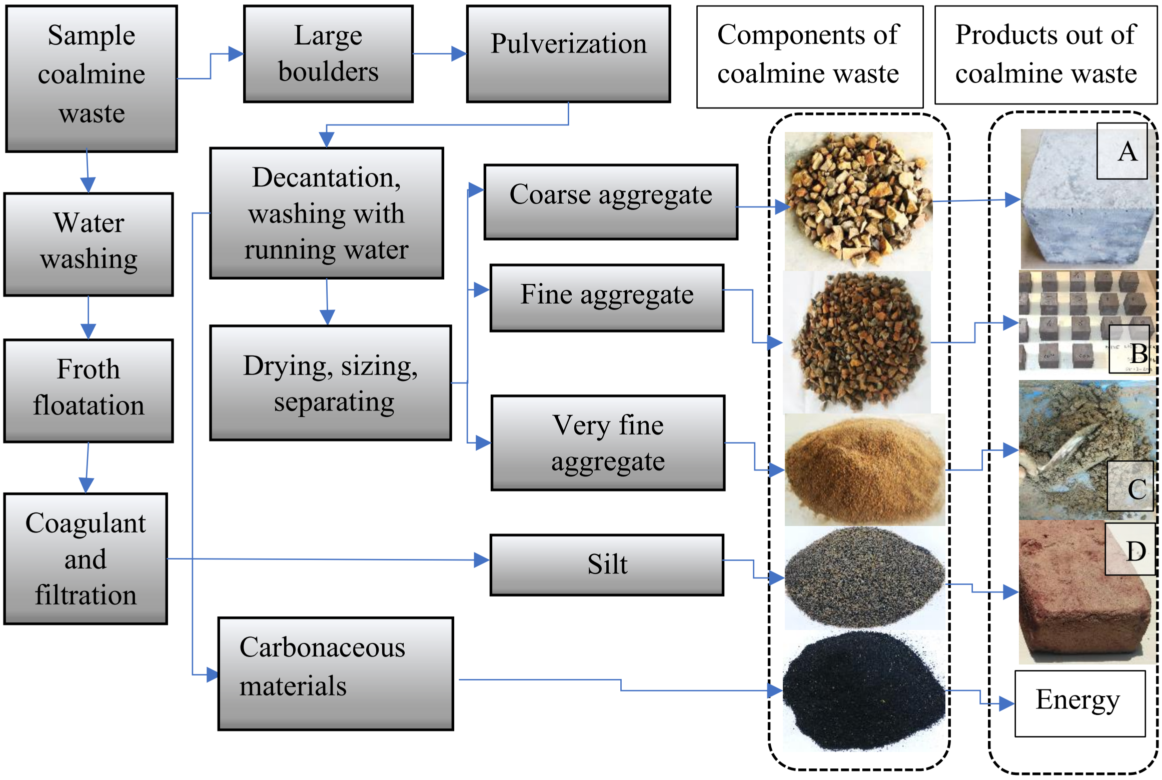

Figure 1: The diagram of the process for separating of different components and their end uses.

A – Concrete B – Bricks C – Mortar D – Fired clay bricks

Therefore, the entire waste materials can be potentially used in various construction works eliminating all the environmental concerns and releasing the land for productive uses while supplementing the natural sources of materials for construction. The recycling of the waste in this way contributes to the circular economy, more so in view of the growing recycling of demolition waste. The paper, for the first time, demonstrates the comprehensive reuse of the entire coalmine overburden waste leading to safe and green coal mining.

References

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