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ORIGINAL PAPER

Performance and leaching analysis of a novel coal sludge-based backfill material

Yuan Yao · Henghu Sun · Shushu Jiang · Rui Zhang · Dan Su · Chao Feng · Xiaoyuan Han

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Abstract In this article, an innovative backfill material is introduced as a green material largely utilizing two major coal mining waste: coal refuse and coal sludge. Coal refuse is rock-like solid waste, comparatively, raw coal sludge is slurry. A smart recipe design of backfill material was introduced, which contains only 1 % of cement and the rest 99 % of raw material is from industry waste. The backfill material at 75 % pulp density shows excellent performance such as high unconfined compressive strength, great flowability, and low bleeding rate. Also, the article discusses the morphology change of the backfill harden body during different curing ages, the observation through SEM–EDS illustrates the distinguished morphological characterization of the needle-like ettringite and amorphous gel. Furthermore, TCLP results indicate that this designed backfill material is environmentally acceptable and none of the heavy metal leaching has over the limitation by US Environmental Protection Agency (EPA).

Keywords Coal refuse · Coal sludge · Backfill · Performance · Leaching

Y. Yao · H. Sun (✉) · C. Feng
School of Engineering and Computer Science, University of the Pacific, 3601 Pacific Ave, Stockton, CA 95211, USA
e-mail: hsun@pacific.edu

Y. Yao · R. Zhang · D. Su · X. Han
Pharmaceutical and Chemical Science Program, University of the Pacific, Stockton, CA 95211, USA

S. Jiang
Department of Pathology and Microbiology, University of California-Riverside, Riverside, CA 92507, USA

Introduction

The coal industry is still in fast development rate due to the primary energy usage of the coal (CTAB 2010). Only in the US, the total combustion usage of coal is around 1.05 million tons each year (Freese et al. 2008). The coal mining industry procedures are different types of waste such as mill tailings, waste rock, and water treatment sludge (Aubertinet al. 2002). Coal refuse and coal sludge are two major type of waste from coal mining industry. Coal refuse is typically rock-like solid waste, which is one of the largest forms of waste from the coal mining industry and is generally defined as a low BTU-value material under the parameters of minimum ash content combined with maximum heating value and it is estimated that coal mines in the US generates 109 million metric tons (120 million short tons) of coal refuse annually (US EPA 2011). Also, coal sludge is a category of waste treatment sludge from coal industry, which is generated by washing and separating the coal from its surrounding soil and rock before burning (Coal River Mountain Watch 2011). Water treatment sludge from mine operations contains usually between 1 and 30 % solids depending on the treatment method (Benzaazoua et al. 2006). The great amount of sludge also causes serious challenges to the environment and society.

Mining wastes and mineral processing wastes stockpiles worldwide, which occupies land, generates pollution, and may causes serious damage to residents; therefore, the industry and government desire a suitable method to recycling this industry waste to protect the environmental from solid waste pollution. However, large amount of industrial waste having a granular nature accumulate every year in all industrial countries (Katz and Kovler 2004). This reality has provided a strong thrust toward the waste disposal problem (Aqil et al. 2005). In this case, clean mine backfill science