AJSTD

ASEAN Journal on Science & Technology for Development
Vol 38, No 3, 2021, 103–108
DOI 10.29037/ajstd.705
RESEARCH

ABCSA Raw mix Design: Correlation between Chemical Constituents and Mineralogy

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KEYWORDS
Alternative clinker
Bogue calculations
Correlation
Mineralogy
Quantitative estimation

SUBMITTED 10 June 2021
REVISED 26 October 2021
ACCEPTED 18 November 2021

ABSTRACT The cement industry has been identified as one of the main contributors to climate change due to greenhouse gas emissions, mainly CO_2. Therefore, to meet CO_2 reduction targets, cement producers are working on different strategies of minimizing its emission, one of which is alternative clinkers. This study assessed the impact of variations of the raw mix design, concerning the type and proportions of materials, on the formation of calcium sulphoaluminate belite-type clinkers. Various materials were used to produce raw mixes for different percentages of belite, yeeliminite, and other minerals in resultant clinkers. Computer-based theoretical mixes were designed with different percentages of SiO_2, CaO, Al_2O_3, Fe_2O_3, and SO_3 and then the designed mixes were fired in a laboratory furnace at 1250°C with 20 min retention time. The resultant clinker samples were characterized with X-ray diffraction. The quantification of minerals in each sample was carried out with Rietveld refinement. The obtained results confirmed the correlation between the mineralogy and chemical constituents in the raw mix. The C_4AF percentage of the resultant clinker samples increased with an increase in Fe_2O_3 percentage. $C_4A_3\$$ content varied with the amounts of Al_2O_3, SO_3, and CaO. The mineral percentage of C_2S in the designed mixes had a clear correlation with the constituents of SiO_2 and CaO. Anhydrite percentage in the resultant minerals changed with the SO_3 content in the raw mix. These results should aid in the determination of the optimum amount of chemical constituents and minerals required for the development of calcium sulphoaluminate clinker.

1. INTRODUCTION

The cement industry consumes huge amounts of natural limestone, other raw materials, and fuels. The production of cement involves decarbonization of $CaCO_3$ and requires a high temperature at around 1450°C. Both these processes produce CO_2 into the environment. Hence, the cement industry has been identified as one of the main contributors to climate change due to greenhouse gas emissions, mainly CO_2. In 2018, global cement production was about 3.99 billion tonnes, accounting for about 8% of all anthropogenic carbon dioxide emissions (CEMBUREAU 2019). Ordinary Portland cement (OPC), a blend of clinker (about 95%) and gypsum, is the most used binder in the world. The OPC clinker is usually obtained by heating a mixture (raw meal) of limestone (Tregambi et al. 2018; Barcelo et al. 2014) and other additives such as laterite, bauxite, clay, etc., in a rotary kiln at about 1500°C. The entire process of clinker production involves consumption of thermal and electrical energy and releases about 0.83 kg of CO_2/1 kg of OPC.

Now the scenario of global cement changes into sustainability and minimization of CO_2 production and targets for CO_2 reduction came into the picture in all the countries through low carbon technology road map (LCTR) (World Business Council for Sustainable Development 2018). Because of LCTR guidelines, all the cement industries are working out on different levers to minimize CO_2 production. According to the LCTR, alternative clinker is one of the potential levers for reducing CO_2. In this direction, researchers are working out to develop new alternative clinker systems to mitigate CO_2 emissions. Belite sulphoaluminate clinker is also one of the established alternative clinkers to address the CO_2 mitigation effectively (Telesca et al. 2017; Schneider 2019; Shi et al. 2019; Gartner and Sui 2018; Walling and Provis 2016). Some countries (China and Japan) already started the production of BCSA clinker and produced blended types of cement with different percentages along with the conventional clinker in bulk quantity for commercial applications.

For the conventional clinker, a quality expert uses Boague or Taylor (Bogue 1929; Taylor 2015) theoretical calculations to understand the mineralogy of the resultant clinker for its further applications. But, so far very few theoretical calculations are reported to assume its mineral percentage instead of quantitative estimation for its effective applications (Borštnar et al. 2020; Telesca et al. 2020; Winnefeld et al. 2017; Beltagui et al. 2017; Chen and Juenger 2011). In the present paper, the authors studied the impact of chemical constituents (Fe_2O_3, Al_2O_3, SiO_2, SO_3, and CaO) of the raw mix on the formation of the mineral such as ferrite (C_4AF), yeeliminite (C_4A_3S), Belite (C_2S), and anhydrite (C$) in the BCSA clinker and discussed the correlation between the chemical constituents of raw mix and its mineralogy of the clinker.

IJEP 44 (5) : 387-395 (2024)
(ISSN : 0253-7141)

Adsorption Studies of *Moringa oleifera* Seed Powder in Removal of Cadmium, Zinc and Chromium from Water

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This work suggests the use of natural alternative coagulation method in the removal of Cd, Zn and Cr compared to chemical coagulants as they are toxic, unfriendly and unaffordable by nature, which are commonly used. The functional groups present in the *Moringa oleifera* seed powder (MOSP), which help in the adsorption of metal ions were identified and analysed by Fourier transform infrared (FTIR). It is identified that, at optimum levels of pH and dosage, the maximum elimination of Cd, Zn and Cr was observed at 89.01, 80.74 and 69.24%, respectively. The physico-chemical characteristics of metal ions and the selective biosorption of MOSP functional groups are consistently correlated in single sorption, with the order of biosorption preference being Cd, Zn and Cr. Due to the fact that the sorption capacities (q_m) of MOSP for Cd, Zn and Cr were 6.40, 5.77 and 4.25 mg/g, respectively, in comparison to Freundlich models, the adsorption values fit more closely. MOSP adsorbent favoured the adsorption processes of Cd, Zn and Cr in acquiring the separation factor (R_L) at the required range of 0-1. Hence, this study emphasizes the effective adsorption of MOSP in removal of heavy metal ions from contaminated water.

KEYWORDS

Moringa oleifera seed powder, Adsorbent, Langmuir adsorption, Freundlich adsorption, Separation factor, Adsorption capacity

1. INTRODUCTION

Every living thing needs water, which is a necessary and inescapable component of life. However, because of the numerous human sources of pollution that result from the various industrial breakthroughs achieved over the years, this resource is becoming increasingly scarce in its natural condition. Water contamination is becoming a major issue for the entire world and has had a harmful influence on both the environment and human health [1]. Rapid industrialisation has caused an excessive discharge of heavy metals into the environment, which has raised serious concerns around the world. Industrial wastewaters from the metal plating, mining, smelting, battery manufacturing, tanneries, petroleum refining, paint manufacturing, pesticide manufacturing, pigment manufacturing, printing and photographic industries, etc., are frequently found to contain cadmium, zinc, copper, nickel, lead, mercury and chromium [2]. Continuous discharge of industrial, domestic and agricultural wastes in rivers and lakes causes deposition of pollutants into sediments. Such pollutants include heavy metals, which endanger public health after being incorporated into food chain. Heavy metals cannot be destroyed through biological degradation, as is the case with most organic pollutants [3]. Several methods have been devised for the treatment and removal of heavy metals, the commonly used procedures for removing metal ions from aqueous streams include chemical precipitation, lime, coagulation, ion exchange, reverse osmosis and solvent extraction [4]. However, in coagulation-flocculation method, recent research has identified numerous significant negative effects of utilising aluminium salts, including Alzheimer's disease and other health issues linked to residual aluminium in treated waters [5].

Adsorption is one of the physico-chemical treatment processes found to be effective in removing heavy metals from aqueous solutions. Adsorbent can be considered cheap or low-cost if it is abundant in nature,

International Journal of Advanced Research in Engineering and Technology (IJARET)
Volume 12, Issue 11, November 2021, pp. 1-12, Article ID: IJARET_12_11_001
Available online at https://iaeme.com/Home/issue/IJARET?Volume=12&Issue=11
ISSN Print: 0976-6480 and ISSN Online: 0976-6499
DOI: https://doi.org/10.34218/IJARET.12.11.2021.001

STUDY THE CORRELATION OF CLINKER QUALITY, RESIDE, PSD ON THE PERFORMANCE OF PORTLAND CEMENT

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ABSTRACT

This research establishes the correlation between clinker quality, residue, particle size distribution and performance behaviour of cement. Different qualities of clinker were identified to understand the influence of mineralogy on the performance of cement. Chemical and mineralogical evaluation of clinker and gypsum were carried out as per the Indian specified standards, XRD and Optical microscopy. Cement samples were prepared by inter mixing of clinker and gypsum with 95 and 5% respectively for different fineness zones such as 225, 250, 275, 300, 325 and 350 m2/kg. The resultant samples were studied for residue, particle size distribution and performance evaluation as per IS 4031. It was observed that clinker quality plays an important role to achieve the desired performance characteristics in addition to the residue and particle size distribution of the cements.

Key words: Cement, residue, particle size distribution and strength.

Cite this Article: Suresh Palla, Suresh Vanguri, S Ramakrishna, S K Chaturvedi and B N Mohapatra, Study the Correlation of Clinker Quality, Reside, PSD on the Performance of Portland Cement, *International Journal of Advanced Research in Engineering and Technology (IJARET)*. 12(11), 2021, pp. 1-12.
https://iaeme.com/Home/issue/IJARET?Volume=12&Issue=11

1. INTRODUCTION

It is known that the quality and type of cement are significant factors to determine the strength development of concrete, which is specifically affected by the fineness and mineral composition of cement. The fineness of cement also affects its reactivity with water. Generally, the finer the cement, the more rapidly it will react [1,2]. However, the cost of grinding and the heat evolved on hydration set some limits on fineness.

ScienceDirect

Journal of Building Engineering
Volume 51, 1 July 2022, 104218

Solar thermal treatment of phosphogypsum and its impact on the mineralogical modification for effective utilization in cement production

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Abstract

Gypsum is a key component in cement because it plays vital role in controlling the setting behavior of the cement. PG is a chemical gypsum, contains substantial amount of SO_3 and has the potential to replace mineral gypsum in cement. PG acts as super retarder by extending cement setting process. The retardation property of PG calcinated at 250–550 °C was investigated by taking around 5% of resultant PG in cement. All the samples were characterized by chemical analysis, X-ray diffraction and isothermal calorimetry. No significant variation of phosphate content was observed in untreated and thermally treated samples. Mineralogical characterization showed that the phosphate was converted into inert form at and above 350 °C. The retardation behavior of PG in cement was studied by using isothermal calorimetry and observed that it was reduced in treated samples than untreated sample. Solar thermal treatment at optimized temperature of PG was performed and the resultant PG exhibited shorten setting time than the untreated PG in cement.

Introduction

India is the 2nd largest producer of cement in the world with an installed capacity of 545 million tonnes per annum [1]. A large volume of mineral gypsum (generally 5% in cement) is