THE MAIN STAGES OF PORTLAND CEMENT PRODUCTION PROCESS

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Abstract: The Portland cement production process significantly impacts the environment, particularly with the mining of raw materials and the high CO_2 emissions. From this perspective, the study aimed to analyze the technical possibilities of utilizing granite rock waste and clay cement waste, produced during the production of aggregates for civil construction, in Portland cement production. Research into the use of limestone residue as a partial substitute for clay in the production of Portland clinker was found to be lacking. Furthermore, there was a noted gap in studies analyzing the potential of this residue as a mineralizer. To address this, the raw materials were characterized physically, chemically, and mineralogically, and based on these results, two types of cement production were proposed. First, cement was produced with about 95% limestone and 5% clay, using clinkerization at a temperature of 1450 °C. Later, a second type of cement was produced with 25%, 50%, 75%, and 100% clay replaced by the residue, also using clinkerization at 1450 °C.

Keywords: Portland cement, Portland clinker, granite rocks, cement waste.

Introduction: Portland cement is the most widely consumed industrial product globally and is responsible for utilizing large quantities of raw materials. It is defined as a hydraulic binder produced by grinding the clinker, primarily composed of calcium silicates and aluminates. Figure 1 illustrates the global consumption of cement, which is closely related to construction and economic activities, highlighting Asia as the market leader [1].

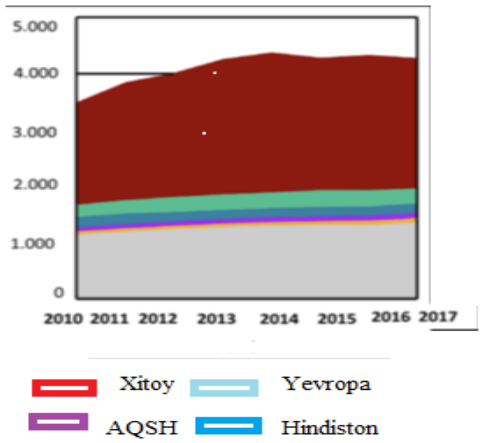

Figure 1: Global Cement Production since 2010.

According to the 2012 annual report from the National Cement Industry Federation (SNIC,

2013), Asia contributed 77% of the global cement consumption, followed by Europe at 11%. China, which is at the top of the production chain, produced 2.14 billion tons of cement. The construction sector in India accounts for 22% of CO_2 emissions, with projections for cement production increasing from 300 million tons in 2010 to 600 million tons by 2020.

Main Body

As shown in Figure 2, by 2050, the global cement production scenario is projected to grow, similar to population growth. Over the period from 1950 to 2015, the demand for cement increased tenfold, and it is expected that future production will exceed these values, making it socially acceptable as well. About 90% of cement production occurs in countries not belonging to the Organization for Economic Cooperation and Development (OECD). China's share in global production has already peaked, and by 2050, it is expected to decrease from 50% to 30%.

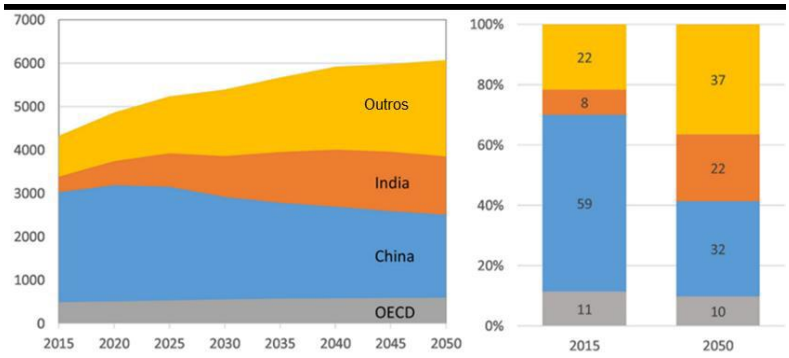

Figure 2: Scenario of High Portland Cement Consumption Worldwide.

Method and Materials: Environmental Impact: After water, concrete is the most widely used material on earth, and thus the cement industry is one of the largest consumers of natural resources, significantly impacting the environment. According to reports, producing one ton of cement requires approximately 1.5 tons of raw materials. The cement industry is notorious for its environmental impact during each stage of the production process, including raw material extraction (quarrying), clinkerization (gas emissions), and energy consumption [3].

Cement kilns use various energy sources to achieve the high temperatures necessary to form clinker's essential mineral phases. These can include fossil fuels such as mineral coal, fuel oils, petroleum coke, natural gas, diesel, or alternative fuels like biomass. The large-scale production of cement and the need for raw materials and energy make the cement industry a source of environmental protection concerns, primarily due to the high CO_2 emissions from fossil fuels and the decarbonization of limestone during clinker production [3].

Proposals and Recommendations

The cement production process consists of several stages, as shown in Figure 3: raw material extraction, crushing, dosing and mixing, clinkerization, cooling, grinding, and packaging. In conclusion, cement production is a combination of searching and processing raw materials, such as limestone and clay.

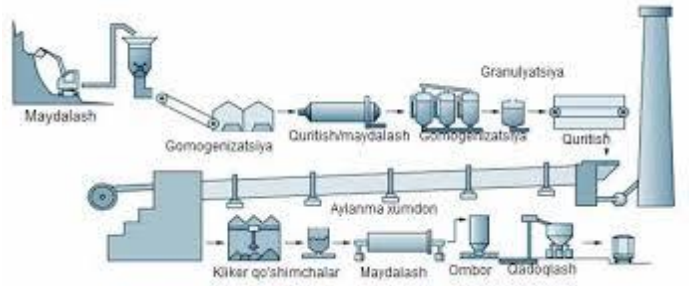

Figure 3: Stages of Portland Cement Production.

The phases in clinker can be identified, along with their quantities and the temperature at which the liquid phase forms during clinkerization. Raw materials can be dosed based on their specific mineralogical composition and firing temperatures. However, it should be noted that due to the absence of compounds responsible for the formation of iron oxide and other phases (C4AF and periclase), the determination of the liquid phase formation temperature is considered a theoretical value, not observed practically. Therefore, phase diagrams are not commonly used in the industry for dosing cement raw materials in Portland cement production [4].

Table 1. Reactions of Clinker Formation

C3S = 4,071 CaO – 7,602 SiO2 – 1,430 Fe2O3 – 6,719 Al2O3
C2S = 2,868 SiO2 – 0,754 C3S
C3A = 2,650 Al2O3 – 1,692 Fe2O3
C4AF = 3,043 Fe2O3

Conclusion

The Portland cement production process has a significant environmental impact, particularly due to raw material extraction and the high CO_2 emissions. The primary aim of this work was to analyze the technical possibilities of using granite rock waste and clay cement waste, produced during aggregate production for civil construction, in Portland cement production. Research into the use of this residue as a partial replacement for clay in the production of Portland clinker was found to be lacking. Furthermore, there has been a lack of studies analyzing the potential of this residue as a mineralizer.

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