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Materials Today: Proceedings

Available online 5 May 2023

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# Mineralogical, pozzolanic and microscopic characterization of dolomite mine overburden

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Available online 5 May 2023.

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https://doi.org/10.1016/j.matpr.2023.04.465

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## Abstract

Waste generated during the cutting and processing of stones is a severe environmental problem. Using waste materials in civil engineering applications is beneficial for sustainable construction practices. The stone industry generates a very high quantity of overburden during mining processes. This overburden is discarded as its composition is not similar to that in the pure state. This study aims to characterize the dolomite mine overburden in its native state. This characterization is based on mineralogical, pozzolanic and microscopic characteristics of dolomite overburden. The mineralogical characterization was done using XRD and XRF analysis. XRD tests showed the presence of dolomite [$CaMg(CO_3)_2$] and Silica Oxide ($SiO_2$) in significant compositions. The predominant presence of 30.54 % of Calcium Oxide (CaO), 18.71 % Silica Oxide (SiO2) and 7.6 % of (MgO) was determined by XRF analysis. Frattini and Strength Activity Index (SAI) tests were performed to check the presence of pozzolanic properties in the material. Frattini test results showed the non-pozzolanic/inert nature of overburden. The inert nature of dolomite overburden was confirmed by SAI test results. The modified mix failed to fulfill the criteria of 75 % and 85 % strength of the control mix after 7 and 28 days of curing. The microscopic analysis was carried out by SEM analysis. SEM images showed the irregular shape and rough surface texture of dolomite overburden. The pozzolanic characterization proves that the dolomite mine overburdened can't be used as a cementitious material. Its application can be tested for filler material or as a replacement for coarse/fine aggregates in concrete and mortar mixes. It can also be tested as filler material in bituminous mixes or stabilizing agent in soil stabilization.

## Introduction

India is the biggest producer of natural stones, accounting for 27 % of total natural stone production worldwide. There are more than 12,000 stone-crushing industries in India that provide employment to around 500,000 skilled and unskilled workers. In total, the Indian stone industry accounts for providing employment to over 3 million workers. Rajasthan is the second biggest mineral-rich state in India, behind Bihar. Rajasthan is a dominant producer of marble, sandstone, limestone, granite etc. It has a wide variety of mineral deposits. Most of Rajasthan's mined stones are used for India's domestic market [1], [2].

Every year, around 8415 million tonnes of dolomite is produced in India. Predominant dolomite producers in India are Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Karnataka, Odisha, Rajasthan, and Telangana [3]. As per data available on the Ministry of Mines, Govt. of Rajasthan website, there are 599.4 million tons of dolomite reserves in Rajasthan. Significant dolomite sources are in Rajasthan's Ajmer, Bhilwara, Chittorgarh, Jaipur, Jodhpur, and Udaipur districts [4]. Dolomite powder is commercially available and widely used in many industries. Steel industries utilize its primary component along with cement, agriculture, glass, ceramic, and rubber industries [5].

Dolomite has been successfully utilized in various civil engineering applications. In combination with dolomite powder (3:1), fly ash has been successfully used in self-compacting concrete [6]. A reduction in slump value was observed when the dolomite powder was used as filler material in self-compacting concrete [7]. Dolomite stone can be used as the base material in road construction [8]. Dolomite fines of up to 20 % – 30 % can replace fine and coarse aggregates in concrete and mortar [9], [10]. Lime is conventionally used as a stabilizing agent in clayey soils [11], [12]. In most cases, lime used is having less than 5 % Magnesium Oxide content. Dolomite is a variety of limestone with 35 % – 45 % of Magnesium Oxide (MgO) [13]. In some cases, dolomitic lime is also used alone or combined with other materials is also used to stabilize problematic soils [14], [15], [16].

As we go deeper, the purity of rock/mineral in a mine improves. The top layer of mines is known as overburden. This overburden is discarded as it is not having a chemical composition similar to that in the pure state. The in pit dumping of the overburden reduces the problem of rehandling but creates instability issues [17], [18]. External dumping results in less efficient material handling and land use. External dumping also leads to greater social and environmental consequences [19], [20]. A similar problem arises with dolomite mines as well. A very high amount of overburden is generated in dolomite mines which are discarded as waste material. There are various applications of dolomite, and it is commercially available in the market, but the possible applications of overburden are still unexplored. The mining industry is facing severe problems related to the disposal of this waste.

The principal objective of this research is the characterization of dolomite overburden in its native state. The process will include its mineralogical, mechanical and microscopic characterization. The mineralogical characterization will be done using XRD and XRF test results. The mechanical characterization will include tests for pozzolanic activity i.e., Frattini and strength activity index. The microscopic characterization will include the analysis of SEM images. This characterization will help in predicting the possible applications of dolomite overburden for providing areas in which further research is required.

## Section snippets

### Cement and sand

Ordinary Portland Cement (OPC) of grade 43 is used in this study. The natural sand (Zone II, grading as per IS 383–1970) used in this study was procured locally. The specific gravity of sand was 2.65 and the fineness modulus of sand was 2.53. …

### Dolomite overburden (DO)

Dolomite overburden was collected from the Udaipur region of Rajasthan. The overburden is available in abundance in this region and discarded as waste material. The dolomite overburden received was in chunks of stone. These chunks of stone were ground into …

### Mineralogical characterization

The mineral composition of dolomite mine overburden was done by using X-Ray Diffraction (XRD) test. Fig. 2 shows the XRD test results of the dolomite mine overburden. XRD test results showed a major proportion of dolomite [$CaMg(CO_3)_2$] and Silica Oxide ($SiO_2$) in the dolomite mine overburden. XRF test was conducted on the material to check its oxide composition. XRF test results showed 30.54 % of Calcium Oxide (CaO), 18.71 % Silica Oxide/Quartz ($SiO_2$) and 7.6 % of (MgO) in predominant …

### Possible applications based on characterization

From the above characterization, the following can be the possible applications of dolomite mine overburden:

- As the non-pozzolanic/inert behavior of dolomite powder is confirmed by Frattini and SAI test results, this material can't be used as a cementitious material. …
- The presence of magnesium oxide is not recommended in construction materials as it results in the formation of ettringite which is expansive in nature. As the dolomite mine overburden has less composition of magnesium oxide than pure …

…

### Conclusions

From the above test results, the following conclusions have been drawn:

- XRD test results showed the presence of dolomite and quartz as major minerals. XRF test results confirmed the presence of Calcium Carbonate (30.54 %), Quartz (18.71 %) and Magnesium Carbonate (7.6 %) as predominant oxide compounds in dolomite overburden. …
- Frattini test (as per BS EN 196–3) test results showed non-pozzolanic behavior of dolomite overburden. …
- The non-pozzolanic activity was confirmed by SAI test results. Modified …

…

## CRediT authorship contribution statement

**Nishant Sachdeva:** Conceptualization. **Neha Shrivastava:** Methodology, Supervision. **Sandeep Shrivastava:** Methodology, Supervision. …

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …



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> …The TGA-DSC profile shown in Fig. 1 B complements the information, revealing a major endothermic event corresponding to a mass loss of 40.48% between 600 and 800 °C, with the minimum heat flow occurring at 790 °C. The observed thermal event corresponds to the gradual decomposition of the present carbonates, starting with Mg carbonate and later followed by Ca carbonate, as indicated by in-situ XRD [46,58]. TGA-DSC did not exhibit exothermic events, confirming the absence of organic matter in the starting mineral.…

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