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A Review on To Evaluates the Mechanical Performance of Concrete When Cement is Partially Replaced with Dolomite Powder

***Prateek Sahu*[a], *Vinay Kumar Singh Chandrakar*[b]**

M.Tech. Scholar[a], Associate Professor[b], Madhyanchal Professional University, Faculty of Engineering & Technology, School of Civil Engineering Bhopal, M.P., India

Abstract

This review evaluates the mechanical performance of concrete when cement is partially replaced with dolomite powder, a mineral-based material known for its rich calcium and magnesium content. The increasing demand for sustainable construction materials and the environmental impact of cement production have led researchers to explore alternative binders such as dolomite powder. Various studies have investigated the influence of dolomite powder on the fresh and hardened properties of concrete, including workability, compressive strength, split tensile strength, and flexural strength. Results generally indicate that replacing cement with dolomite powder up to an optimal percentage—typically between 10% and 20%—can enhance strength characteristics and durability while reducing the carbon footprint and cost of concrete. This review consolidates the findings from multiple experimental studies to provide a comprehensive understanding of the potential of dolomite powder as a partial cement replacement in concrete production.

Key Words:-mechanical performance, dolomite powder, environmental impact, workability, compressive strength, split tensile strength

Introduction

Concrete is the most widely used construction material globally due to its versatility, durability, and economic viability. However, the production of its primary binding component, cement, contributes significantly to environmental degradation, particularly through the emission of carbon dioxide during manufacturing. In response to the urgent need for sustainable construction practices and reduction in cement consumption, researchers and engineers are exploring various supplementary cementations materials (SCMs) to partially replace cement without compromising the mechanical performance of concrete. Among these alternatives, dolomite powder, a naturally occurring mineral composed of calcium magnesium carbonate ($CaMg(CO_3)_2$), has gained considerable attention due to its availability, low cost, and potential pozzolanic or filler properties. When finely ground and used as a partial replacement for cement, dolomite powder has been shown to influence the fresh and hardened properties of concrete, including workability, compressive strength, flexural strength, and split tensile strength. This review aims to critically evaluate the mechanical behavior of concrete incorporating dolomite powder as a partial cement substitute, analyze the optimum replacement levels suggested in various studies, and identify the implications of such substitutions on strength development, durability, and long-term performance. By examining existing experimental findings, this study seeks to provide insight into the feasibility of using dolomite powder in concrete, contributing to both environmental sustainability and improved material efficiency in modern construction.

Literature Review

Harish K S et al (2023) Concrete, a fundamental building material composed of cement, fine and coarse aggregates, and water, is becoming increasingly expensive due to rising costs of raw materials. As a result, there is a growing need to find cost-effective and sustainable alternatives that reduce construction expenses without compromising quality. One such approach gaining traction in the housing and construction industry is the partial replacement of cement with industrial by-products such as marble powder, which is a waste material generated by marble industries. This method not only lowers the cost of concrete production but also contributes to energy savings and environmental protection by reducing the carbon footprint associated with cement manufacturing. Incorporating marble powder in concrete aligns with advancements in progressive concrete technologies, which aim to enhance both the mechanical and durability properties of concrete. Additionally, research into using dolomite powder alongside marble powder as partial cement replacements further improves concrete's structural performance. Such innovations are critical in minimizing environmental degradation while supporting the development of infrastructure that ensures long-term serviceability, sustainability, and user convenience.

Sagar R. Raut et al (2022) this study investigates the effects of partially replacing cement with dolomite powder in concrete to reduce both construction costs and CO_2 emissions, given the environmental impact of cement production. Concrete, composed of cement, fine and coarse aggregates, and water, becomes costlier due to rising material prices, prompting the exploration of sustainable alternatives. Dolomite powder, derived from sedimentary rock and sharing similar properties with cement, was tested as a substitute at 0%, 5%, 10%, 15%, 20%, and 25% replacement levels by weight of cement in M20 grade concrete. The mechanical properties—compressive strength, split tensile strength, and flexural strength—were assessed and compared with control specimens on the 7th and 28th days. The results revealed that incorporating dolomite powder enhances these strengths up to an optimal replacement level, beyond which performance may decline. Overall, dolomite powder demonstrated potential as an effective and sustainable partial replacement for cement in concrete production.

NomanSaif et al (2022) Lightweight concrete has gained significant attention in recent years due to its numerous advantages over conventional concrete, including reduced dead weight, faster construction, and lower transportation and handling costs. One of its key benefits lies in its low density and high thermal conductivity, which make it particularly suitable for energy-efficient and load-sensitive structures. Traditionally, cinder from steel mills, which is characterized by its porous and uneven surface due to mineral deposits, has been used as a coarse aggregate to achieve lightweight properties. This is because cinder has a lower specific gravity compared to natural aggregates, resulting in a lighter concrete mix. According to various studies, the use of cinder not only contributes to cost reduction but also minimizes construction waste and reduces the structural dead load. In this context, an experimental study was conducted to assess the effect of partially replacing conventional fine aggregate with cinder powder in M25 grade concrete. The investigation involved creating mixes with varying proportions of cinder—0%, 20%, 40%, 60%, 80%, and 100%—as well as replacing fine aggregate with dolomite powder at levels of 10%, 20%, 30%, 40%, and 50%. All samples were cured for 28 days to evaluate their strength and durability, aiming to identify the optimal mix for structural applications while promoting sustainability and waste utilization in concrete production.

Gund K.C et al (2020) Concrete is the most widely used construction material globally, relying heavily on natural resources such as lime, aggregates, and water. However, the rapid increase in cement production to meet construction demands has led to a significant rise in carbon dioxide (CO_2) emissions, contributing to environmental pollution. To mitigate this impact, researchers have explored the use of supplementary materials like Dolomite Powder and Fly Ash as partial replacements for cement. Among these, Dolomite Powder has attracted interest due to its similar properties to cement and its potential to improve concrete performance while reducing costs. This study investigates the effectiveness of using Dolomite Powder as a partial cement replacement at varying proportions of 0%, 5%, 10%, and 15% by weight of cement. Experimental tests were conducted to assess the compressive, split tensile, and flexural strengths of concrete incorporating dolomite powder, and results were compared with conventional concrete samples. The findings reveal that replacing cement with Dolomite Powder leads to an enhancement in all three strength parameters—compressive, tensile, and flexural—demonstrating its suitability as a sustainable and cost-effective alternative material in concrete production, with promising future research potential in the construction industry.

KaushalPrajapati et al (2019) Concrete is one of the most versatile and widely used construction materials, having been utilized for centuries. However, its production relies heavily on natural resources, leading to the depletion of these resources and increased energy consumption. Moreover, cement manufacturing is one of the major contributors to carbon dioxide emissions, a potent greenhouse gas responsible for global warming. The rising cost of concrete materials in building and civil engineering projects has also become a concern for society. These issues have prompted researchers to explore alternative materials to partially replace conventional concrete ingredients, aiming to reduce both environmental impact and production costs. Among the various alternatives, dolomite powder has shown promise as a partial replacement for cement. The primary objective of this paper is to evaluate the desirable properties of concrete at 7, 14, and 28 days of curing when dolomite powder is used at different replacement levels. This study is based on a review of existing literature focused on the mechanical and chemical properties of concrete with dolomite powder, with the aim of producing eco-friendly concrete that offers comparable or improved strength.

K. Sathish Kumar et al (2017) conducted an experimental study to evaluate the combined effect of dolomite powder and copper slag as partial replacements in M20 grade concrete. In their investigation, dolomite powder was used to replace cement at varying percentages of 20%, 25%, and 30%, while copper slag replaced 20% of the fine aggregate by weight. The concrete mix had a proportion of 1:1.5:3 (cement: sand: coarse aggregate). Concrete cubes and cylinders were prepared with these replacement levels and tested for compressive and split tensile strength after 7, 14, and 28 days of curing. The results showed a significant improvement in both compressive and tensile strength with the inclusion of dolomite powder and copper slag. Specifically, the compressive strength of the M20 control mix, which was 27 MPa, increased upon the addition of these materials, indicating enhanced performance. This study demonstrated that the integration of dolomite powder and copper slag not only improves concrete strength but also offers an environmentally friendly solution by utilizing industrial waste materials, effectively converting waste into a valuable construction resource.

A. Muthukumaran et al (2017), an experimental investigation was carried out on M25 grade concrete by partially replacing cement with dolomite powder at 10%, 20%, and 30%, and fine aggregate with manufactured sand (M-sand) at 10%, 20%, and 30% by weight. The objective was to evaluate the effects of these replacements on the mechanical properties of concrete. The target mean compressive strength for M25 grade concrete was 31.6 N/mm². The experimental results revealed that a 10% replacement of cement with dolomite powder combined with a 10% replacement of fine aggregate with M-sand yielded the best mechanical performance. At this optimal mix ratio, the compressive strength was significantly enhanced to 36.55 N/mm², which is notably higher than the target mean strength. Furthermore, this same combination also achieved improved tensile and flexural properties, with a split tensile strength of 2.96 N/mm² and a flexural strength of 3.84 N/mm². These findings indicate that the partial replacement of cement and sand with dolomite powder and M-sand, respectively, not only contributes to sustainability by reducing the use of natural materials but also enhances the overall strength characteristics of the concrete mix.

AthulyaSugathan et al (2017) This experimental investigation aims to explore the potential of utilizing dolomite powder (DP) as a partial replacement for cement in concrete production, with a focus on enhancing sustainability and reducing environmental impact. Cement, a crucial component in concrete, is responsible for a significant portion of CO_2 emissions due to the calcination process involved in its manufacturing, particularly in a country like India, the second-largest producer of cement globally, where each ton of cement contributes approximately 0.8 tons of CO_2 to the atmosphere. In this context, the use of dolomite powder, a finely ground form of the sedimentary mineral dolomite that shares certain physical and chemical characteristics with cement, is proposed as an eco-friendly alternative. The study evaluates the mechanical performance of concrete when cement is partially replaced with dolomite powder at varying levels—0%, 5%, 7.5%, 10%, and 15% by weight. Experimental results from compressive and split tensile strength tests reveal that the inclusion of dolomite powder not only helps in reducing the overall cost of concrete but also improves its strength properties compared to conventional concrete without dolomite. The findings suggest that dolomite powder, when used in suitable proportions, can serve as an effective cement replacement material, contributing both to performance enhancement and environmental sustainability in construction practices.

Mrs.N.ShifuJahan et al (2016) the experimental program was designed to evaluate the feasibility of reducing carbon dioxide emissions in concrete production by partially substituting Portland cement with finely ground dolomite powder—a material whose calcination requires significantly lower temperatures and thus emits less CO_2—within an M30 mix having a constant water-to-cementations materials ratio of 0.45. Four mixtures were prepared in which cement was replaced by dolomite at 0%, 10%, 25%, and 50% by mass, and each was cast into standard cubes, cylinders, and beams for compressive strength, split-tensile strength, and flexural strength tests, respectively, after 28 days of curing. The results showed a marginal reduction in early-age compressive strength at the 10% replacement level but an overall comparable or slightly enhanced performance at 25% replacement, with compressive strengths reaching approximately 95–100% of the control mix; at 50% replacement a noticeable decline was observed, yet the split-tensile and flexural strengths of the 25% dolomite blend exceeded those of the control by 5–8% and 6–10% respectively, indicating that the micro-filler effect of dolomite enhances the interfacial transition zone and crack-resistance. These findings suggest that a 25% cement replacement with dolomite powder optimizes the balance between reduced CO_2 emissions and mechanical performance, offering a promising low-carbon alternative for sustainable concrete construction.

J. Satheesh Kumar et al (2016), M20 grade concrete was investigated by partially replacing cement with dolomite powder at varying percentages of 0%, 5%, 10%, 15%, and 20%. The research focused on evaluating both fresh and hardened properties of the concrete, including workability, compressive strength, flexural strength, and split tensile strength, supported by microstructural analysis using FTIR (Fourier Transform Infrared Spectroscopy), SEM (Scanning Electron Microscopy), and EDAX (Energy Dispersive X-ray Analysis). The results revealed that at lower replacement levels, particularly between 5% and 15%, dolomite powder acted as an effective cementations material, contributing positively to the hydration process and improving the mechanical properties of the concrete. This behavior suggests that dolomite powder can act as an active component, enhancing strength and performance due to its filler effect and potential pozzolanic activity. However, when the replacement percentage increased to 20%, a dilution effect was observed, indicating that excessive dolomite powder reduces the availability of cementations compounds necessary for strength development, thereby negatively impacting the concrete's performance.

PreethiGetal et al (2015) conducted an experimental investigation to evaluate the effects of using dolomite powder as a partial replacement for cement in M20 grade concrete. In this study, dolomite powder was substituted for cement in varying proportions—0%, 5%, 10%, 15%, 20%, and 25%—and the mechanical properties of the resulting concrete mixes were compared with those of a conventional control mix. The compressive strength, split tensile strength, and flexural strength were measured, and the results demonstrated that all three strengths initially increased with the replacement percentage, reaching optimal values before declining with higher replacement levels. The highest compressive strength (31.24 N/mm^2) and flexural strength (8.48 N/mm^2) were observed at 10% replacement, while the maximum split tensile strength (4.25 N/mm^2) was achieved at 15% replacement. This corresponded to a 10.4% increase in compressive strength, a 17.8% increase in flexural strength, and a significant 39.8% increase in split tensile strength on the 28th day, compared to the control mix. Additionally, the use of dolomite powder proved to be cost-effective, as dolomite is less expensive than cement, contributing to a reduction in the overall cost of concrete without compromising its performance within optimal replacement limits.

DeepaBalakrishnanet al (2013) conducted an experimental investigation to assess the workability and strength characteristics of self-compacting concrete (SCC) incorporating fly ash and dolomite powder as partial replacements for cement. In their study, cement was replaced by fly ash at varying levels of 12.5%, 18.75%, 25%, and 37.5% by mass, while dolomite powder was used to replace cement at levels of 6.25%, 12.5%, and 25%. The aim was to develop high-volume fly ash SCC with improved performance characteristics. The results indicated that for all combinations of fly ash and dolomite powder, the fresh properties of SCC such as flow ability, filling ability, and passing ability were enhanced due to the finer particles and spherical shape of fly ash, which improves the lubrication effect, and the filler property of dolomite powder, which contributes to better packing density. Moreover, the hardened properties including compressive strength, split tensile strength, and flexural strength also showed superior performance compared to the control mix. This improvement can be attributed to the pozzolanic reaction of fly ash and the micro-filling ability of dolomite powder, which together lead to a denser microstructure and reduced porosity in the concrete. Thus, the study demonstrated that a well-proportioned combination of fly ash and dolomite powder not only improves the sustainability of concrete by reducing cement content but also enhances its overall performance.

M.M. et al. (2012) conducted a study to evaluate the bond workability and mixture uniformity, focusing on the toughness and bond strength of self-compacting concrete (SCC) mixes incorporating dolomite powder. In their experimental investigation, they used either silica fume or fly ash along with dolomite powder to enhance the bond strength between steel and concrete. A total of seven different mixes were prepared, and a push-out test was conducted to assess the bond performance. The study revealed that the inclusion of dolomite powder significantly improved the bond strength of SCC, with a noticeable increase observed as the replacement level of Portland cement with dolomite powder rose. The normal bond strength results confirmed the suitability of the steel-concrete bond for structural applications. All SCC mixes containing up to 30% dolomite powder demonstrated adequate bond strength for design purposes. Furthermore, the use of dolomite powder in SCC was found to contribute to faster construction due to improved workability and bond performance. Notably, reinforced concrete (RC) beams made with these modified SCC mixes exhibited higher shear strength compared to conventional SCC without dolomite powder, highlighting the structural advantages of using dolomite as a partial cement replacement.

SalimBarbhuiya et al (2011) conducted a study to investigate the feasibility of using dolomite powder in the production of self-compacting concrete (SCC). The experimental results demonstrated that SCC could effectively be manufactured by incorporating a combination of fly ash and dolomite powder. Specifically, the mix with a 3:1 ratio of fly ash to dolomite powder not only complied with the workability and performance criteria outlined by the European Federation of Producers and Contractors of Specialist Products for Structures (EFNARC) guidelines for SCC but also showed promising mechanical properties. The compressive strength results revealed that the SCC mix with 75% fly ash and 25% dolomite powder achieved sufficient strength levels, making it suitable for structural applications. This suggests that dolomite powder can be used as a partial replacement material in SCC, contributing to sustainable construction practices by reducing the reliance on cement while maintaining the concrete's quality and performance.

Methodology

In this review study aimed at evaluating the mechanical performance of concrete when cement is partially replaced with dolomite powder, the methodology involves an extensive analysis of previous experimental research and relevant literature. The selected studies focus on varying replacement levels of cement with dolomite powder, typically ranging from 0% to 30% by weight, to observe changes in fresh and hardened concrete properties. The mix designs are generally based on standard concrete grades such as M20, M25, and M30, maintaining a constant water-cement ratio while substituting cement with dolomite powder in incremental percentages. The concrete specimens—mainly cubes, cylinders, and beams—are cast and cured under standard conditions, usually for 7, 14, and 28 days. Mechanical tests including compressive strength, split tensile strength, and flexural strength are then conducted using standard IS or ASTM procedures. Workability tests like slump cone and compaction factor tests are performed to determine the influence of dolomite on fresh concrete behavior. The results are compared with control mixes to identify the optimal replacement level that improves or sustains mechanical performance without compromising structural integrity. The review also considers the microstructural behavior and pozzolanic activity of dolomite powder to assess its role in cement hydration and strength development.

Conclusion

The review concludes that the partial replacement of cement with dolomite powder in concrete significantly influences its mechanical performance, particularly in enhancing compressive, split tensile, and flexural strengths up to an optimum replacement level. Most studies indicate that incorporating dolomite powder at replacement levels ranging from 5% to 15% improves strength characteristics due to its filler effect, better particle packing, and pozzolanic reactivity, which contribute to a denser microstructure and reduced porosity. Beyond the optimal dosage, however, a decline in mechanical performance is observed, likely due to the dilution of cementations material and reduced calcium silicate hydrate (C–S–H) formation. Furthermore, dolomite powder improves the workability of fresh concrete and contributes to the sustainability of construction practices by reducing the consumption of Portland cement, thereby lowering CO_2 emissions. Overall, dolomite powder is a promising supplementary cementations material for producing eco-friendly and mechanically efficient concrete when used in controlled and optimized proportions.

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