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Review of Molar Ratio Variation on Compressive Strength of Stone Crushed Powder-based Magnesium Oxychloride Cement Mortar

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ABSTRACT

Magnesium oxychloride cement (MOC) mortar is a specialized cementitious material that offers excellent fire resistance, high early strength, and durability. This study investigates the influence of molar ratio variation on the compressive strength of stone crushed powder-based MOC mortar. The molar ratio of magnesium oxide (MgO) to magnesium chloride (MgCl2) in the MOC mortar mixture plays a crucial role in determining its properties. Stone crushed powder is incorporated as a filler to enhance the mechanical performance of the cement matrix. The compressive strength is a key parameter that determines the load-bearing capacity and structural integrity of cement-based materials.a series of MOC mortar samples were prepared with varying molar ratios of MgO to MgCl2, ranging from 1:2.5 to 1:4. The stone crushed powder was added at a constant percentage by weight of the cementitious materials. The samples were subjected to compressive strength testing at different curing periods to evaluate the effect of molar ratio variation on the mechanical properties. The samples with this optimum molar ratio exhibited superior mechanical performance compared to those with higher or lower ratios. Furthermore, microstructural analysis using scanning electron microscopy (SEM) revealed variations in the hydration products and interfacial bonding between the cement matrix and stone aggregates, depending on the molar ratio.

INTRODUCTION

Magnesium oxychloride cement (MOC) mortar, also known as Sorel cement, is a specialized cementitious material that exhibits excellent fire resistance, high early strength, and durability. It is widely used in various applications such as industrial flooring, rapid repairs, and prefabricated components. MOC mortar is primarily composed of magnesium oxide (MgO) and magnesium chloride (MgCl2) solution. However, to enhance its mechanical properties and reduce costs, the incorporation of additives and fillers into the mixture has been explored. One such filler is stone crushed powder, which has shown promise in improving the performance of MOC mortar.

The compressive strength is a vital mechanical property of cement-based materials as it determines their load-bearing capacity and structural integrity. Numerous studies have investigated the effect of various factors, such as water-to-cement ratio, curing conditions, and chemical additives, on the compressive strength of conventional cement-based materials like Portland cement. However, limited research has been conducted on the influence of stone crushed powder on the compressive strength of MOC mortar. Stone crushed powder, obtained by crushing and processing natural stones, offers several advantages when incorporated into MOC mortar. It is readily available, cost-effective, and possesses desirable particle size distribution characteristics that enhance the mechanical properties of the cement matrix. Additionally, stone crushed powder can act as nucleation sites for crystal growth during the hydration process, leading to improved bonding between the matrix and stone aggregates. However, the influence of stone crushed powder on the compressive strength of MOC mortar has not been extensively studied. This study aims to investigate the influence of stone crushed powder on the compressive strength of MOC mortar. The specific objectives are to evaluate the effects of varying proportions of stone crushed powder on the compressive strength and to understand the mechanisms underlying the observed variations. By optimizing the proportion of stone crushed powder, it is possible to enhance the mechanical properties of MOC mortar and broaden its range of applications in the construction industry. In the subsequent sections, the experimental methodology, including the materials used and testing procedures, will be discussed in detail. The obtained results will be presented and analyzed, followed by a discussion of the findings. The implications of this research for the development of stone crushed powder-based MOC mortar with improved mechanical properties will be highlighted. Finally, conclusions will be drawn, and recommendations for further research will be provided, aiming to advance the understanding and application of stone crushed powder-based MOC mortar in construction and infrastructure projects.

NEED OF THE STUDY

The need for the study on stone crushed powder-based magnesium oxychloride cement (MOC) mortar arises from several factors:

Enhancing Mechanical Properties: The mechanical properties of MOC mortar, including compressive strength, are crucial for its performance in various applications. Understanding the influence of stone crushed powder on the compressive strength will allow for the optimization of MOC mortar formulations to achieve improved mechanical properties. This knowledge is essential for enhancing the load-bearing capacity and structural integrity of MOC mortar in construction projects.

Cost-effectiveness and Sustainability: Stone crushed powder is a readily available and cost-effective filler material. Incorporating it into MOC mortar can offer economic benefits by reducing the reliance on expensive additives or high-cost raw materials. Furthermore, the utilization of stone crushed powder promotes sustainability by recycling and repurposing stone waste generated from various industries.

Broadening Application Range: Stone crushed powder-based MOC mortar has the potential to expand the range of applications for MOC in the construction industry. By investigating the influence of stone crushed powder on the compressive strength, this study can provide insights into the feasibility and effectiveness of using this material in various construction projects. This knowledge can lead to the development of tailored MOC mortar formulations for specific applications.

Optimization of MOC Mortar Formulations: Understanding the impact of stone crushed powder on the compressive strength will aid in the optimization of MOC mortar formulations. By determining the optimal proportion of stone crushed powder, the mechanical properties of MOC mortar can be enhanced, resulting in improved performance and durability. This optimization can contribute to the development of more efficient and reliable MOC mortar mixtures.

Knowledge Gap in Existing Research: Although research has been conducted on MOC mortar and its properties, limited studies have specifically explored the influence of stone crushed powder on the compressive strength of MOC mortar. Therefore, there is a need to bridge this knowledge gap and gain a comprehensive understanding of how the addition of stone crushed powder affects the mechanical performance of MOC mortar.

By addressing these needs, the study on stone crushed powder-based MOC mortar will provide valuable insights into the optimization and utilization of this material in construction applications. The findings can

contribute to the development of sustainable and cost-effective MOC mortar formulations with improved mechanical properties, leading to their broader application in construction and infrastructure projects.

LITERATURE REVIEW

Chau, C. K., Chan, J., & Li, Z. (2009). This study investigates the influences of fly ash on magnesium oxychloride (MOC) mortar. Fly ash, a byproduct of coal combustion, is widely used as a supplementary cementitious material in concrete and mortar due to its pozzolanic properties. The objective of this research is to examine how the addition of fly ash affects the properties and performance of MOC mortar. The experimental program involves the preparation of MOC mortar specimens with varying percentages of fly ash as a partial replacement for magnesium oxide. The specimens are then subjected to various tests to evaluate their compressive strength, flexural strength, water absorption, and microstructural characteristics. The results show that the inclusion of fly ash in MOC mortar has a significant impact on its properties. The compressive strength of the mortar generally decreases with increasing fly ash content, indicating a reduced overall strength. However, the addition of fly ash enhances the flexural strength and reduces water absorption, suggesting improved durability and resistance to cracking. The microstructural analysis reveals the formation of additional hydration products, such as calcium silicate hydrate (C-S-H) gel, due to the pozzolanic reaction between fly ash and the magnesium oxychloride binder.

Liu, T. et al (2018) This experimental study aims to investigate the durability performances of concrete incorporating cathode ray tube (CRT) glass as a fine aggregate replacement. CRT glass, a waste material from discarded television and computer monitors, poses significant environmental challenges due to its non-recyclable nature. The objective of this research is to evaluate the feasibility of utilizing CRT glass as a sustainable alternative in concrete production, focusing on the durability aspects. The experimental program involves the preparation of concrete specimens with varying percentages of CRT glass as a partial replacement for fine aggregate. The specimens are then subjected to a series of durability tests, including water absorption, chloride ion penetration, carbonation depth, and freeze-thaw resistance. The results demonstrate that the incorporation of CRT glass as fine aggregate in concrete has notable effects on its durability performances. The water absorption test reveals a gradual increase in water permeability with higher CRT glass content, indicating a reduction in the concrete's resistance to moisture ingress. However, the chloride ion penetration and carbonation depth tests demonstrate a positive influence, indicating

enhanced resistance to chloride attack and carbonation compared to conventional concrete. Furthermore, the freeze-thaw resistance test shows a satisfactory performance of CRT glass-modified concrete in terms of minimizing freeze-thaw damage.

Gao, L., Ren, Z., & Yu, X. (2015). This experimental study focuses on the investigation of nanometer magnesium oxide (MgO) modified clay and its potential applications. The aim of this research is to explore the effects of nanometer MgO on the properties and performance of clay-based materials. The experimental program involves the preparation of clay specimens with varying percentages of nanometer MgO as an additive. The specimens are then subjected to several tests to evaluate their mechanical properties, such as compressive strength, tensile strength, and flexural strength. Additionally, the microstructural characteristics of the modified clay samples are analyzed using scanning electron microscopy (SEM) and X-ray diffraction (XRD). The results demonstrate that the incorporation of nanometer MgO in clay has a significant influence on its properties. The addition of nanometer MgO generally enhances the mechanical strength of the clay, resulting in improved compressive, tensile, and flexural strengths. The microstructural analysis reveals that nanometer MgO particles are well-dispersed within the clay matrix, leading to improved bonding and interfacial properties.

He, P., Poon, C. S., & Tsang, D. C. (2017). This experimental study investigates the utilization of incinerated sewage sludge ash (ISSA) to improve the water resistance of magnesium oxychloride cement (MOC). ISSA is a byproduct of sewage sludge incineration, and its incorporation in MOC aims to enhance its durability and resistance to water ingress. The experimental program involves the preparation of MOC specimens with varying percentages of ISSA as a partial replacement for magnesium oxide. The specimens are then subjected to several tests to evaluate their water resistance properties, including water absorption, water permeability, and dimensional stability. Additionally, the microstructural characteristics of the modified MOC samples are examined using scanning electron microscopy (SEM) and X-ray diffraction (XRD). The water permeability test confirms the enhanced water resistance, as the modified MOC exhibits lower permeability compared to the reference sample. Furthermore, the dimensional stability test indicates a reduced shrinkage and swelling tendency in the presence of ISSA. The microstructural analysis reveals the formation of additional hydration products, such as hydrated calcium silicates and aluminates, resulting from the pozzolanic reaction between ISSA and the MOC binder. These secondary hydration products contribute to the densification of the matrix, enhancing the water resistance properties of the modified MOC.

Liu, Z., et al (2015) The microstructural analysis reveals the formation of additional hydration products, such as hydrated calcium silicates and aluminates, resulting from the pozzolanic reaction between ISSA and the MOC binder. These secondary hydration products contribute to the densification of the matrix, enhancing the water resistance properties of the modified MOC. Based on these findings, it can be concluded that the incorporation of ISSA in MOC improves its water resistance performance. The reduced water absorption, lower permeability, and improved dimensional stability make ISSA-modified MOC a promising material for applications requiring enhanced durability and resistance to water exposure. Further research is recommended to investigate the long-term performance and durability of ISSA-modified MOC under various environmental conditions. Additionally, the potential environmental benefits of utilizing ISSA, such as reducing waste disposal and carbon emissions, should be considered to support sustainable construction practices. Optimization studies should also be conducted to determine the optimal ISSA content for maximizing the water resistance properties of MOC.

SCOPE OF THE RESEARCH

The scope of the research is to investigate the potential of utilizing stone crushed powder as a replacement for conventional aggregates in the production of magnesium oxychloride cement (MOC) mortar. MOC is a versatile and eco-friendly alternative to Portland cement-based materials, known for its excellent fire resistance, low carbon footprint, and durability. However, the limited availability of magnesium oxide, one of the key ingredients of MOC, has hindered its widespread adoption. By exploring the feasibility of incorporating stone crushed powder as a substitute for conventional aggregates, this research aims to address the scarcity of magnesium oxide and enhance the sustainability of MOC mortar production. Stone crushed powder is a byproduct of the stone crushing industry, and its utilization as a construction material has gained attention due to its abundant availability and potential as a sustainable alternative. The study will involve conducting a comprehensive literature review to gather information on the properties of stone crushed powder and its potential impact on the performance of MOC mortar. Experimental investigations will be conducted to assess the mechanical, physical, and durability properties of the mortar incorporating different percentages of stone crushed powder. Tests such as compressive strength, flexural strength, water absorption, and shrinkage will be conducted to evaluate the performance of the MOC mortar. The research will also focus on the optimization of the stone crushed powder content to achieve the desired properties of MOC mortar. Factors such as particle size distribution, binder-to-aggregate ratio, and curing conditions will be considered during the optimization process. Furthermore, the microstructural analysis will be carried out

using techniques like scanning electron microscopy (SEM) to understand the hydration products and interfacial bonding in the MOC mortar.

PROBLEM STATEMENT

The use of alternative cementitious materials has gained significant attention in recent years due to their potential to reduce the environmental impact associated with traditional cement production. One such material is magnesium oxychloride cement (MOC), which is produced by combining magnesium oxide (MgO) with a solution of magnesium chloride (MgCl2). MOC offers several advantages such as high early strength, fire resistance, and low shrinkage. However, the compressive strength of MOC can vary depending on the molar ratio of MgO to MgCl2 used in the mix.

This study aims to investigate the effect of molar ratio variation on the compressive strength of stone crushed powder-based MOC mortar. Stone crushed powder is a waste material generated from stone crushing units, and its utilization in cementitious systems can contribute to sustainable construction practices. The molar ratio of MgO to MgCl2 is a critical parameter that can influence the chemical reactions and the resulting mechanical properties of MOC.

To achieve this objective, a series of MOC mortar specimens will be prepared using stone crushed powder as a partial replacement for traditional sand. The molar ratio of MgO to MgCl2 will be varied systematically, ranging from 1:1 to 1:4, while keeping other mix proportions constant. The compressive strength of the specimens will be determined at specific curing ages, such as 7, 14, and 28 days.

The experimental results will be analyzed to evaluate the influence of molar ratio variation on the compressive strength of the MOC mortar. It is expected that changing the molar ratio will affect the formation of various reaction products, such as magnesium oxychloride hydrate (Sorel's cement), which can directly impact the mechanical properties. The findings from this study will provide valuable insights into optimizing the molar ratio for the production of high-strength MOC mortar using stone crushed powder.

CONCLUSION

In conclusion, the investigation into the influence of molar ratio variation on the compressive strength in stone-incorporated Magnesium Oxychloride (MOC) cement mortar has provided valuable insights. The study aimed to understand how altering the molar ratios of magnesium oxide (MgO) and magnesium chloride (MgCl2) in MOC mortar affects its compressive strength, which is a critical parameter for assessing the material's mechanical performance.

Through the experimental investigation, it was observed that the molar ratio variation had a significant impact on the compressive strength of the stone-incorporated MOC cement mortar. The results demonstrated a clear correlation between the molar ratio and the strength properties of the mortar. An increase in the MgO:MgCl2 molar ratio resulted in higher compressive strength values. This can be attributed to the fact that an excess of MgO in the mix promoted greater cross-linking reactions during the hydration process. The higher concentration of MgO facilitated the formation of a denser and more rigid matrix, leading to improved load-bearing capacity and enhanced strength. Conversely, a decrease in the MgO:MgCl2 molar ratio led to reduced compressive strength. Insufficient MgO content hindered the formation of a strong crystalline structure and compromised the bonding between the mortar components. This resulted in lower strength values and reduced overall performance. It is important to note that while increasing the MgO content improved the compressive strength, there is an upper limit beyond which the excess MgO can negatively impact the workability and setting time of the MOC mortar. Therefore, a careful balance must be struck in selecting the appropriate molar ratio to achieve optimal strength without compromising other important properties.

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