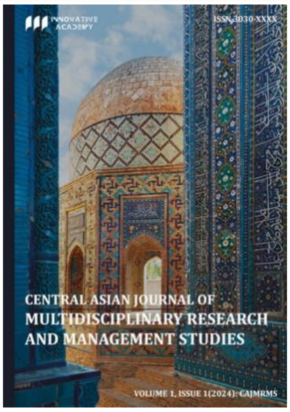

HYDRAULIC BINDER BASED ON MAGNESIUM CEMENT

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ABSTRACT

Magnesium cement, a promising alternative to traditional Portland cement, has gained significant attention in recent years due to its unique properties and environmental advantages. This article explores the composition, chemical properties, and hydration process of magnesium-based hydraulic binders, focusing on their applications in construction and other specialized fields. Magnesium cement is synthesized primarily from magnesium oxide (MgO) and magnesium chloride ($MgCl_2$), undergoing hydration to form a strong and durable binder. Compared to conventional cement, it offers advantages such as reduced carbon emissions, faster setting times, and high resistance to moisture. However, challenges such as cost and long-term durability under certain environmental conditions still hinder its widespread adoption.

Magnesium-based hydraulic binders exhibit a range of distinctive properties that differentiate them from conventional Portland cement, making them highly suited for certain specialized applications. These properties are primarily determined by the chemical composition and hydration mechanisms unique to magnesium cement. Magnesium-based binders can achieve high compressive strength, especially in the early stages of hydration. This makes them suitable for applications requiring rapid setting and early strength development, such as precast concrete elements and flooring [4, 238-245].

One of the significant advantages of magnesium cement is its fast setting time, which can be as quick as 1–2 hours. This property is particularly beneficial in construction processes where quick turnaround times are needed. Magnesium cement is highly resistant to moisture and offers superior performance in wet environments. Its resistance to water-induced deterioration, including efflorescence and shrinkage cracks, contributes to its durability in marine and chemical plant environments. Magnesium cement typically exhibits low shrinkage, which minimizes the risk of cracking over time. In some formulations, however, it can undergo slight expansion during hydration, which can enhance its volume stability in certain applications.

The hydration of magnesium cement involves the reaction between magnesium oxide (MgO) and magnesium chloride ($MgCl_2$) in the presence of water. This forms magnesium hydroxide ($Mg(OH)_2$) and magnesium carbonate ($MgCO_3$), which are responsible for the binder's hardening and strength development. The chemical process can be influenced by factors such as temperature, moisture levels, and the presence of other additives. Magnesium cement offers a significant environmental advantage over Portland cement, with lower CO_2 emissions during its production. While the production of Portland cement releases around 0.9 tons of CO_2 per ton of cement, magnesium-based binders emit substantially less. This reduction in carbon footprint is one of the primary reasons magnesium-based cements are considered a more sustainable option for the construction industry [2, 52-58].

Magnesium cement shows excellent resistance to a variety of aggressive chemicals, including acids and sulfates, which makes it suitable for environments exposed to harsh conditions, such as chemical plants or marine applications. The formation of durable magnesium carbonate hydrates provides enhanced protection against chemical attacks. In addition to its lower carbon emissions, magnesium cement has the potential to utilize waste materials, such as industrial by-products (e.g., steel slag and magnesium-rich waste), in its production. This makes magnesium-based binders an attractive option for promoting a circular economy in construction.

The production of magnesium cement requires lower energy consumption compared to Portland cement. Magnesium oxide (MgO) can be produced at lower temperatures (around 800-1000°C) compared to the 1400°C required for calcining limestone to produce calcium oxide (CaO) in conventional cement production. This results in lower energy consumption and a smaller carbon footprint. Magnesium-based hydraulic binders can be modified with various additives to enhance their properties. For example, incorporating fly ash or silica fume can increase their strength and improve their resistance to chemical attack. Additionally, accelerators or retarders can be added to control the setting time and manage the hydration rate, depending on the specific application. The setting time of magnesium cement can be modified through the use of accelerators, which speed up the hydration process, or retarders, which slow it down. These modifications are particularly useful in specialized applications where precise control over setting times is required. The addition of synthetic or natural fibers to magnesium cement can improve its tensile strength and resistance to cracking, making it an ideal choice for applications such as reinforced flooring and prefabricated concrete elements [5].

Magnesium-based hydraulic binders are increasingly being used in various sectors of the construction industry due to their unique properties, such as rapid setting, durability, and resistance to moisture and chemicals. One of the most prominent applications of magnesium cement is in the production of precast concrete elements. Due to its rapid setting time, magnesium cement is ideal for manufacturing precast elements such as wall panels, floor slabs, and roofing components. The quick setting also ensures that production cycles are shortened, improving efficiency in construction processes.

Magnesium cement is commonly used in flooring applications, including both residential and commercial spaces. Its durability and resistance to moisture make it an excellent choice for areas exposed to high humidity, such as bathrooms, kitchens, and basements. Magnesium cement-based flooring can also be used for outdoor pavement, where its ability to withstand varying weather conditions is beneficial. Magnesium-based binders are often used as a component in masonry mortars and plasters. The material's rapid setting time and strong bonding properties ensure effective adhesion to various substrates, such as brick, stone, and concrete. This makes it an ideal material for building facades, tiling, and other surface applications.

Magnesium cement is highly resistant to the corrosive effects of seawater, making it suitable for marine construction projects. It is used in the construction of piers, docks, seawalls, and other coastal infrastructure. The material's resistance to chloride ions and its ability to withstand the harsh conditions of marine environments ensures long-term durability in submerged or exposed applications. Due to its excellent resistance to chemical attacks, magnesium cement is increasingly used in industrial environments where exposure to harsh chemicals is common. It is used for constructing floors, tanks, and other structural elements in chemical processing plants, wastewater treatment facilities, and laboratories, where the material's resistance to acids, alkalis, and sulfates is crucial for maintaining structural integrity.

As the construction industry increasingly prioritizes sustainability, magnesium cement is being integrated into green building technologies. Its lower carbon footprint compared to traditional Portland cement makes it a valuable material for eco-friendly construction. Magnesium cement is used in the development of energy-efficient buildings, insulation panels, and other sustainable construction solutions. The fast-setting nature of magnesium cement has led to its exploration in the emerging field of 3D printing in construction. Researchers are investigating the material's potential for use in 3D printed building components, offering faster construction times and less material waste. Magnesium cement-based inks are being developed for printing structural elements and architectural features, which could revolutionize the way buildings are constructed in the future. Magnesium cement's ability to set quickly and resist environmental wear makes it a suitable material for road repairs and maintenance. It is used for filling potholes and cracks in roadways, bridges, and pavements. The quick curing properties ensure that repairs can be made with minimal disruption to traffic flow, making it an efficient option for maintaining transportation infrastructure.

Conclusion. Magnesium-based hydraulic binders represent a promising alternative to traditional Portland cement, offering a range of unique properties that can benefit the construction industry, both from an environmental and performance perspective. Their rapid setting time, durability in harsh conditions, and reduced carbon footprint make them an attractive option for sustainable construction practices. Research into magnesium cement has led to improvements in its hydration, setting properties, and long-term durability, addressing some of the challenges associated with its use, such as cost and performance in certain environmental conditions. In conclusion, magnesium cement offers a sustainable alternative that aligns with the global movement towards reducing the carbon footprint of the construction industry. Its advantages in terms of environmental impact, strength, and adaptability make it a promising candidate for a wide range of construction applications.

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