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Hybrid Concrete Admixture: A Multifunctional Integral Water-Resisting and Durability-Enhancing Admixture for Concrete Protection

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The ingress of water and aggressive substances is the main reason responsible for all the major physical and chemical degradation of concrete structures and pavements, which in turn shortens their life span and results in substantial costs to the asset owners. Much research has been conducted to improve the durability and service life of concrete infrastructure, using different integral water-resisting (also known as 'waterproofing') admixtures and surface coatings or membranes. The use of an effective integral water-resisting admixture has several benefits over traditional surface protection because it does not require regular maintenance, is not vulnerable to deterioration, can be used where it is too complex or impossible to apply a layer of protection and does not require labour. As an admixture added to concrete at the batching plant, or sometimes to concrete trucks on the job site, this product saves time and cost and eliminates the expense of ongoing maintenance.

Despite these benefits, some water-resisting admixtures can negatively affect certain concrete properties, particularly mechanical strength. Although hydrophobic and crystalline admixtures can lower water absorption rates to some extent, they often contribute to a reduction in compressive strength, typically 5-15% [1]. Furthermore, their influence on key durability factors – such as reinforcement corrosion resistance and microbial-induced degradation – remains unclear, necessitating further research.

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The selection of an appropriate water-resisting admixture depends on the specific requirements of the structure. Densifiers, for example, improve the compactness of concrete but are ineffective at sealing cracks, making them better suited for simpler structural applications where a lower level of water-resistance and durability is required [2, 3]. Water-repelling admixtures, while effective at increasing the contact angle of water on the concrete surface to prevent moisture ingress, often reduce the material's mechanical strength. These admixtures slow down the rate of water absorption under static water pressure but do not reduce permeability under hydrostatic pressure [1]. Crystalline admixtures, such as sodium acetate, offer an alternative approach by enhancing water -resisting properties and facilitating self-healing in newly formed cracks when applied under strict conditions [4]. However, these admixtures sometimes result in reduced strength, and their water-resisting performance is highly dependent on the type of concrete, chemistry of cement and other admixtures used, water-cement ratio, and other factors.

Commercially available waterproofing admixtures have relied on a single waterproofing mechanism, such as water-repellence, crystallisation, pore-blocking, or densification. However, recent research demonstrated that combining these mechanisms into a "hybrid" admixture significantly improves performance. This has led to the development of an advanced hybrid (or multifunctional) water-resisting and durability-enhancing admixture (Patent No. 2023902368) that provides superior durability, waterproofing, environmental benefits and cost-effectiveness compared to traditional water-resisting admixtures. This formulation (hybrid admixture) integrates multiple water-resisting technologies, including self-healing compounds, pore-blocking agents, densifiers, hydrophobic agents, and nano-sized chemical additives, creating a more comprehensive and reliable waterproofing system. The hybrid water-resisting admixture substantially enhances fresh properties, strength, durability, and water- resistance of concrete under static and heavy hydrostatic pressure by severely disrupting the capillary system within the concrete matrix. Compared to untreated concrete with the same cement content and slump, this advanced hybrid admixture has been shown to reduce water absorption rate and permeability by 70 to 95% and increase compressive, flexural, and tensile strengths by 20-50%, depending on the dosage used. It has been proven to generate positive impacts on other concrete properties as well.

Besides improving concrete fresh properties, structural performance, and tripling service life, this next-generation water-resisting and durability-enhancing admixture contributes significantly to sustainability efforts as well. By improving strength and reducing the required cement content by up to 32% while simultaneously improving durability and water resistance and extending the lifespan of structures, it offers a sustainable alternative to traditional concrete mixes and admixtures. This substantially reduces carbon emissions, saving approximately 135 kg of CO_2 per cubic metre of concrete from reduced cement usage and an additional 975 kg per cubic metre due to increased lifespan and eliminated regular maintenance, reconstruction and repairs (over a given service life). In total, these improvements translate into a remarkable reduction of approximately 1,110 kg CO_2 per cubic metre of concrete – representing over 85% decrease in emissions compared to conventional concrete mixes throughout its lifespan.

The introduction of this innovative hybrid waterproofing/durability-enhancing admixture marks a significant advance in concrete technology. It enhances durability, water-resistance, reduces or eliminates maintenance costs, and promotes environmental sustainability. This novel solution has recently garnered considerable attention from the concrete and construction industries and has been successfully implemented in several projects worldwide. Ongoing research and development in this field should continue to refine these solutions, ensuring their widespread adoption in modern construction. Additional information regarding innovative this hybrid concrete admixture is available at www.chemconcrete.com.au

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