THE ROLE OF CHEMICAL ADMIXTURES IN THE PRODUCTION OF MODERN CONSTRUCTION MATERIALS: A COMPARATIVE STUDY OF INTERNATIONAL PRACTICES

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Abstract: This article analyzes the role of chemical admixtures in the production of modern construction materials, their influence on physical and mechanical properties, and the global experience of their application. Today, chemical admixtures play a crucial role in the production of environmentally friendly, energy-efficient, and high-strength concretes. The study compares the practices of European countries, the USA, Japan, China, Korea, and CIS states, focusing on the use and efficiency of polycarboxylate-based superplasticizers, accelerators, retarders, air-entraining, and hydrophobic agents. The findings highlight that these admixtures significantly enhance concrete strength, durability, and frost resistance while reducing water absorption. The paper concludes with recommendations for developing admixtures suitable for Uzbekistan's local climate and raw material base.
Keywords: concrete, chemical admixture, superplasticizer, water-cement ratio, hydrophobic agent, international standards.

In recent years, the global construction industry has been developing under the principles of environmental sustainability and energy efficiency. Chemical admixtures play a vital role in improving the quality of concrete and reinforced concrete products by affecting the hydration process of cement, reducing the water-cement ratio, and improving the rheological properties of the mixture.
Modern production technologies, especially those using **polycarboxylate ether (PCE)-based superplasticizers**, allow for a 30–35% reduction in water consumption while maintaining or even improving workability and strength. Therefore, studying international practices and developing locally adapted chemical admixtures are of great importance for Uzbekistan's construction materials industry.
Chemical admixtures are classified according to their functional purpose. The main types include:

- **Water-reducing and superplasticizing agents** – disperse cement particles, reduce water demand, and increase the density and strength of concrete.
- **Accelerators and retarders** – control the setting and hardening rate, optimizing the construction schedule.

- **Air-entraining agents** – create micro air bubbles in concrete, increasing its frost resistance.
- **Hydrophobic additives** – decrease water absorption and enhance the waterproofing capacity of concrete.
- **Corrosion inhibitors and antifreeze admixtures** – protect steel reinforcement and ensure concreting at low temperatures.

Modern polycarboxylate superplasticizers form an electrostatic barrier around cement particles, preventing agglomeration and allowing for a uniform hydration process, which can increase compressive strength by up to 25%.

The effectiveness of admixtures depends largely on **accurate dosing and the sequence of mixing**. Superplasticizers are typically used at 0.5–1.2% of the cement mass, with optimal dosage determined experimentally to avoid segregation.

By using admixtures, the **water-cement ratio (W/C)** can be reduced from 0.45 to 0.30, resulting in:

- Increased workability and flowability;
- 15–25% higher compressive strength;
- Reduced water absorption and enhanced frost resistance;
- Slower carbonation and lower risk of corrosion.

In modern plants, production is monitored through **online control sensors** that measure real-time rheological behavior, moisture, temperature, and setting time. This automation minimizes human error and ensures product consistency.

Europe (Germany, France, Italy):

According to **EN 934-2**, admixtures are classified by their function. In Germany, **PCE-based superplasticizers (e.g., BASF Glenium series)** are widely used, achieving up to 35% water reduction and 25% strength increase. In France, the **Vicat LC3 system** (limestone–calcined clay cement) reduces CO_2 emissions by 15%.

USA and Canada:

The **ASTM C494** standard defines seven types (A–G) of admixtures, with **Type F and G superplasticizers** being the most common. Air-entraining agents are widely used to produce concretes with frost resistance ratings up to F400. Corrosion inhibitors (e.g., $Ca(NO_2)_2$) extend reinforcement durability in marine and road structures.

Japan and South Korea:

In Japan, **JIS A 6204** regulates admixture use, emphasizing rheological control. The combination of **PCE + VMA (viscosity modifiers)** is applied in 3D-printed concrete to reduce layer segregation by 70%. In South Korea, ultra-high-performance concretes (UHPC) achieve compressive strengths of 150–180 MPa using nano-silica with PCE.

China and Singapore:

China's chemical admixture industry exceeds 5 million tons annually. Domestic producers such as *Sobute* and *Kelong* export PCE-based products globally. Singapore promotes "green concrete" with **silica fume + PCE + slag**, reducing cement use by 50% and earning **LEED Green Building** certification.

CIS and Uzbekistan:
CIS countries, including Uzbekistan, follow **GOST 24211-2008**. Given the region's hot, dry, and saline climate, the combination of **air-entraining, hydrophobic, and antifreeze additives** is most effective. Developing **locally synthesized PCE admixtures** based on methacrylic acid and ethylene glycol is a promising direction.

Global experience demonstrates that chemical admixtures significantly improve both technical and operational properties of concrete:

- Compressive strength increases by **20–30%**;
- Water absorption decreases **1.5–2 times**;
- Frost resistance improves from **F100 to F300**;
- Construction cycles shorten by **15–20%**.

From an ecological standpoint, reducing cement consumption lowers CO_2 emissions by **25–40 kg per m³ of concrete**, contributing to "green construction" and global decarbonization goals.

For Uzbekistan, the development of admixtures compatible with **PC 400 D0** and **PC 500 D0** cements is particularly relevant. Local admixtures such as **BAAS-MIXPLAST 140W** and **PCAN-55** can enhance concrete workability under hot climate conditions and ensure controlled hardening.

In conclusion, chemical admixtures are an essential component of modern concrete technology. Their proper selection and application not only improve strength and durability but also make construction more sustainable and cost-effective. Adopting global innovations and localizing them to Uzbekistan's conditions will elevate the country's construction materials industry to an international level.

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