

Summary of Gypsum-Based Self-Leveling Materials

Yueyun Fang¹, Hao Cui²

¹Guangdong University of Science & Technology, Dongguan, 523083, China;

²China Nuclear Industry Huaxing Construction Co. Ltd, Nanjing, 210000, China.

Abstract

Self-leveling material is a new type of self-leveling material for building floor, which is based on inorganic or organic cementitious materials, adding proper amount of aggregate, water reducing agent, water retaining agent and other additives. Self-leveling materials can be divided into organic and inorganic materials according to the different substrates. Among them, inorganic gypsum-based self-leveling materials have better thermal insulation, sound insulation and fire prevention and durability. So gypsum-based self-leveling thermal insulation materials have a wide application prospect.

Keywords

Gypsum-based, chemical gypsum, self-leveling thermal insulation materials, gypsum thermal insulation material.

1. Introduction

Self-leveling material is a new type of self-leveling material for building floor, which is based on inorganic or organic cementitious materials and is composed of appropriate aggregate, water reducing agent, water retaining agent and other additives. Its greatest feature is leveling, which can flow freely under its own gravity to form a flat ground, and overcome the common problem of uncontrollable leveling in the construction of ordinary cement mortar [1].

The main substrates of self-leveling materials can be divided into organic system and inorganic system. Organic self-leveling materials mainly refer to epoxy self-leveling materials. Their unique chemical structure and two-component organic compounds make the organic self-leveling materials have good physical and mechanical properties, acid resistance, oil and other chemical properties, and have become the most widely used self-leveling materials. Inorganic self-leveling materials can be divided into cement-based self-leveling materials and gypsum-based self-leveling materials. Cement self-leveling material has high strength, good fluidity and excellent water resistance, which is widely recognized in the market. Gypsum-based self-leveling material has good thermal insulation, sound insulation, fire protection and durability. Compared with cement-based material, gypsum-based self-leveling material is slightly elastic, with good self-weight, light foot and high comfort. Gypsum-based self-leveling materials have higher quality for gypsum, but there are fewer high-quality natural gypsum in China, so chemical gypsum self-leveling system has great development potential and economic effect [2].

2. Composition of Gypsum-Based Self-Leveling Material

Gypsum exists mainly in dihydrate gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and anhydrite (CaSO_4) in nature. As a useful industrial raw material, gypsum can lose part or all of its crystalline water when heated and become mature gypsum. When hydrated gypsum is exposed to water, it solidifies and forms dihydrate gypsum with original chemical composition. These phenomena are called dehydration and hydration respectively. At room temperature, dihydrate gypsum is a stable phase, but with the increase of temperature and different external conditions, various variants of hemihydrate gypsum and anhydrous gypsum can be obtained.

The key technology of gypsum-based self-leveling material is to have good cohesiveness, prevent bleeding and segregation, and improve the rheological properties of the material on the premise of greater fluidity. Therefore, the main technical route of gypsum-based self-leveling material is usually to add some compound and efficient additives to reduce the water-binder ratio, improve the fluidity of mortar and maintain it. Proper viscosity coefficient makes the mixture have self-compacting, self-leveling properties and the required viscosity to resist segregation [3].

Gypsum-based self-leveling mortar is a complex system composed of many kinds of materials. It has complex mortar formula. It requires strict variety and dosage of raw materials. The quality or variety of raw materials varies. Even the performance of mortar prepared with the same formula will be different. However, although the formulations of gypsum-based self-leveling mortar are different, the main components of gypsum-based self-leveling mortar are composed of the following four parts.

First, it is the cementitious materials. Gypsum is the main cementing material in self-leveling mortar.

Second, it is the aggregate. Sand is the aggregate in gypsum-based self-leveling mortar and plays the role of skeleton. The particle size distribution of sand has an important impact on the fluidity and mechanical properties of gypsum mortar.

Third, it is the additives. Additives are indispensable modification materials for gypsum-based self-leveling mortar. The additives can be grouped into the following varieties.

(1). Water-retaining agent (cellulose ether)

At present, fiber ethers used in mortar mainly include methyl hydroxyethyl cellulose ether (MHEC), methyl hydroxypropyl cellulose ether (MHPC) and methyl cellulose ether (MC). The water retention of mortar increases with the increase of cellulose ether content, viscosity and fineness. The higher viscosity of cellulose ether, the higher molecular weight of cellulose ether, the lower the solubility of cellulose ether, which has a negative impact on the strength and construction performance of the material. The higher viscosity, the more obvious thickening effect on the material, but it is not proportional. The higher the viscosity is, the more sticky the wet mortar will be. In construction, it is shown that the adhesive blade and the adhesion to the base material are high, but the increase of the structural strength of the mortar is not significant. The fineness of cellulose ether has great influence on its solubility. Coarser cellulose ethers are usually granular and easily dispersed in water without caking, but the dissolution rate is very slow. Cellulose ether is dispersed in aggregates, fine aggregates and cementitious materials. Only enough fine powder can avoid fiber ether agglomeration when water is added. When fiber ether is dissolved in water, it is difficult to disperse and dissolve again.

(2). Redispersible latex powder

As early as 1000 years ago, people have found that the use of natural resins or protein materials can significantly improve the durability and bonding properties of inorganic cementitious materials. For example, Zhaozhou Bridge in China has not been destroyed for thousands of years. This experience has continued to this day, especially the invention and popularization of cement. In the 1950s, synthetic resins began to be used in traditional building materials.

At present, the widely used redispersible latex powders are ethylene and vinyl chloride and vinyl laurate terpolymer powder (E/VC/VL), acrylic and styrene copolymer powder (A/S), vinyl acetate and acrylic acid and vinyl ester terpolymer powder (VAC/A/VeoVa), vinyl acetate and vinyl laurate terpolymer powder (VAC/A/VeoVa), vinyl acetate and vinyl alcohol terpolymer powder and vinyl ester ternary copolymer rubber powder (VAC/E/VeoVa), vinyl acetate and vinyl higher fatty acid copolymer rubber powder (VAC/VeoVa), styrene and butadiene copolymer rubber powder (SBR), vinyl acetate homopolymer rubber powder (PVAC), vinyl acetate and copolymer rubber powder (VAC/E), etc.

When the redispersible latex powders are added into gypsum-based materials and mixed together, the polymer particles are evenly dispersed in gypsum-based materials. When gypsum meets water, the hydration reaction begins. The polymer particles are deposited on the gel and unhydrated gypsum particles. With the hydration reaction proceeding, the water is continuously consumed and the hydration product is produced. With the increase of materials, polymer particles gradually accumulate in the capillaries and form a compact accumulation layer on the surface of gels and unhydrated gypsum particles. The aggregated polymer particles gradually fill the capillaries and cover the inner surface of capillaries which they can not fully fill. The water content is further reduced due to hydration and drying. Closely packed polymer particles on the gel and in the voids coagulate into continuous films, forming a mixture of matrix and gypsum slurry, and cementing hydration products and aggregates. Because the hydration products with polymer form a covering film at the interface and the polymer condenses into a film in the gap of the interface transition zone, the interface transition zone of gypsum-based materials is more compact. As a result, the performance of gypsum-based materials is improved, the internal stress is alleviated, the stress concentration is reduced, and the generation of micro-cracks is reduced. Moreover, the polymer film not only plays a hydrophobic role, but also does not block the capillary, so that the material has good hydrophobicity and permeability. At the same time, due to the sealing effect caused by the polymer film, the impermeability, chemical resistance and freeze-thaw durability of the material are greatly improved, the crack resistance, bending strength, adhesion strength, elasticity and toughness of the material are improved, and ultimately shrinkage cracking of the material can be avoided, and the thickness of the bonding layer can be reduced.

The tensile strength of mortar can be improved by adding fine dispersed organic polymer into gypsum-based materials. In addition to forming film in mortar, the material forms rigid skeleton after hydration of gypsum. The film formed by polymer in skeleton has the function of movable joint, which can ensure the elasticity and toughness of rigid skeleton. The tensile strength of polymer film is more than 10 times higher than that of ordinary mortar. Fine aggregate organic polymer can also improve the tensile strength of mortar. From the point the view of macromolecule chemistry, if the molecular chain contains both flexible and rigid chains, the polymer exhibits the characteristics of rigidity and flexibility, forming a strong network structure in gypsum hydrate, and improving its mechanical properties in gypsum like reinforcing bars.

(3). Water reducing agent

Water reducing agent is an additive that can reduce the amount of mixing water under the condition of maintaining the same consistency of mortar. At present, the main types of water reducing agent are naphthalene-based reducers, melamine reducers, lignin-based reducers and polycarboxylate-based reducers. The thermal movement of gypsum particles in solution causes them to collide and attract each other at some edges and corners to form flocculent structure. Because the flocculent structure contains a lot of water, it can not provide enough water for the hydration of cementitious materials, so it reduces the workability of the lower materials. After adding water reducing agent, the hydrophilic groups are adsorbed on the surface of gypsum cementitious material in a directional way, which makes the surface of the cementitious material have the same charge, makes the particles of the cementitious material repel each other, and releases the water included in the flocculent structure, thus improving the workability of the material.

(4). Retarder

Retarder is an additive that can reduce the hydration speed and heat of hydration of gypsum and other materials and prolong the setting time. The retarders can be divided into carbohydrates, lignosulfonates, hydroxycarboxylic acids, salts and inorganic salts. Different retarders have different retarding mechanisms for gypsum. Taking citric acid as an example,

citric acid has little effect on the dissolution of hemihydrate gypsum. The effect is mainly manifested in inhibiting the formation of dihydrate gypsum nucleus. In terms of growth, citric acid is adsorbed on the newly formed dihydrate gypsum embryo through complexation, which reduces the surface energy of the embryo and increases the potential energy barrier of nucleation. The time for the embryo to reach the critical nucleation size is prolonged, and the induction period of gypsum is delayed correspondingly due to absorption. By the side effect, the nucleation probability and quantity of dihydrate gypsum decrease, the superposition rate of ions on each crystal plane decreases, the crystal growth is delayed, and the crystal nucleus has sufficient time and space to grow. So the crystal size is obviously coarsened. The dihydrate gypsum (111) surface is mainly composed of calcium ions. Citric acid selectively adsorbs the nuclear crystal through complexation, inhibits the growth of the crystal plane along the C axis, changes the growth rate of the Z axis, inhibits the growth of the long axis, and transforms the crystal from needle to short column.

The fourth component of gypsum-based self-leveling mortar is mineral fillers. In gypsum-based self-leveling mortar, mineral admixtures such as fly ash, ground slag, portland cement, heavy calcium powder and light calcium powder are often added in order to improve the fluidity and stability of the mortar system, reduce the water requirement for mixing and improving its mechanical properties. Mineral admixtures as micro-aggregates, also known as active mineral admixtures, can produce specific cementitious properties while improving the gradation of gypsum particles and stimulated by gypsum hydration products, thus improving the performance of pastes. As a kind of material, saving resources and energy is also for its own sustainable existence and development. Whether self-leveling material can be used as ground finishing material for a long time, and whether it can become green material is also very important. If we still use a lot of resources and energy at the cost of inefficient and extensive development, it will not only consume our limited resources and energy, but also bring a heavy burden to environmental protection. Mineral admixtures have broad prospects in the application of green building materials in the twenty-first century because they are mostly industrial wastes and take advantage of technological advantages [4].

3. Characteristics of Gypsum-Based Self-Leveling Material

At present, in the construction of buildings in China, cement mortar is still used and traditional manual method is used to make leveling layer, and then the ground is decorated. As a result, the development of self-leveling gypsum in China has the following characteristics.

Firstly, only a few big cities have sales, such as Bayer self-leveling gypsum. There are less than ten producers, with annual output and sales of only about 10,000 tons. But there is no large-scale production, and most manufacturers use building gypsum to prepare, and by increasing the amount of chemical additives, additive cost accounts for about two-thirds of the production cost of self-leveling gypsum, to ensure that the corresponding performance requirements are met, resulting in the application cost of self-leveling gypsum is higher than that of cement mortar, and the promotion resistance is greater, the exhibition is slow.

Secondly, self-leveling gypsum as the ground leveling layer has incomparable advantages compared with other materials, so its market prospects are broad. Our country adds nearly 2 billion square meters of construction area every year. If the ground using self-leveling gypsum accounts for 60%, about 20 kilograms per square meter, the annual market demand will be more than 20 million tons.

Thirdly, it is high added value. If the price of self-leveling gypsum is 1700 yuan per ton in Beijing area, 40% sand can be added into the self-leveling gypsum if the high strength gypsum produced by desulphurization gypsum is used to make self-leveling gypsum, thus reducing the cost to less than 700 yuan per ton.

Fourthly, with the operability of the national support policy, it can obtain the administrative support and promotion of the government as gypsum dry mortar [5].

4. Conclusion

Self-leveling material is a new type of material. With the deep understanding of the design department and construction department and the expanding gap of labor force in our country, the low labor intensity, high comfort, good stability, good heat preservation effect, environmentally friendly and pollution-free chemical gypsum-based self-leveling material will gradually enter the national vision. Ground paving materials play an increasingly important role, with good economic benefits and environmental protection effect, is a promising new material.

References

- [1] Nurhayat Degirmenci. Utilization of phospho gypsum as raw and calcined material in manufacturing of building products. *Construction and Building Materials*, 2008, 22(8):1857-1862.
- [2] Mridul Garg, Neeraj Jain, Manjit Singh. Development of alpha plaster from phospho gypsum for cementitious binders. *Construction and Building Material*, 2009, 23(10):3138-3143.
- [3] Jeongyun Do, Yangseob Soh. Performance of polymer-modified self-leveling mortars with high polymer-cement ratio for floor finishing. *Cement and Concrete Research*, 2003, 33(10):1497-1505.
- [4] Paul Hughes, Stephanie Glendinning. Deep dry mix ground improvement of a soft peaty clay using blast furnace slag and red gypsum. *Q J Engineering Geology and Hydrogeology*, 2004, 37:205-216.
- [5] Fauziah I, Zauyah S, Jamal T. Characterization and land application of red gypsum: a waste product from the titanium dioxide industry. *Science of the Total Environment*, 1996, 188(2-3):243-251.